IEC 62446-2

Edition 1.0 2020-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance –
Part 2: Grid connected systems – Maintenance of PV systems

Systèmes photovoltaïques (PV) – Exigences pour les essais, la documentation et la maintenance –
Partie 2: Systèmes connectés au réseau électrique – Maintenance des systèmes PV

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International Standard IEC 62446-2 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/1656/FDIS	82/1676/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62446 series, published under the general title *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance*, can be found on the IEC website.

This International Standard is to be used in conjunction with IEC 62446-1:2016.

The requirements in IEC 62446-2 are to be used with the requirements in IEC 62446-1:2016, and supplement or modify clauses in IEC 62446-1:2016. All Clauses 1 to 9 of IEC 62446-1:2016 apply, including the applicable Annexes. When IEC 62446-2 contains clauses that add to, modify, or replace clauses in IEC 62446-1:2016, the relevant text of IEC 62446-1:2016 is to be applied with the required changes.

Clauses, subclauses, figures, tables and annexes additional to those in IEC 62446-1:2016 are numbered in continuation of the sequence existing in IEC 62446-1:2016.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This Part 2 of IEC 62446 gives requirements and recommendations for the maintenance of PV systems, including periodic inspections, safety and performance related preventive maintenance, corrective maintenance and troubleshooting. Grid connected PV systems are generally considered to be a very low maintenance means of power generation. While this is true relative to conventional generation sources that utilize fuel and/or rotating machinery, PV systems do require some level of preventive and corrective maintenance to perform as anticipated over lifetimes that can exceed 20 years. The level of maintenance required or recommended for performance can vary considerably based on the owner's preference or contractual obligations for power production; however, a minimum level of monitoring or maintenance is critical for safety and reducing the risk of fire. Adherence to a minimum set of maintenance requirements is also integral to the goals of the IECRE Conformity Assessment system, which is intended to drive the licensing and certification of PV systems and plants from the design to the operations stage.

PHOTOVOLTAIC (PV) SYSTEMS – REQUIREMENTS FOR TESTING, DOCUMENTATION AND MAINTENANCE –

Part 2: Grid connected systems – Maintenance of PV systems

1 Scope

This clause of IEC 62446-1:2016 is applicable with the following exception:

Addition:

This Part 2 of IEC 62446 describes basic preventive, corrective, and performance related maintenance requirements and recommendations for grid-connected PV systems. The maintenance procedures cover:

- Basic maintenance of the system components and connections for reliability, safety and fire prevention
- Measures for corrective maintenance and troubleshooting
- Worker safety

This document also addresses maintenance activities for maximizing anticipated performance such as module cleaning and upkeep of vegetation. Special considerations unique to rooftop or ground-mounted systems are summarized. This document does not cover off-grid systems or systems that include batteries or other energy storage technologies; however, parts may be applicable to the PV circuits of those systems.

This document also does not cover maintenance of medium and high voltage a.c. equipment that are sometimes integral to larger scale systems, as those requirements are not specific to PV systems.

Maintenance of PV systems is often lumped into the catch-all term operations and maintenance (O&M.) This document does not address business or management operational processes (e.g. forecasting, utility pricing incentives, etc.) or other considerations driven by factors outside of basic system working condition, safety and performance.

The confirmation of a system's compliance with the appropriate design and installation standards is covered in Part 1 and takes place during initial project commissioning.

The objectives of this document are to:

- Identify a baseline set of maintenance requirements which may differ by system type (residential, commercial, utility scale), owner, or financing requirements.
- Identify additional maintenance steps that are recommended or optional.
- Identify factors to be used to determine appropriate maintenance intervals.
- Ensure that remote diagnostic methods are allowed as means for periodic verification, problem identification and early failure detection.
- Ensure that alternate means of achieving maintenance related requirements are allowed to accommodate for innovation, manufacturer specific methods, evolving customer requirements, etc.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

This clause of IEC 62446-1:2016 is applicable, with the following exception:

Addition

IEC TS 61724-2, *Photovoltaic system performance – Part 2: Capacity evaluation method*

IEC TS 61724-3, *Photovoltaic system performance – Part 3: Energy evaluation method*

IEC TS 61836:2016 , *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 62020, *Electrical accessories – Residual current monitors for household and similar uses (RCMs)*

IEC 62446-1:2016, *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection*

IEC TS 62446-3:2017, *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 3: Photovoltaic modules and plants – Outdoor infrared thermography*

IEC 62548, *Photovoltaic (PV) arrays – Design requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 as well as those in Clause 3 of IEC 62446-1:2016 are applicable, with the following additions:

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

Addition:

3.17
support structure
equipment (also known as “racking”) used to physically support modules or groups of modules and position them in a fixed or moving orientation relative to the path of the sun

3.18
equipment pad
foundation typically (but not exclusively) made of concrete or cement used for mounting and securing inverters, disconnectors, transformers, or other equipment associated with a PV system

Note 1 to entry: Equipment pads are typically installed in ground-mount systems, or adjacent to buildings for large rooftop systems where equipment is too large to be wall-mounted.

3.19
combiner box
junction box in which the parallel connections for PV strings, subarrays or arrays are made

3.20
qualified person
person, who has acquired, through training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the required task correctly

[SOURCE: IEC 62548:2016, 3.1.7 “competent person”]

3.21
PV array combiner box
junction box where PV sub-arrays are connected and which may also contain overcurrent protection and/or switch-disconnection devices

Note 1 to entry: Small arrays generally do not contain sub-arrays but are simply made up of strings whereas large arrays are generally made up of multiple sub-arrays.

[SOURCE: IEC 62548:2016, 3.1.36]

3.22
balance of system
in a renewable energy system, all components other than the mechanism used to harvest the resource (such as photovoltaic panels or modules)

3.23
lockout/tagout
LOTO
safety procedure used to ensure equipment is properly de-energized and prevented from being re-energized by a locking mechanism until service personnel deems it safe to do so

Note 1 to entry: LOTO is a practice applying to some countries. Different safety procedures, such as the “five safety rules” of EN 50110-1 for Europe, apply in different parts of the world.

3.24
personal protective equipment
PPE
any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards whilst performing live working

[SOURCE: IEC 60050-651:2014, 651-23-01]

3.25
authorized personnel
persons approved or assigned by the system owner/operator to perform a specific type of duty or duties for which they are qualified, or to be at a specific location or locations at the installation site

3.26
wiring harness
cable assembly that aggregates the output of multiple PV string conductors along a single main conductor. The harness may or may not include fuse components on the individual string conductors

3.27
central inverter
inverter which has multiple sub-array or array circuits as inputs

Note 1 to entry: Central inverters are large in capacity relative to string inverters. Typical sizes range from 100 kW to 4 MW.

3.28
module-level monitoring
MLM
device or equipment used to monitor power and voltage at the PV module level

Note 1 to entry: Some microinverters and module level d.c.to d.c. converters include such a functionality.

3.29
micro-crack
pressure or stress induced crack in a crystalline PV module cell that is not generally visible to the naked eye

Note 1 to entry: One visible manifestation of micro-cracks is a discoloration effect known in the PV industry as “snail trails.” Snail trails result from moisture diffusion through the micro-crack to the cell surface. Subsequent corrosive or chemical reactions cause very noticeable discoloration along the paths of the cracks. Not all micro-cracks result in snail trails, but all snail trails are caused by cracks or micro-cracks.

3.30
data acquisition system
DAS
system for monitoring various PV system parameters, e.g. inverter status, power output, voltages and currents (at array, sub-array, string and/or module level), solar irradiance, temperatures, wind speed, etc.

3.31
shutdown control
automated de-energization of targeted PV array d.c. circuits by either isolation, disconnection, or attenuation of voltage to safe limits

Note 1 to entry: In some countries such equipment is available as “rapid shutdown” equipment for emergency services and is activated by a.c. side system disconnection or other remote control means.

4 System documentation requirements

This clause of IEC 62446-1:2016 is applicable with the following exceptions:

4.1 General

Addition:

Additional documentation should be maintained in support of maintenance measures and activities and should be recorded by maintenance personnel following any inspection, maintenance or repair activity. The date, description of the activity, and any findings should be included in the record.

4.8 Operation and maintenance information

Addition:

h) Monitoring system alarm settings.

i) Schedule of verification and maintenance intervals as determined in 10.2.

j) Evolving site-specific recommendations for periodic or follow-up testing based on findings during maintenance activities, tests, or inspections.

k) As-built construction drawings and an accurate major components list, noting any substitutions, damaged and/or replaced components.

l) A spare-parts list and schedule of replacement for applicable components.

m) Any site-specific recommendations for periodic monitoring and testing for novel experimental components or sub-systems.

n) Schedule of component calibrations, including power and weather monitoring devices.

o) Certificates and dates of component calibrations, or a history of their replacement dates, as applicable.

O&M personnel shall work with the system owner or responsible operator to locate or re-create any missing documentation covered by this list while keeping documentation in a safe and secured place.

Addition:

4.10 Performance benchmarking

System performance benchmarks shall be maintained from test reports conducted according to one or more of the following:

a) Performance related clauses of IEC 62446-1:2016,

b) IEC TS 61724-2,

c) IEC TS 61724-3, and,

d) Any additional performance related testing.

The benchmarking shall be used for comparison with repeated performance checks taken during maintenance procedures called out in IEC 62446-2. Benchmarking information should at a minimum include parameters and information covered by the model PV array test report provided in informative Annex C of IEC 62446-1:2016.

4.11 Documentation of records

Test data and results from the maintenance procedures detailed in Clause 9 of IEC 62446-1:2016 shall be maintained. These records should be used for reference, trending of performance and corrective actions, and for general record keeping in the case of warranty claims or a change of ownership of the system.

5 Verification

This clause and the subclauses of IEC 62446-1:2016 are applicable where specifically called out by the requirements in IEC 62446-2.

6 Test procedures – Category 1

This clause and the subclauses of IEC 62446-1:2016 are applicable where specifically called out by the requirements in IEC 62446-2.

7 Test procedures – Category 2

This clause and the subclauses of IEC 62446-1:2016 are applicable where specifically called out by the requirements in IEC 62446-2.

8 Test procedures – Additional tests

This clause and the subclauses of IEC 62446-1:2016 are applicable where specifically called out by the requirements in IEC 62446-2.

9 Verification reports

This clause of IEC 62446-1:2016 is applicable for specific instances, such as a condition for re-sale or valuation, but is not required on a regular basis.

Addition:

10 Maintenance protocols

10.1 General

This clause describes various maintenance protocols for grid-connected PV systems. These include:

- Periodic verification to determine, as far as reasonably practical, whether the installation and all its constituent equipment remain in a satisfactory condition for safe use. The periodic verification includes inspections and safety-related maintenance testing.
- Recommended periodic performance related maintenance.
- Conditional or condition-based maintenance activities, performed in response to issues or problems detected through monitoring, inspections or testing.
- Administrative maintenance activities – those required by contracts and warranties. This includes preventive maintenance, typically used to describe procedures carried out on a periodic basis to support component life targets.
- Corrective maintenance procedures – the specific mitigating or restorative procedures carried out in response to identified issues.
- Troubleshooting, including generalized measures described in this document, as well as manufacturer specific procedures for individual equipment components.

The intention is that these protocols will be inherently flexible to:

- Allow remote diagnostic methods as means for periodic verification, problem identification and early failure detection.
- Ensure that alternate means of achieving maintenance related requirements are allowed to accommodate for innovation, manufacturer specific methods, evolving customer requirements, etc.

Personnel performing inspections or maintenance of electrical equipment should be qualified and skilled in the procedures and should follow the general guidelines described in Annex E.

10.2 Verification intervals and triggers

Based on the recommendations or warranty requirements of component manufacturers and system integrators, it may be necessary to schedule preventive maintenance activities in advance of detecting a failure in the field, instead of allowing parts to fail. This keeps equipment in superior operating condition while minimizing downtime by scheduling maintenance, ideally during non-production hours, as well as avoiding longer downtime for unplanned repairs. For larger commercial and utility scale power plant systems it is recommended that replacement parts for key components be stored in order to minimize response time. Depending on the manufacturer recommendations and owner/operator preferences, activities may include cleaning/replacing inverter filters, replacing plastic module cable ties, cycling switches, replacing fuses, etc. Replacements made during periodic or corrective maintenance activities shall be made with the same parts or equivalent parts that are pre-approved by the equipment manufacturer or responsible system operator.

Periodic verification and maintenance should be performed at intervals throughout the life of a PV system, and in response to specific triggers. These intervals can vary considerably based on:

– Type of system (ground mount power plant, commercial, residential, etc.).
– Extent of remote monitoring capabilities.
– Contractual requirements or performance guarantees.
– Manufacturer recommended practices for maintenance of specific components.
– Site specific considerations.
– Cost benefit analyses.

NOTE Two IEC publications support the linkage between maintenance activities, system availability, and life-cycle costs, and provide a basis for gathering data in a format to support the various metrices and analyses. See IEC 60300-3-3 and IEC TS 63019.

This document does not specify verification or maintenance intervals given the extensive set of factors that vary by application, site, and owner or operator obligations. However, Table 3 identifies verification tasks at the system and component level and provides guidance for determining verification intervals. The Interval basis column describes specific examples of issues that would justify more frequent verification intervals. For example, systems located at sites prone to flooding or lightning storms should have more frequent inspections or performance verification of particular components.

Table 3 also identifies the relevant clause or subclause in this document describing each of the verification tasks or procedures. Columns “P” and “I” indicate whether the conditional verification tasks are commonly triggered by detected performance issues (“P”), such as low measured output, or specific incidents (I), such as faults or component failures.

Table 3 – Verification and maintenance tasks and basis for determining task intervals

Component/Task		Relevant Clause/ subclause	P	I	Interval basis
Modules					
	Inspect for cracks, delamination, breakage, burn marks	11.3.3	X	X	Areas with high lightning or wind activity, nearby construction activity, aging systems (in case of delamination).
	Inspect for micro-cracks or "snail trails"				Products with history of micro-cracks. Sites with snow and wind driven forces on modules, etc. Impacts may be greater in high humidity areas.
	Inspect for excessive build-up of soil or droppings			X	Where site is susceptible to high levels of soiling, bird droppings, etc.
	Thermal imaging for junction box, cell variations, internal connections, partial operation.	11.3.3	X	X	Can be the default method for large plants (e.g. using aerial imaging). Locations susceptible to lightning e.g. for bypass diode diagnostics, Seasonal bias for testing to ensure high irradiance, e.g. summer.
	Connector checks – visual damage, sample tightness	11.3.4	X	X	Where connectors are aging or exposed to high winds or other sources of movement or strain. Where dissimilar connector manufacturers are used. For sites with atypically high use of field-assembled connectors, or history of issues with field-assembled connectors.
	Imaging of module connectors for resistive, cracked or compromised connections	11.3.4	X	X	Only conditional based, unless system has history of connector problems, and arc-fault connection and/or sensitive ground fault detection is not included.
Array					
	Debris or stored items under array	11.2.1		X	For ground-mounted power plants following construction or substantial maintenance activities. Consider other types of debris that comes from wind or another source.