Photovoltaic power plant inspection report

FVE na louce

Report reference number: 21581	**According to**: IEC TS 62446-3
Inspection date and time: Saturday 2023/07/29 16:17	**Report creation date**: Wednesday 2023/08/09 00:00
Inspection site: FVE na louce	
Address: Louková 1	**GPS coordinates**: 49.4197989, 17.7172499

SITE OWNER

COMPANY NAME/NAME
Demo projekt

COMPANY ID NUMBER/DATE OF BIRTH
Demo projekt

CLIENT

NAME
DroneTech s.r.o.

PHONE NUMBER
+420 724 302 040

CONTACT PERSON
Ing. Ondřej Staněk

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INSPECTION PROCESSOR

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TECHNICIAN
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stanek@dronetech.cz

POWER PLANT

POWER
1.5 MW_{dc}

INVERTERS
SMC 10000TL, SMC 7000TL, SMC 11000TL, SMC 9000TL

MODULES (NUMBER OF MODULES: 8 712)
Canadian Solar Canadian Solar CS6P-230 230W, Canadian Solar CS-6P-220 220W, Placeholder Placeholder 315W, Schuco SPV 170 SME-1 170W

STRUCTURE
pozemní instalace

MODULE TECHNOLOGY
-

MODULE LAYOUT
-

DATA COLLECTION

NAME
DroneTech s.r.o.

PILOT
Ing. Ondřej Staněk

UAS
Matrice 30T

CAMERA
M30T

WEATHER

HUMIDITY
52 %

TEMPERATURE
27° C

WIND SPEED
4 m/s

INTENSITY OF SOLAR RADIATION
950 W/m^2

CLOUD COVER

INSPECTION

INSPECTION TYPE
DEFAULT ~~REGULAR~~ ~~EMERGENCY~~

Overall assessment

The following anomalies were found on the panels of the inspected photovoltaic power plant, with a total of **295 on 355 modules**.
The total estimated annual power loss is **39 430,00 kWh**.

Anomaly name	Number of anomalies *(1)	Number of modules *(2)	Estimated power loss (kW) *(3)	Estimated power loss (%) *(4)	Estimated annual power loss (kWh) *(5)	Estimated annual financial loss (CZK) *(6)
Cell High	10	10	0,63 kW	0,04 %	630,00 kWh	8 889,16 CZK
Cell Low	72	72	4,58 kW	0,25 %	4 580,00 kWh	64 136,94 CZK
Cell Medium	28	28	1,67 kW	0,09 %	1 670,00 kWh	23 354,38 CZK
Cell Multi High	33	33	3,23 kW	0,18 %	3 230,00 kWh	45 185,00 CZK
Cell Multi Low	40	40	4,30 kW	0,24 %	4 300,00 kWh	60 200,00 CZK
Cell Multi Medium	31	31	2,95 kW	0,16 %	2 950,00 kWh	41 300,00 CZK
Cracking	4	4	0,68 kW	0,04 %	680,00 kWh	9 520,00 CZK
Diode	29	29	2,29 kW	0,13 %	2 290,00 kWh	32 126,78 CZK
Diode Multi	5	5	0,76 kW	0,04 %	760,00 kWh	10 640,00 CZK
Internal Short Circuit High	4	4	0,24 kW	0,01 %	240,00 kWh	3 418,80 CZK
Internal Short Circuit Low	5	5	0,38 kW	0,02 %	380,00 kWh	5 266,80 CZK
Internal Short Circuit Medium	4	4	0,37 kW	0,02 %	370,00 kWh	5 151,30 CZK
Module	6	6	1,49 kW	0,08 %	1 490,00 kWh	20 860,00 CZK
Physical Obstruction	1	1	0,06 kW	0,00 %	60,00 kWh	785,40 CZK
String	4	64	14,72 kW	0,82 %	14 720,00 kWh	206 080,00 CZK
Total	**295**	**355**	**39,43 kW**	**2,18 %**	**39 430,00 kWh**	**551 986,40 CZK**

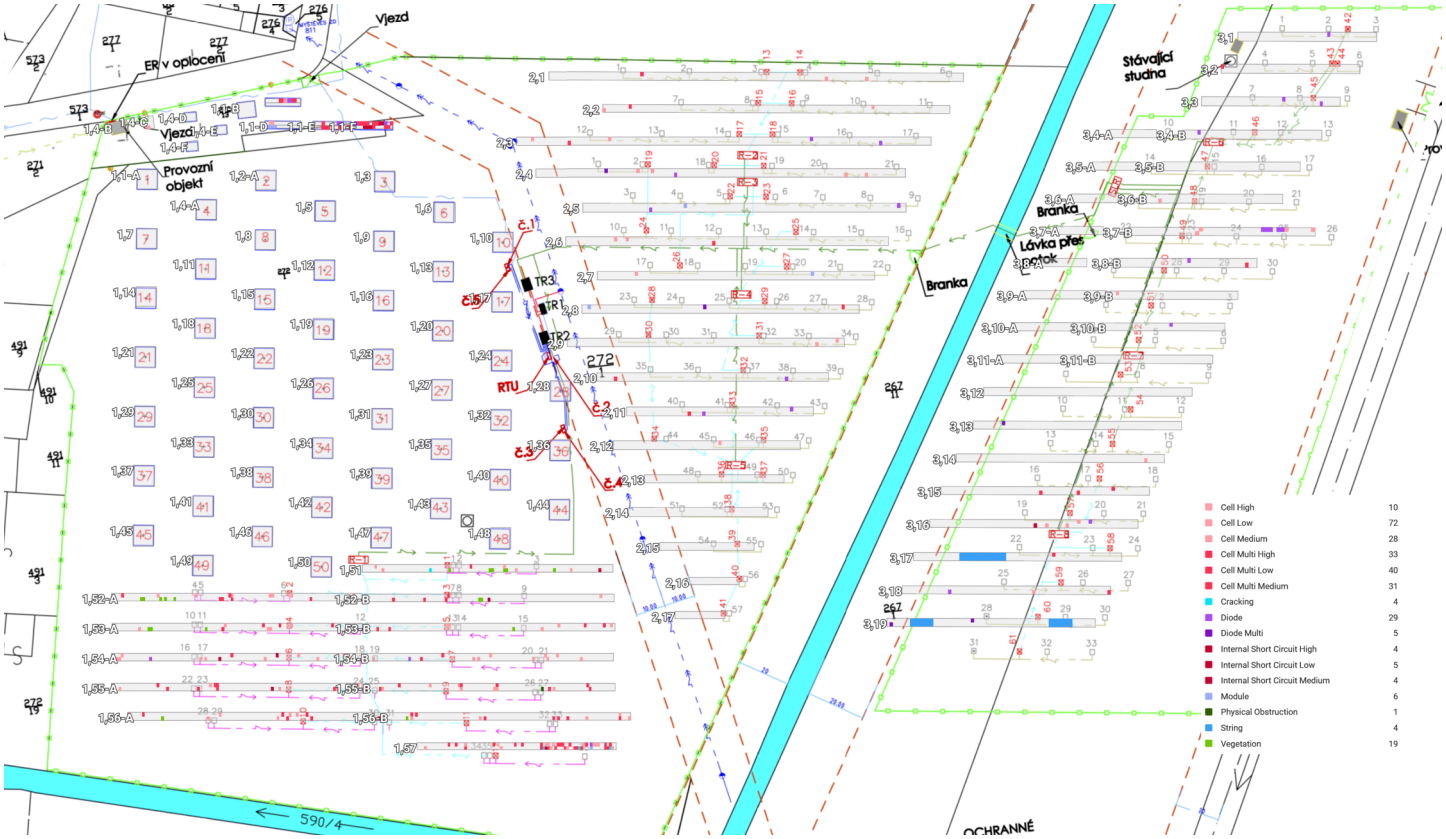
Anomaly name	Number of anomalies *(1)	Number of modules *(2)	Estimated power loss (kW) *(3)	Estimated power loss (%) *(4)	Estimated annual power loss (kWh) *(5)	Estimated annual financial loss (CZK) *(6)
Vegetation	19	19	1,08 kW	0,06 %	1 080,00 kWh	15 071,84 CZK
Total	**295**	**355**	**39,43 kW**	**2,18 %**	**39 430,00 kWh**	**551 986,40 CZK**

Overall assessment

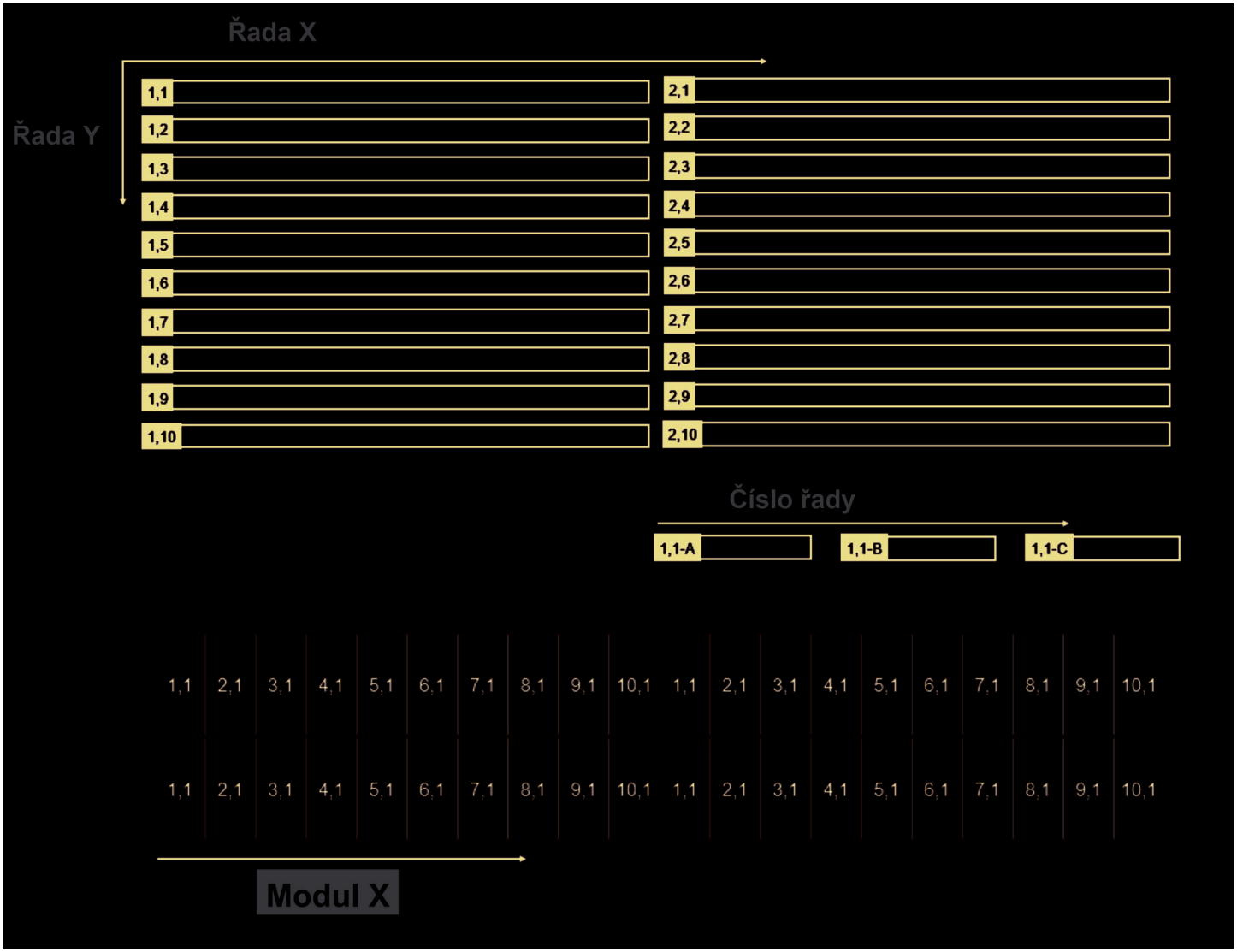
*(1) Anomaly: Number of occurrences of a given anomaly type.
*(2) Modules: Number of modules affected by the given anomaly type.
*(3) Estimated Power Loss (kW): The estimated power loss is defined as the product of the number of affected modules, the plant's peak power (STC), and the anomaly-specific performance impact factor (on a scale from 0 to 1).
*(4) Estimated Power Loss (%): The estimated power loss expressed as the ratio of the lost power to the plant's total capacity, shown in percentage terms.
*(5) Estimated Annual Power Loss (kWh): The estimated annual energy loss in kilowatt-hours, calculated as the power loss multiplied by the number of solar hours per year.
*(6) Estimated Annual Financial Loss (CZK): The estimated annual financial loss is calculated based on the annual energy loss in kilowatt-hours multiplied by the price per kilowatt-hour. The price per kilowatt-hour is determined according to the feed-in tariff provided by the client for the purpose of this calculation.

For more information about individual anomaly types, please refer to the end of this document.

Anomaly map


Vjezd
ER v oplocení
Provozní objekt
Vjezd
Stávající studna
Branka
Lávka přes potok
Branka
TR3
TR1
TR2
RTU
č.1
č.2
č.3
272
267
590/4
OCHRANNÉ
Cell High 10
Cell Low 72
Cell Medium 28
Cell Multi High 33
Cell Multi Low 40
Cell Multi Medium 31
Cracking 4
Diode 29
Diode Multi 5
Internal Short Circuit High 4
Internal Short Circuit Low 5
Internal Short Circuit Medium 4
Module 6
Physical Obstruction 1
String 4
Vegetation 19

Anomaly localization



Course and Processing of Aerial Thermographic Measurement

For the purpose of this report, the methodology of aerial thermographic inspection was applied, during which infrared thermal images were captured using unmanned aerial systems (drones). This enabled detailed and highly accurate measurement of the thermal characteristics of photovoltaic (PV) modules. The evaluation was performed in accordance with the requirements of **IEC TS 62446-3**. The applied methodology allows for the detection of thermal anomalies and effective diagnosis of system faults from an aerial perspective, ensuring precise localization of identified defects.

Thanks to the optimization of the flight and imaging process, all data were collected within a short time frame and under homogeneous meteorological conditions (particularly constant solar irradiance). This minimized the influence of variable factors and allowed for consistent analysis of individual modules.

The analysis was further supported by comprehensive evaluation of aerial images with very high spatial resolution (3 cm/px), which made it possible to identify anomalies at the level of strings, modules, and even single PV cells.

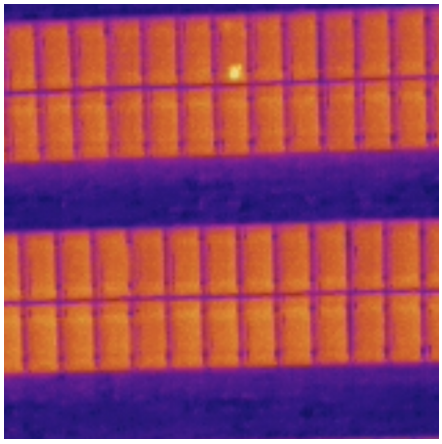
To ensure maximum data integrity and accuracy, all acquired data (RGB color images and infrared IR images) were manually reviewed and cross-correlated, eliminating the possibility of misinterpretation.

Analyzed Anomalies

1. **Cell:** Local thermal anomaly at the level of a single PV cell, indicating a potential defect, typically caused by manufacturing faults, material degradation, or mechanical damage.
2. **Cell Multi:** Multiple thermal anomalies distributed across several adjacent cells of one module, often signaling a more extensive structural defect or degradation.
3. **Circuit:** Fault in the electrical circuit, manifested by outage or underperformance of multiple strings, related to connection or insulation issues.
4. **Combiner:** Anomaly caused by a defect at the point of combining multiple strings into one DC flow, often linked to poor connections, cable degradation, or failure of protective components.
5. **Cracking:** Occurrence of micro-cracks or macro-cracks in the glass or laminated structure of the module, leading to localized overheating, reduced performance, and risk of further degradation.
6. **Damaged:** Mechanical deformation of the module, including bending, displacement, physical damage, or extensive cracking, which may cause significant power losses and increased safety risk.
7. **Delamination:** Separation of the glass, encapsulant, or active layer of the module, leading to degradation of protective properties, higher susceptibility to moisture ingress, and reduced performance.
8. **Diode:** Activation of a bypass diode as a result of a failed cell or module, indicating the presence of a serious localized defect affecting part of the production chain.

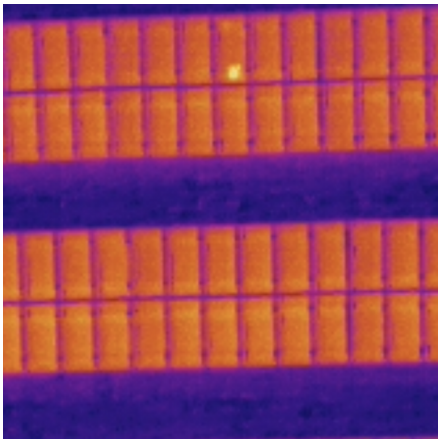
9. **Helix Damage:** Permanent deformation of modules or supporting structures caused by mechanical twisting of the tracker, usually due to a malfunction in movement control.
10. **Hot Spot:** Small area with significantly higher temperature compared to its surroundings, indicating faulty connections, cell degradation, or partial shading, with a high risk of further defects.
11. **Hot Spot Multi:** Occurrence of multiple hot spots within a single module, typically in thin-film panels, indicating more extensive structural damage.
12. **Internal Short Circuit:** Anomaly resulting from an internal short circuit in the module, causing localized heating and significant performance reduction.
13. **Inverter:** Malfunction of the inverter converting DC into AC current, manifested by non-functionality of connected strings and affecting large parts of the system.
14. **Junction Box:** Thermal anomaly at the connection point of strings on the module, often indicating faulty joints, corrosion damage, or overheating of electrical contacts.
15. **Missing Module:** Physically absent module that was documented as installed according to project records, or removed without documentation update.
16. **Module:** Overall thermal anomaly at the level of the entire module, often indicating bypass diode failure, internal damage, or degradation of the whole unit.
17. **Physical Obstruction:** Presence of a foreign object (e.g., leaves, stones, snow) on the panel surface causing shading and localized performance loss.
18. **Reverse Polarity:** Electrical connection with incorrect polarity, leading to power loss, potential equipment damage, and fault risk.
19. **Shading:** Blocking of solar irradiance by vegetation, structures, or other objects, directly reducing energy production efficiency.
20. **Soiling:** Accumulation of dust, dirt, bird droppings, or other debris on the panel surface, causing uneven irradiance and reduced performance.
21. **String:** Set of PV modules connected in series, where faults in individual modules or connections affect the performance of the entire group.
22. **Tracker Tilt:** Incorrect tracker angle setting, reducing the system's ability to optimize energy production during the day.
23. **Underperforming String:** String showing significantly lower temperature difference (and thus output) compared to neighboring strings, usually indicating partial defects.
24. **Vegetation:** Shading of modules by vegetation (grass, shrubs, trees), reducing direct solar irradiance and system efficiency.

Anomaly examples



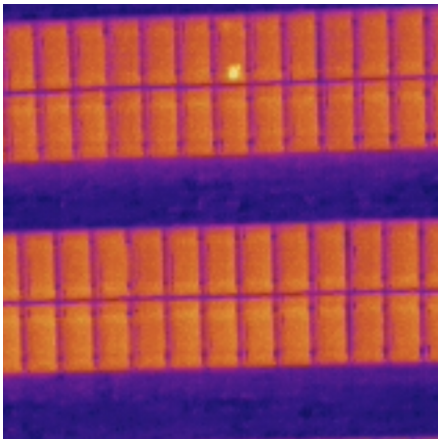
Cell High

Anomaly where the cell temperature is higher than the surrounding area by more than 20 °C.



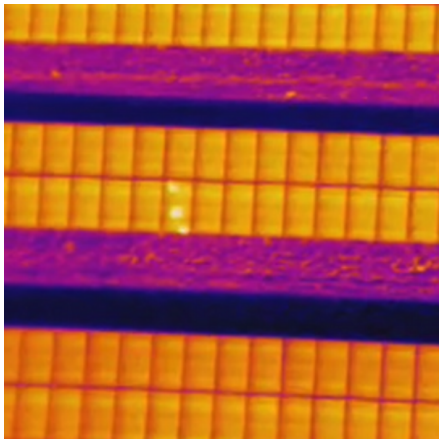
Cell Medium

Anomaly where the cell temperature is higher than the surrounding area by 10–20 °C.



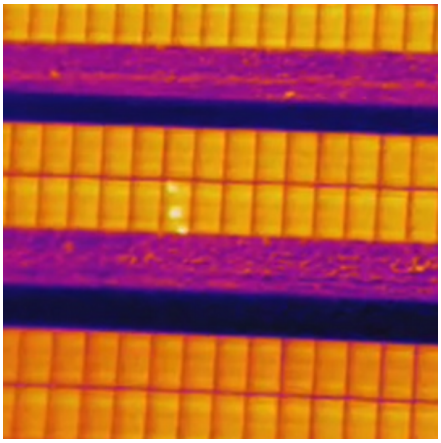
Cell Low

Anomaly where the cell temperature is higher than the surrounding area, but not by more than 10 °C.



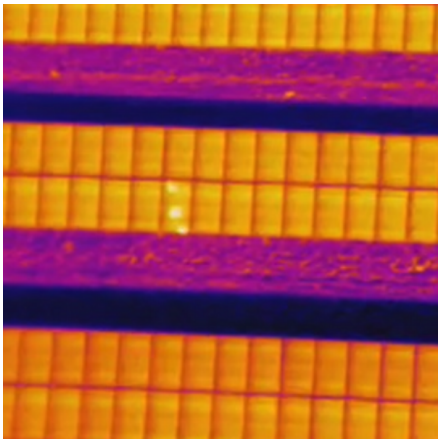
Cell Multi High

Overheating of a group of cells, where the anomaly area temperature is higher than the surrounding area by more than 20 °C.



Cell Multi Medium

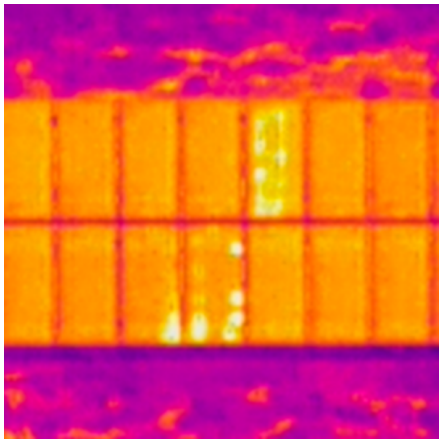
Overheating of a group of cells, where the anomaly area temperature is higher than the surrounding area by 10–20 °C.



Cell Multi Low

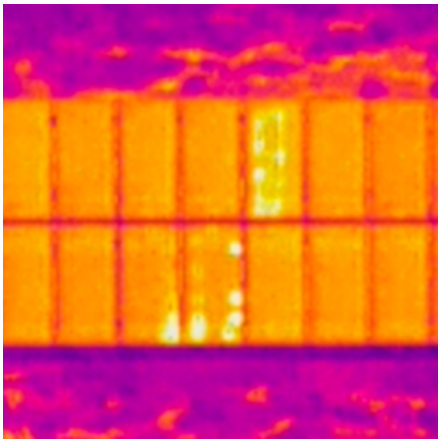
Overheating of a group of cells, where the anomaly area temperature is higher than the surrounding area, but not by more than 10 °C.

Anomaly examples



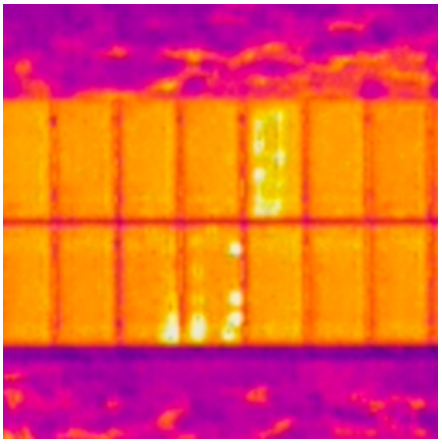
Internal Short Circuit High

Multi-cell anomaly occurring within diode boundaries, where the temperature is higher than the surrounding area by more than 20 °C.



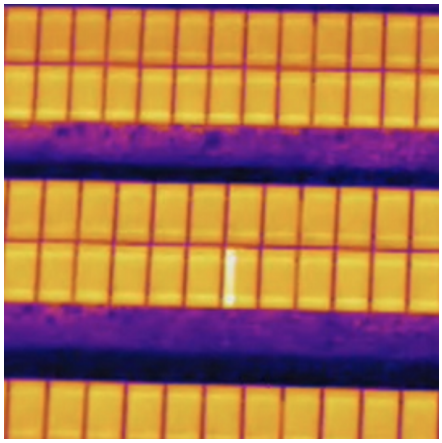
Internal Short Circuit Medium

Multi-cell anomaly occurring within diode boundaries, where the temperature is higher than the surrounding area by 10–20 °C.



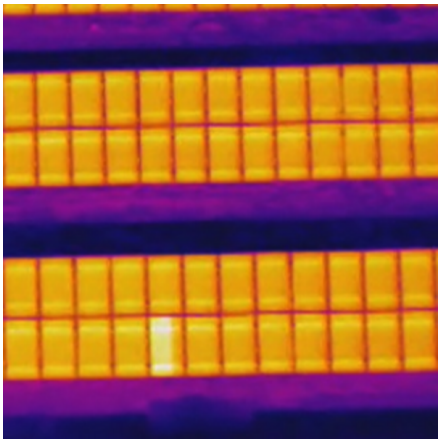
Internal Short Circuit Low

Multi-cell anomaly occurring within diode boundaries, where the temperature is higher than the surrounding area, but not by more than 10 °C.



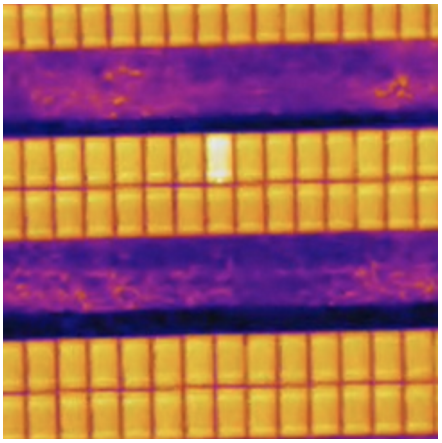
Diode

A bypass diode provides current flow around a faulty cell or module. A diode-type anomaly is indicated as a bypassed diode – typically affecting one-third of the module.



Diode Multi

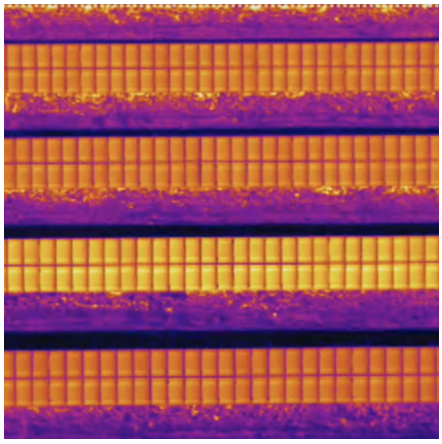
Multiple activated bypass diodes – typically affecting two-thirds of the module.



Module

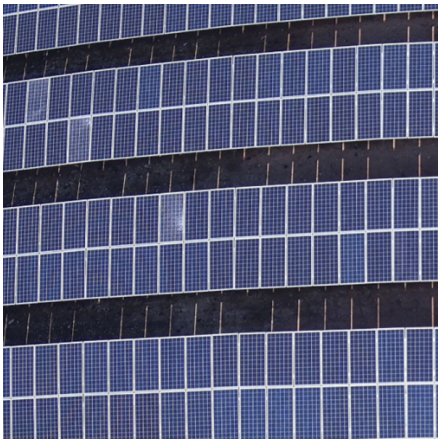
The temperature of the entire module is high compared to the surrounding area.

Anomaly examples



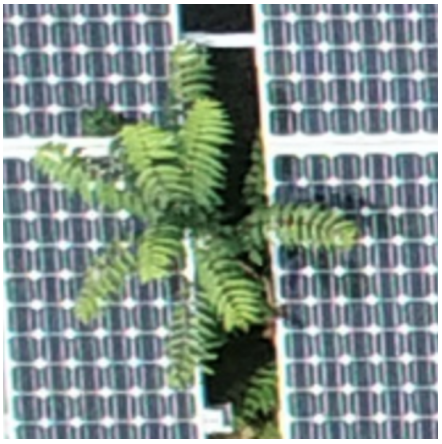
String

A string-type anomaly affects several modules connected in the string simultaneously. The string anomaly indicates a fault in adjacent modules corresponding to the string layout and impacts all modules within the string.



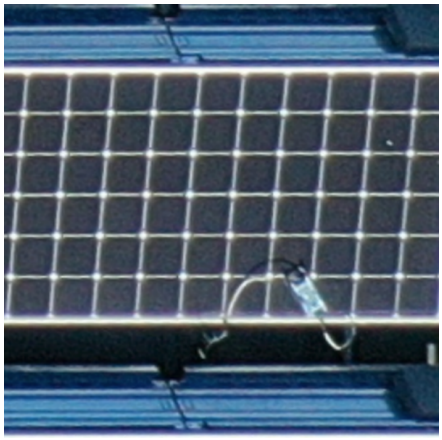
Cracking

Module anomaly caused by surface cracking.



Vegetation

Modules are blocked by vegetation.



Physical Obstruction

Physical obstruction or object on the module surface that blocks sunlight and/or causes shading.