

Training IEC 62446

Fred Martin – TÜV Rheinland Group



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Handelskammer
German-Thai
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Outline

1. Introduction to IEC 62446
2. Basics of IEC 62446
3. Equipment
4. Verification and testing on site
5. Reports

01 Introduction to IEC 62446

Title:

“IEC 62446: Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection”

Introduction:

“Grid connected PV systems are expected to have a lifetime of decades, with maintenance or modifications likely at some point over this period. Building or electrical works in the vicinity of the PV array are very likely, for example roof works adjacent to the array or modifications (structural or electrical) to a home that has a PV system. The ownership of a system may also change over time, particularly for systems mounted on buildings. Only by the provision of adequate documentation at the outset can the long term performance and safety of the PV system and works, on or adjacent to the PV system, be ensured.”

01 Applicable scope

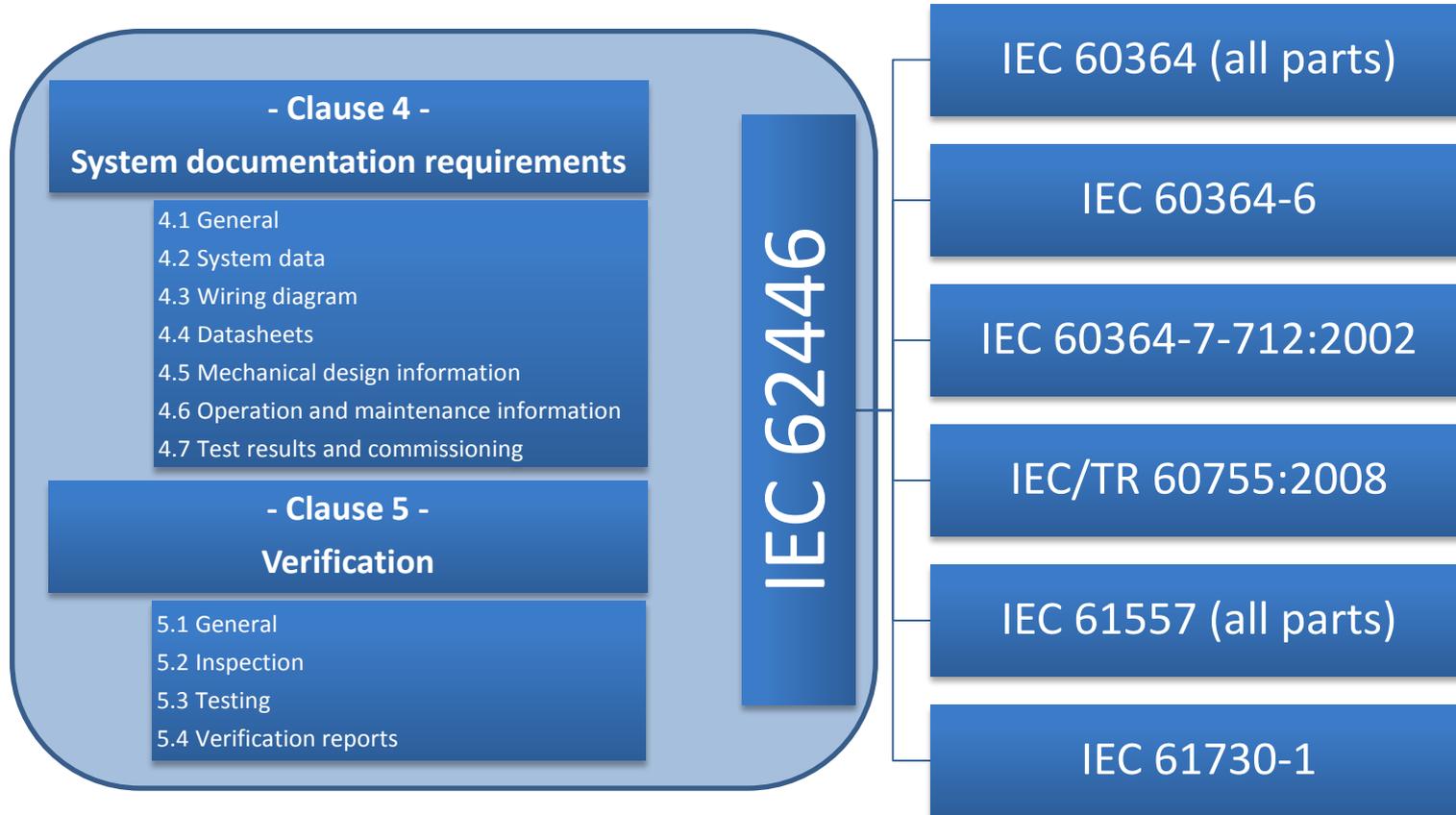
“This International Standard defines the minimal information and documentation required to be handed over to a customer following the installation of a grid connected PV system. This standard also describes the minimum commissioning tests, inspection criteria and documentation expected to verify the safe installation and correct operation of the system. The document can also be used for periodic retesting.

This standard is written for grid connected PV systems only and not for AC module systems or systems that utilize energy storage (e.g. batteries) or hybrid systems.”

This standard is composed into 2 main parts:

- **“System documentation requirements** (Clause 4) – This clause details the information that shall be provided, as a minimum, within the documentation provided to the customer following the installation of a grid connected PV system.
- **Verification** (Clause 5) – This clause provides the information expected to be provided following initial (or periodic) verification of an installed system. It includes requirements for inspection and testing.”

02 Basics of IEC 62446 Overview of sub standards



Normative references

- IEC 60364 (all parts), Low-voltage electrical installations
- IEC 60364-6, Low-voltage electrical installations – Part 6: Verification
- IEC 60364-7-712:2002, Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems
- IEC/TR 60755:2008, General requirements for residual current operated protective devices
- IEC 61557 (all parts), Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures
- IEC 61730-1, Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction

02 Basics of IEC 62446 – Clause 4

“Introduction to “4 System documentation requirements”

■ 4.1 General

- Clause 4 establish minimum documentation to ensure Key system data is available

■ 4.2 System data

- Information about system information, designer and installer

■ 4.3 Wiring diagram

- Single line wiring diagram

■ 4.4 Datasheets

- For all types of modules and inverters

■ 4.5 Mechanical design information

- Data sheet for array mounting system

■ 4.6 Operation and maintenance information

- Correct operation, failure, shutdown, maintenance, cleaning, warranty...

■ 4.7 Test results and commissioning

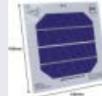
- Copies with results from verification tests”

02 Basics of IEC 62446 - Clause 5

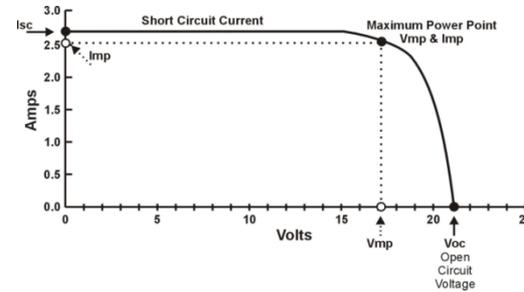
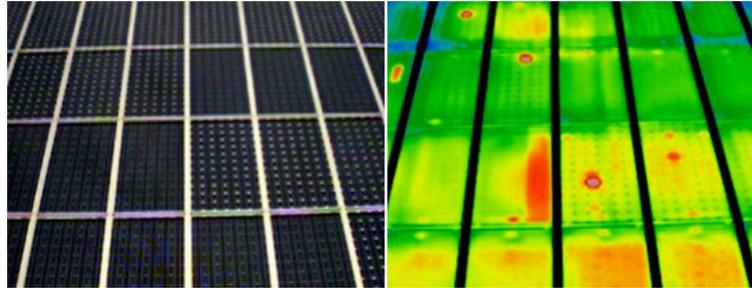
Introduction to “5 Verification”

- 5 Verification
- 5.1 General
- 5.2 General
- 5.3 Inspection
 - 5.3.1 to 5.3.5
- 5.4 Testing
 - 5.4.1 to 5.4.7
- 5.5 Verification reports
 - 5.5.1 to 5.5.3

03 Equipment

1: Parameter	2: Device	
Current, Voltage	Multimeter	
Temperature	Infrared sensor	
IR Camera	Portable	
IV-Curve measurement	Portable	
Insulation resistance	Portable	
Clamp meter, Current	Portable	
Temperature (for IV)	PT 100 sensor	
Irradiation	NES SOZ-03 #7401	

03 Equipment



Verification

Inspection

Testing

Verification reports
Documentation

5.4 Testing 5.4.1 to 5.4.7

04 Testing order

62446 IEC testing order follows a safety approach:

- 1.) Tests to all AC circuit(s) to the requirements of IEC 60364-6.
Once tests to the AC circuit(s) are complete, the following tests shall be carried out on the DC circuit(s) forming the PV array.
- 2.) Continuity of protective earthing and/or equipotential bonding conductors, where fitted (see 5.4.2);
- 3.) Polarity test (see 5.4.3);
- 4.) String open circuit voltage test (see 5.4.4)
- 5.) String short circuit current test (see 5.4.5)
- 6.) Functional tests (see 5.4.6);
- 7.) Insulation resistance of the DC circuits (see 5.4.7).

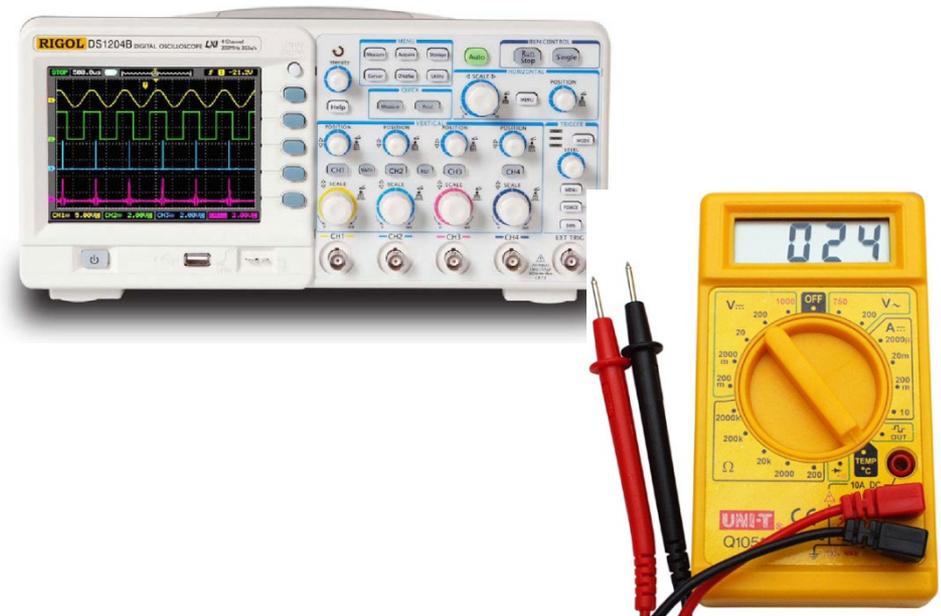
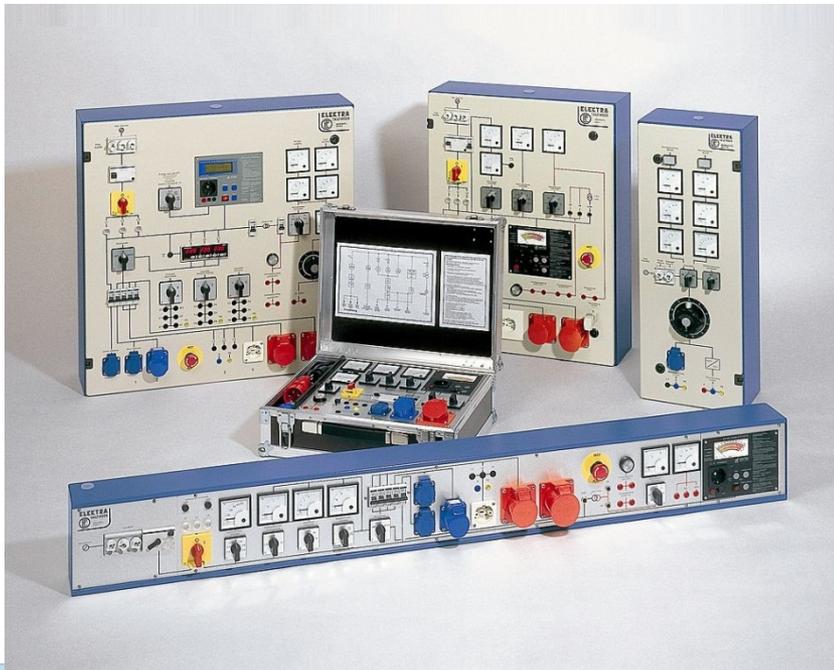


Potential danger increases with each step

04 Testing order – - 5.4.1 General

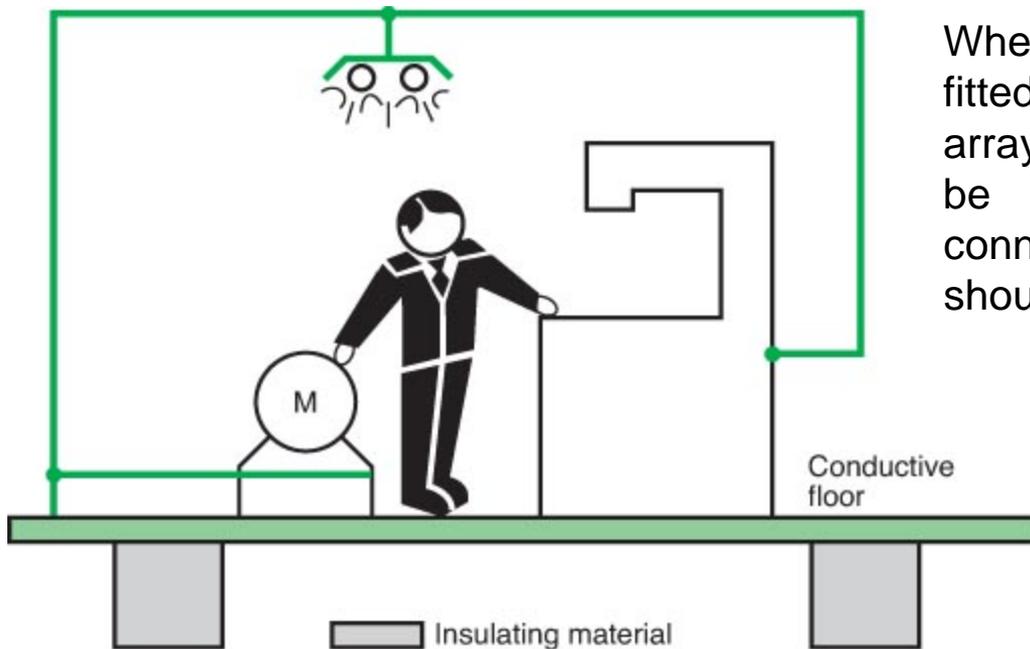
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Once tests to the AC circuit(s) are complete, the following tests shall be carried out on the DC circuit(s) forming the PV array.”

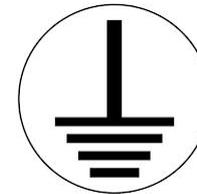


04 Testing order – 5.4.2

„2.) Continuity of protective earthing and/or equipotential bonding conductors



Where protective or bonding conductors are fitted on the DC side, such as bonding of the array frame, an electrical continuity test shall be made on all such conductors. The connection to the main earthing terminal should also be verified.”



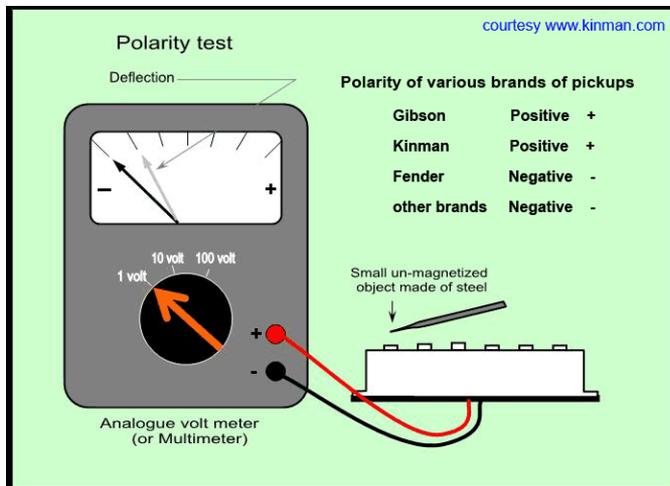
04 Testing order –5.4.2



04 Testing order – 5.4.3 Polarity test

„3.) Polarity test:

The polarity of all DC cables shall be verified using suitable test apparatus. Once polarity is confirmed, cables shall be checked to ensure they are correctly identified and correctly connected into system devices such as switching devices or inverters.”



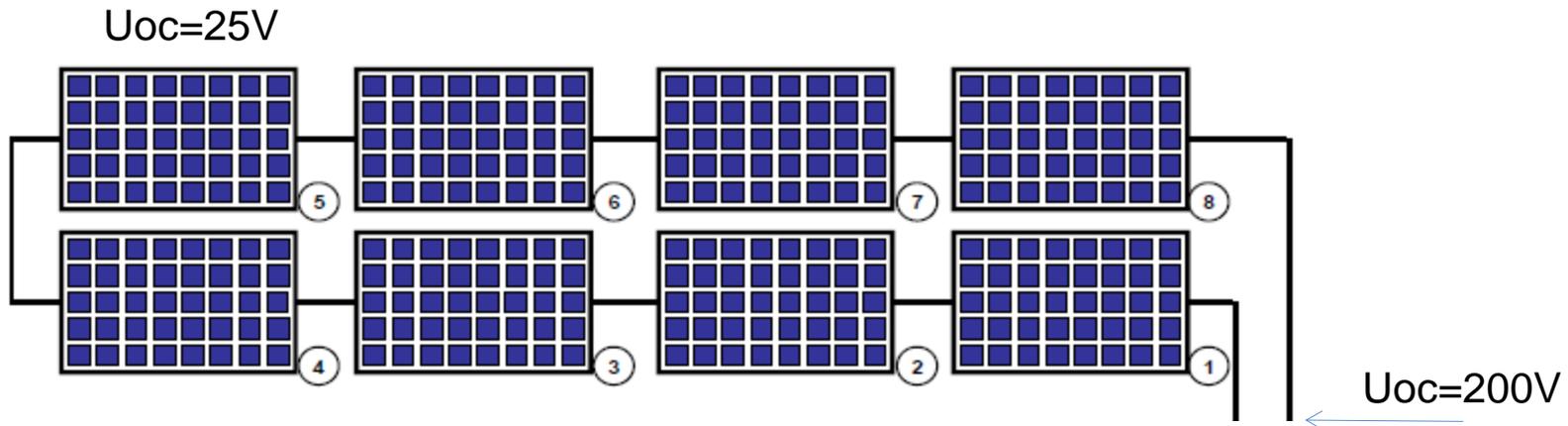
04 Testing order – 5.4.4 Open Voltage test

„4.) PV string - open circuit voltage measurement:

The open circuit voltage of each PV string should be measured using suitable measuring apparatus. This should be done before closing any switches or installing string over-current protective devices (where fitted).

Measured values should be compared with the expected value.

For systems with multiple identical strings and where there is stable irradiance conditions, voltages between strings shall be compared. These values should be the same (typically within 5 % for stable irradiance conditions).”



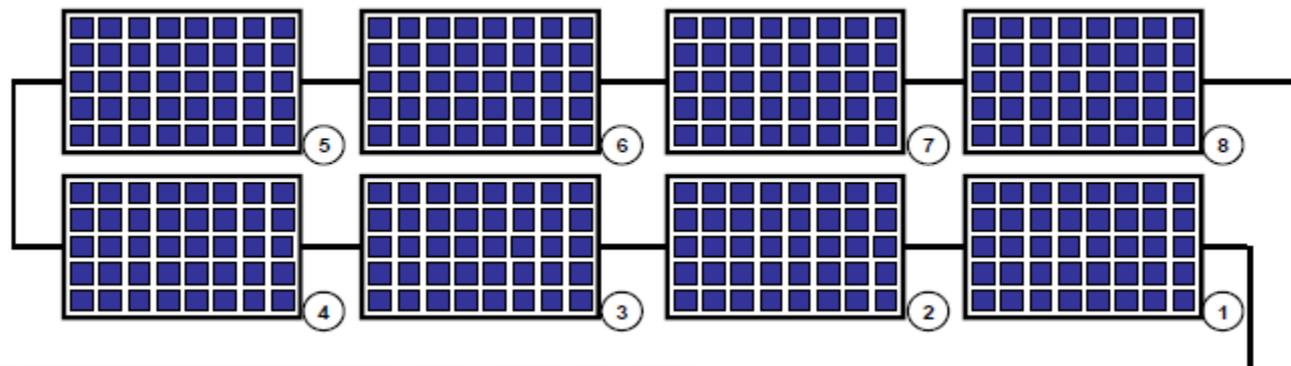
04 Practical exercise

Serial No.	K21124072592
Manufactured Date	120617
Standards Size	1632X986X42mm
Maximum Power (Pmax)	255W
Power Tolerance	-0/+3%
Maximum Power Voltage (Vmpp)	30.00V
Maximum Power Current (Impp)	8.50 A
Open Circuit Voltage (Voc)	37.20 V
Short Circuit Current (Isc)	8.85 A
Maximum System Voltage	1,000 V
Maximum Series Fuse	15 A
Maximum Load	5400Pa
Electrical nominal value at STC	
(1,000W/m ² , AM 1.5 Spectrum, Cell Temperature 25 °C)	

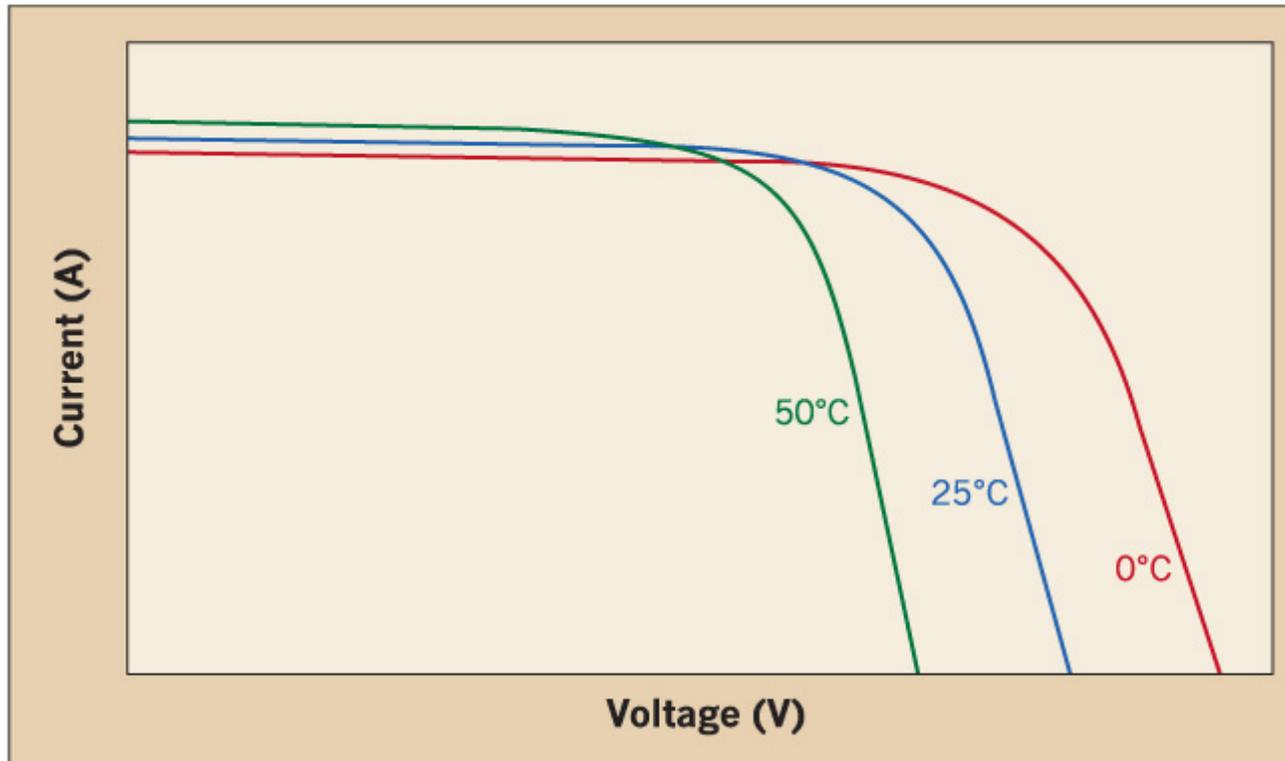
A PV string has 8 modules

What is the system voltage?

$U_{oc}=297.6V$ at STC (25C)



04 Testing order Validation of Voc



PV string - open circuit voltage changes with temperature!

04 Testing order – 5.4.5 Isc Current measurement

“5.4.5 PV string - current measurement

5.4.5.1 General

General introduction to the test methods

5.4.5.2 PV string – short circuit test

Description of short circuit test and selection recommendation

5.4.5.2.1 Short circuit test procedure

Description of short circuit test procedure

5.4.5.3 PV string – operational test

Description of operational test and selection recommendation

Conditions of testing

For non-stable irradiance conditions, the following methods can be adopted:

- testing may be delayed
- tests can be done using multiple meters, with one meter on a reference string
- an irradiance meter reading may be used to adjust the current readings.

Pass-fail criteria:

In either case the switching device and short circuit conductor shall be rated greater than the potential short circuit current and open circuit voltage.”

04 Testing order – 5.4.6 Functional tests

- a) **“Switchgear and other control apparatus shall be tested to ensure correct operation and that they are properly mounted and connected.**

- b) **All inverters forming part of the PV system shall be tested to ensure correct operation. The test procedure should be the procedure defined by the inverter manufacturer.**

- c) **A loss of mains test shall be performed: With the system operating, the main AC isolator shall be opened – it should be observed (e.g. on a display meter) that the PV system immediately ceases to generate. Following this, the AC isolator should be re-closed and it should be observed that the system reverts to normal operation.”**

04 Testing order – 5.4.7 Insulation resistance test

“5.4.7 PV array insulation resistance test

Performing this test presents a potential electric shock hazard, it is important to fully understand the procedure before starting any work. It is recommended that the following basic safety measures are followed:

- Limit the access to the working area.
- Do not touch and take measures to prevent any other persons to touch any metallic surface with any part of your body when performing the insulation test.
- Whenever the insulation test device is energized there is voltage on the testing area. The equipment is to have automatic auto-discharge capability.”



04 Testing order – 5.4.7 Insulation resistance test

“5.4.7.2 PV array insulation resistance test - test methods

2 Tests methods are possible:

TEST METHOD 1 - Test between array negative and earth followed by a test between array Positive and Earth.

TEST METHOD 2 - Test between earth and short circuited array positive and negative

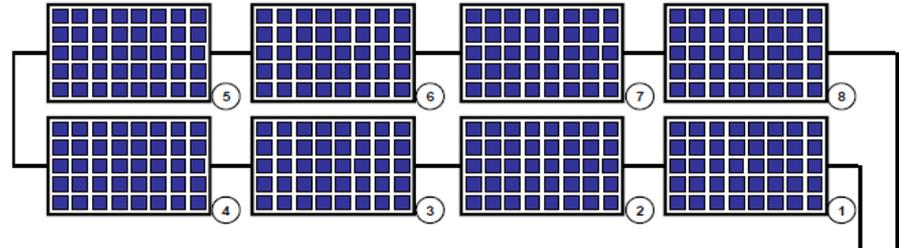
5.4.7.3 PV array insulation resistance - test procedure

Procedure description and Pass-Fail criteria“

Respective Test method	System voltage ($V_{oc\ stc} \times 1.25$) V	Test voltage V	Minimum insulation resistance M Ω
Test method 1 Tests to array positive and array negative (Non shorted)	<120	250	0.5
	120 – 500	500	1
	>500	1000	1
Test method 2 Array positive and negative together (shorted)	<120	250	0.5
	120 – 500	500	1
	>500	1000	1

04 Testing order – 5.4.7 IV Performance test

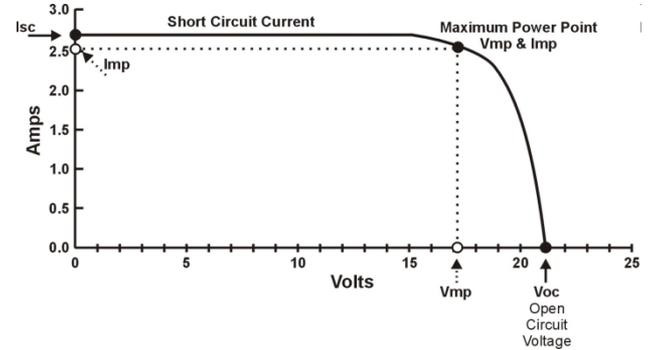
IV measurement: P_{max}

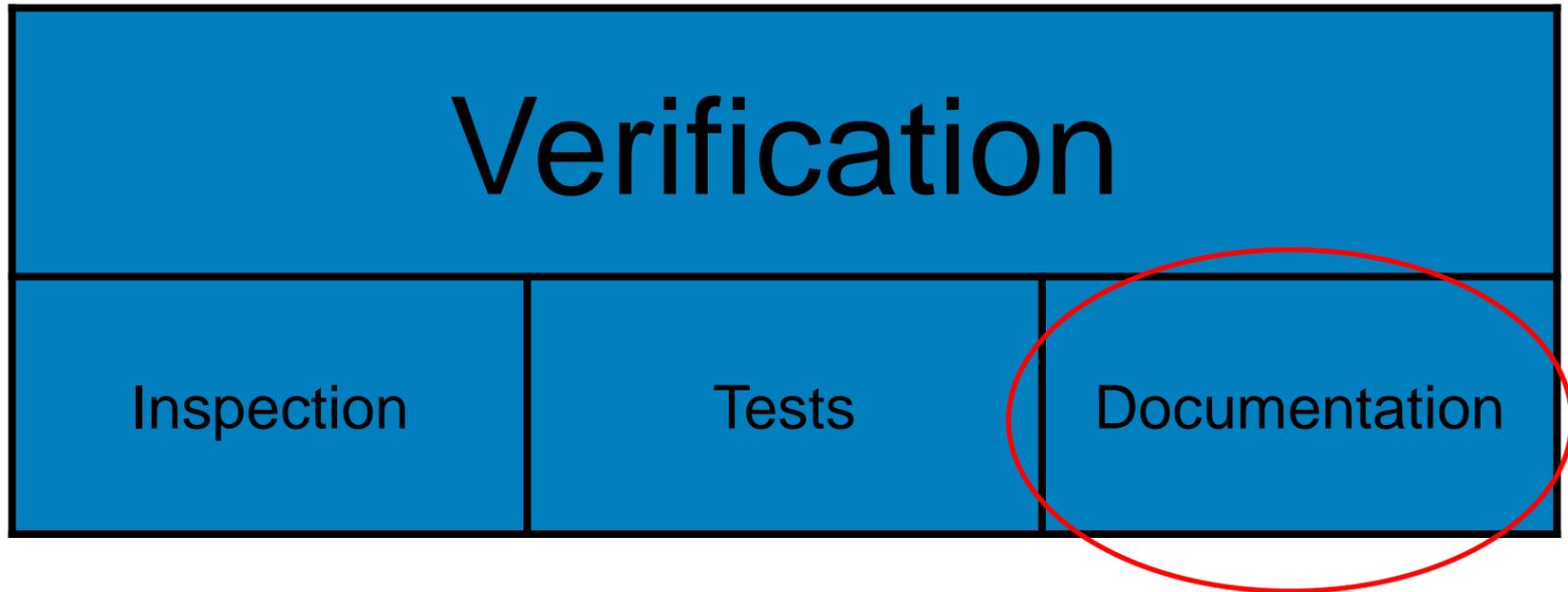


Irradiance sensor



Temperature sensor





“5.5.1 General

Upon completion of the verification process, a report shall be provided. This report shall include the following information:

- Summary information describing the system (name, address, etc.).
- A list of the circuits that have been inspected and tested.
- A record of the inspection.
- A record of the test results for each circuit tested.
- Recommended interval until next verification.
- Signature of the person(s) undertaking the verification.

5.5.2 Initial verification (Reports)

5.5.3 Periodic verification (Reports)”

06 Annexes

- **“Annex A (informative) Model verification certificate**
 - General template for verification report or «certificate»
- **Annex B (informative) Model inspection report**
 - Model template of an inspection report
- **Annex C (informative) Model PV array test report**
 - Template for PV Array testing including all necessary tests
- **Annex D (informative) PV array infrared camera inspection procedure**
 - IR camera inspection procedure and guideline”

Thank you for your attention.

Vielen Dank!



Fred Martín
Team Leader PV Power Plants
TÜV Rheinland Japan Ltd.
fred.martin@jpn.tuv.com
www.tuv.com