

© Copyright SEK. Reproduction in any form without permission is prohibited.

Solcellsanläggningar – Fordringar på provning, dokumentation och underhåll – Del 1: Nätanslutna anläggningar – Dokumentation, provning för idrifttagning och besiktning

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

Som svensk standard gäller europastandarden EN 62446-1:2016. Den svenska standarden innehåller den officiella engelska språkversionen av EN 62446-1:2016.

Nationellt förord

Europastandarden EN 62446-1:2016

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 62446-1, First edition, 2016 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 62446, utgåva 1, 2010, gäller ej fr o m 2019-02-23.

ICS 27.160.00

Denna standard är fastställd av SEK Svensk Elstandard, som också kan lämna upplysningar om **sakinnehållet** i standarden.
Postadress: Box 1284, 164 29 KISTA
Telefon: 08 - 444 14 00.
E-post: sek@elstandard.se. Internet: www.elstandard.se

Standarder underlättar utvecklingen och höjer elsäkerheten

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

SEK är Sveriges röst i standardiseringsarbetet inom elområdet

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

Stora delar av arbetet sker internationellt

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

Var med och påverka!

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

SEK Svensk Elstandard

Box 1284
164 29 Kista
Tel 08-444 14 00
www.elstandard.se

English Version

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

Systèmes photovoltaïques (PV) - Exigences pour les
essais, la documentation et la maintenance - Partie 1:
Systèmes connectés au réseau électrique - Documentation,
essais de mise en service et examen
(IEC 62446-1:2016)

Photovoltaik (PV) Systeme - Anforderungen an Prüfung,
Dokumentation und Instandhaltung - Teil 1: Netzgekoppelte
Systeme - Dokumentation, Inbetriebnahmeprüfung und
Prüfanforderungen
(IEC 62446-1:2016)

This European Standard was approved by CENELEC on 2016-02-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 82/1036/FDIS, future edition 1 of IEC 62446-1, prepared by IEC/TC 82 "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62446-1:2016.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-11-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-02-23

This document supersedes EN 62446:2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62446-1:2016 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

| <u>Publication</u> | <u>Year</u> | <u>Title</u> | <u>EN/HD</u> | <u>Year</u> |
|--------------------|-------------|---|--------------|-------------|
| IEC 60364-6 | - | Low voltage electrical installations -- Part 6: Verification | HD 60364-6 | - |
| IEC 61010 | series | Safety requirements for electrical equipment for measurement, control and laboratory use | EN 61010 | series |
| IEC 61557 | series | Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures | EN 61557 | series |
| IEC 61730 | series | Photovoltaic (PV) module safety qualification | EN 61730 | series |
| IEC/TS 62548 | 2013 | Photovoltaic (PV) arrays - Design requirements | - | - |

CONTENTS

| | |
|--|----|
| FOREWORD..... | 5 |
| INTRODUCTION..... | 7 |
| 1 Scope..... | 8 |
| 2 Normative references | 8 |
| 3 Terms and definitions | 8 |
| 4 System documentation requirements | 10 |
| 4.1 General..... | 10 |
| 4.2 System data..... | 10 |
| 4.2.1 Basic system information | 10 |
| 4.2.2 System designer information..... | 11 |
| 4.2.3 System installer information..... | 11 |
| 4.3 Wiring diagram..... | 11 |
| 4.3.1 General | 11 |
| 4.3.2 Array – General specifications | 11 |
| 4.3.3 PV string information | 11 |
| 4.3.4 Array electrical details | 12 |
| 4.3.5 AC system | 12 |
| 4.3.6 Earthing and overvoltage protection..... | 12 |
| 4.4 String layout | 12 |
| 4.5 Datasheets | 12 |
| 4.6 Mechanical design information | 12 |
| 4.7 Emergency systems..... | 12 |
| 4.8 Operation and maintenance information | 13 |
| 4.9 Test results and commissioning data | 13 |
| 5 Verification | 13 |
| 5.1 General..... | 13 |
| 5.2 Inspection | 14 |
| 5.2.1 General | 14 |
| 5.2.2 DC system – General..... | 14 |
| 5.2.3 DC system – Protection against electric shock..... | 14 |
| 5.2.4 DC system – Protection against the effects of insulation faults | 14 |
| 5.2.5 DC system – Protection against overcurrent | 15 |
| 5.2.6 DC system – Earthing and bonding arrangements | 15 |
| 5.2.7 DC system – Protection against the effects of lightning and overvoltage..... | 15 |
| 5.2.8 DC system – Selection and erection of electrical equipment | 15 |
| 5.2.9 AC system | 16 |
| 5.2.10 Labelling and identification | 16 |
| 5.3 Testing | 16 |
| 5.3.1 General | 16 |
| 5.3.2 Test regimes and additional tests | 17 |
| 5.3.3 Test regimes for systems with module level electronics | 17 |
| 5.3.4 Category 1 test regime – All systems..... | 18 |
| 5.3.5 Category 2 test regime | 18 |
| 5.3.6 Additional tests..... | 19 |
| 6 Test procedures – Category 1..... | 19 |
| 6.1 Continuity of protective earthing and equipotential bonding conductors..... | 19 |

| | | |
|-----------------------|--|----|
| 6.2 | Polarity test | 19 |
| 6.3 | PV string combiner box test | 20 |
| 6.4 | PV string – Open circuit voltage measurement | 20 |
| 6.5 | PV string – Current measurement | 21 |
| 6.5.1 | General | 21 |
| 6.5.2 | PV string – Short circuit test | 21 |
| 6.5.3 | PV string – Operational test | 22 |
| 6.6 | Functional tests | 22 |
| 6.7 | PV array insulation resistance test | 22 |
| 6.7.1 | General | 22 |
| 6.7.2 | PV array insulation resistance test – Test method | 23 |
| 6.7.3 | PV array insulation resistance – Test procedure | 23 |
| 7 | Test procedures – Category 2 | 25 |
| 7.1 | General | 25 |
| 7.2 | String I-V curve measurement | 25 |
| 7.2.1 | General | 25 |
| 7.2.2 | I-V curve measurement of V_{OC} and I_{SC} | 25 |
| 7.2.3 | I-V curve measurement – Array performance | 25 |
| 7.2.4 | I-V curve measurement – Identification of module / array defects or shading issues | 26 |
| 7.3 | PV array infrared camera inspection procedure | 27 |
| 7.3.1 | General | 27 |
| 7.3.2 | IR test procedure | 27 |
| 7.3.3 | Interpreting IR test results | 27 |
| 8 | Test procedures – Additional tests | 28 |
| 8.1 | Voltage to ground – Resistive ground systems | 28 |
| 8.2 | Blocking diode test | 28 |
| 8.3 | PV array – Wet insulation resistance test | 29 |
| 8.3.1 | General | 29 |
| 8.3.2 | Wet insulation test procedure | 29 |
| 8.4 | Shade evaluation | 29 |
| 9 | Verification reports | 30 |
| 9.1 | General | 30 |
| 9.2 | Initial verification | 31 |
| 9.3 | Periodic verification | 31 |
| Annex A (informative) | Model verification certificate | 32 |
| Annex B (informative) | Model inspection report | 33 |
| Annex C (informative) | Model PV array test report | 36 |
| Annex D (informative) | Interpreting I-V curve shapes | 37 |
| D.1 | General | 37 |
| D.2 | Variation 1 – Steps or notches in curve | 38 |
| D.3 | Variation 2 – Low current | 38 |
| D.4 | Variation 3 – Low voltage | 38 |
| D.5 | Variation 4 – Rounder knee | 39 |
| D.6 | Variation 5 – Shallower slope in vertical leg | 39 |
| D.7 | Variation 6 – Steeper slope in horizontal leg | 40 |
| Figure 1 | – Example sun-path diagram | 30 |

Figure D.1 – I-V curve shapes..... 37

Table 1 – Modifications to the test regime for systems with module level electronics 17

Table 2 – Minimum values of insulation resistance – PV arrays up to 10 kWp 24

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PHOTOVOLTAIC (PV) SYSTEMS – REQUIREMENTS FOR TESTING,
DOCUMENTATION AND MAINTENANCE –****Part 1: Grid connected systems – Documentation,
commissioning tests and inspection**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62446-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This first edition cancels and replaces IEC 62446 published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical change with respect to IEC 62446:2009:

- the scope has been expanded to include a wider range of system test and inspection regimes to encompass larger and more complex PV systems.

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

| | |
|--------------|------------------|
| FDIS | Report on voting |
| 82/1036/FDIS | 82/1056A/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.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

This part of IEC 62446 is split into two sections:

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

This part of IEC 62446 references IEC TS 62548:2013, which is in the process of being converted into an International Standard. It is envisaged that work on the second edition of IEC 62446-1 will start when IEC 62548 is completed.

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

Part 1: Grid connected systems – Documentation, commissioning tests and inspection

1 Scope

This part of IEC 62446 defines the information and documentation required to be handed over to a customer following the installation of a grid connected PV system. It also describes the commissioning tests, inspection criteria and documentation expected to verify the safe installation and correct operation of the system. It can also be used for periodic retesting.

This part of IEC 62446 is written for grid connected PV systems that do not utilize energy storage (e.g. batteries) or hybrid systems.

This part of IEC 62446 is for use by system designers and installers of grid connected solar PV systems as a template to provide effective documentation to a customer. By detailing the expected commissioning tests and inspection criteria, it is also intended to assist in the verification/inspection of a grid connected PV system after installation and for subsequent re-inspection, maintenance or modifications.

This part of IEC 62446 defines the different test regimes expected for different solar PV system types to ensure that the test regime applied is appropriate to the scale, type and complexity of the system in question.

NOTE This part of IEC 62446 does not address CPV (concentrating PV) systems, however many of the parts may apply.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60364-6, *Low-voltage electrical installations – Part 6: Verification*

IEC TS 62548:2013, *Photovoltaic (PV) arrays – Design requirements*

IEC 61730 (all parts), *Photovoltaic (PV) module safety qualification*

IEC 61557 (all parts), *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures*

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use*