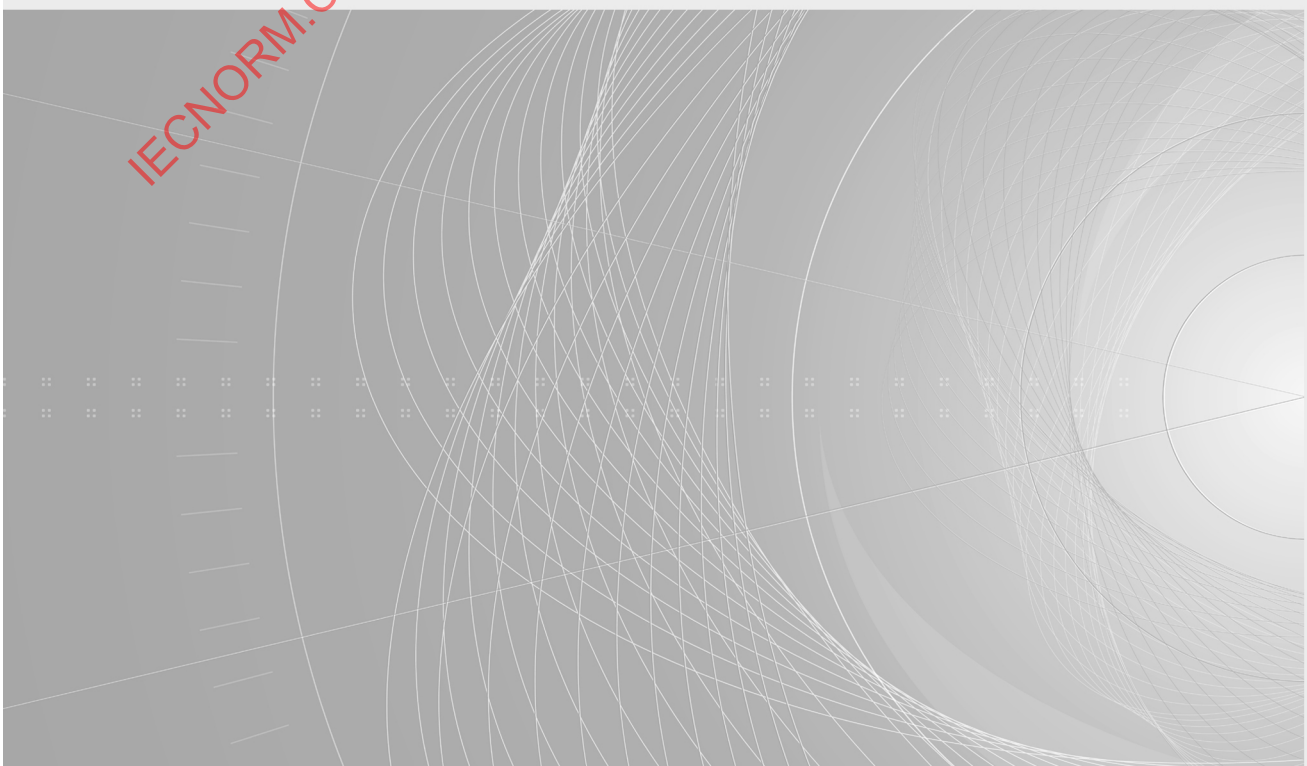
IEC TS 62257-9-8

Edition 1.0 2020-06

TECHNICAL SPECIFICATION

**Renewable energy and hybrid systems for rural electrification –
Part 9-8: Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W**



IEC TS 62257-9-8:2020-06(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC TS 62257-9-8

Edition 1.0 2020-06

TECHNICAL SPECIFICATION

Renewable energy and hybrid systems for rural electrification –
Part 9-8: Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-8239-7

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-8: Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62257-9-8, which is a Technical Specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/1643/DTS	82/1685/RVDTS 82/1685A/RVDTS

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

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

This part of IEC 62257 is to be used in conjunction with IEC TS 62257-9-5.

A list of all parts in the IEC 62257 series, published under the general title *Renewable energy and hybrid systems for rural electrification*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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

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

INTRODUCTION

IEC 62257 (all parts) provides support and strategies for institutions involved in rural electrification projects. It documents technical approaches for designing, building, testing, and maintaining off-grid renewable energy and hybrid systems with AC nominal voltage below 500 V, DC nominal voltage below 750 V and nominal power below 100 kVA.

These documents are recommendations to support buyers who want to connect with good quality options in the market:

- to choose the right system for the right place,
- to design the system, and
- to operate and maintain the system.

These documents are focused only on technical aspects of rural off-grid electrification concentrating on, but not specific to, developing countries. They are not considered as all inclusive to rural electrification. The documents do not describe a range of factors that can determine project or product success: environmental, social, economic, service capabilities, and others. Further developments in this field could be introduced in future steps.

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems, and costs. The main objectives are to support the capabilities of households and communities that use small renewable energy and hybrid off-grid systems and inform organizations and institutions in the off-grid power market.

The purpose of this document is to provide baseline standards for quality, durability and truth-in-advertising to protect consumers of stand-alone renewable energy products. This document is specifically related to renewable energy products that are packaged and made available to end-use consumers at the point of purchase as single, stand-alone products that do not require additional system components to function. This document applies to products with peak power ratings of 350 W or less. While most provisions apply to all products in this range, a few are applicable only to products with peak power ratings greater than 10 W and less than or equal to 350 W.

The term "stand-alone renewable energy product" is used in this document to describe this class of products. Other equivalent terms, including "off-grid solar" or "rechargeable," are often used by manufacturers, distributors, and other stakeholders to describe these products. Many of these systems meet the definition of type T_2I (individual electrification systems with energy storage) in IEC TS 62257-2.

The intended users of this document are:

- market support programmes that support the off-grid lighting market with financing, consumer education, awareness, and other services;
- manufacturers and distributors that need to verify the quality and performance of products;
- bulk procurement programmes that facilitate or place large orders of products; and,
- trade regulators such as government policymakers and officials who craft and implement trade and tax policy.

This document establishes minimum requirements for quality standards and warranty requirements. Products are compared to specifications based on test results from IEC TS 62257-9-5 and other information about the product. The requirements are designed to be widely applicable across different markets, countries, and regions.

RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-8: Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W

1 Scope

This part of IEC 62257 provides baseline requirements for quality, durability and truth in advertising to protect consumers of off-grid renewable energy products. Evaluation of these requirements is based on tests described in IEC TS 62257-9-5. This document can be used alone or in conjunction with other international standards that address the safety and durability of components of off-grid renewable energy products.

This document applies to stand-alone renewable energy products having the following characteristics:

- The products are powered by photovoltaic (PV) modules or electromechanical power generating devices (such as dynamos), or are designed to use grid electricity to charge a battery or other energy-storage device for off-grid use. The requirements may also be appropriate as guidance for evaluating the quality of devices with other power sources, such as thermoelectric generators.
- The peak power rating of the PV module or other power generating device is less than or equal to 350 W.
- All components required to provide basic energy services are sold/installed as a kit, included as a part of family of products as defined in 4.2.5, or integrated into a single component, including at a minimum:
  - a battery/batteries or other energy storage device(s);
  - power generating device, such as a solar panel, capable of charging the battery/batteries or other energy storage device(s);
  - cables, switches, wiring, connectors and protective devices sufficient to connect the power generating device, power control unit(s) and energy storage device(s).
- The system evaluated includes all the loads (lighting, television, radio, fan, etc.) and load adapter cables that are sold or included as part of the kit or integrated into kit components.
- The PV module maximum power point voltage and the working voltage of any other components in the kit do not exceed 35 V. Exceptions are made for AC-to-DC converters that meet appropriate safety standards. Systems that include PV modules (or combinations of PV modules) with ratings that exceed 240 W at peak power, 35 V at open circuit or 8 A at short circuit are subject to additional safety requirements beyond those assessed in IEC TS 62257-9-5.

NOTE This voltage limit corresponds to the definition of decisive voltage classification A (DVC-A) for wet locations in Table 6 of IEC 62109-1:2010. The limits of 240 W, 35 V and 8 A are consistent with the definition of Class III in IEC 61730-1.

- These requirements cover only DC outputs and loads. Products that include inverters, AC outputs/outlets, or AC appliances are not within the scope of this document. Products can have AC inputs.
- No design expertise is required to choose appropriate system components.
- All electrical connections, except for permanent connections made at the time of installation, can be made using plug-and-socket connectors without the use of any tools. All connections made in the field are straightforward to make and do not require technical expertise, such as wrapping wire in a specific direction, soldering, or crimping.

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.

IEC 60364-7-712, *Low voltage electrical installations – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60904-9, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 61215 (all parts), *Terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61215-2, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

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

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC 62109-1:2010, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

IEC TS 62257-9-5, *Recommendations for renewable energy and hybrid systems for rural electrification: Integrated systems – Laboratory evaluation of stand-alone renewable energy products for rural electrification*

IEC TS 62257-12-1, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 12-1: Selection of lamps and lighting appliances for off-grid electricity systems*

IEC 62281, *Safety of primary and secondary lithium cells and batteries during transport*

IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC 62930, *Electric cables for photovoltaic systems with a voltage rating of 1,5 kV DC*

ISO 4892, *Plastics – Methods of exposure to laboratory light sources*

EN 50618, *Electric cables for photovoltaic systems*

HD 605, *Electric cables – Additional test methods*

UL 1741, *Standard for inverters, converters, controllers and interconnection system equipment for use with distributed energy resources*

UL 1973, *Standard for batteries for use in stationary, vehicle auxiliary power and light electric rail (LER) applications*

UL 2054, *Standard for Household and Commercial Batteries*

UL 62133, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

United Nations. *Recommendations on the transport of dangerous goods: manual of tests and criteria*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 and the following apply.

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

3.1 Terms related to photometric tests

3.1.1
illuminance
E
areal density of the luminous flux incident at a point on a surface

[SOURCE: ANSI/IES RP-16-17, 3.3.1]

3.1.2
colour rendering index
CRI
measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation

[SOURCE: IEC 60050-845:1987, 845-02-61, modified – The symbol "R" has been replaced by "CRI" and the note has been omitted.]

3.1.3
correlated colour temperature
CCT
temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions

Note 1 to entry: The correlated colour temperature is expressed in kelvins (K).

[SOURCE: IEC 60050-845:1987, 845-03-50, modified – Notes 1 and 2 have been replaced by a new note to entry.]

3.1.4
full width half maximum
FWHM
range of a variable over which a given characteristic is greater than 50 % of its maximum value

Note 1 to entry: FWHM can be applied to characteristics such as radiation patterns, spectral linewidths, etc., and the variable can be wavelength, spatial or angular properties, etc., as appropriate.

[SOURCE: IEC 60050-731:1991, 731-01-57, modified – in note 1, "may" has been replaced with "can".]

3.2
light emitting diode
LED
solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

[SOURCE: IEC 60050-845: 1987, 845-04-40]

3.3
power supply
electric energy converter which draws electric energy from a source and supplies it in a specified form to a load

[SOURCE: IEC 60050-151:2001, 151-13-76]

3.4
overvoltage protection
protection intended to operate when the power system voltage is in excess of a predetermined value

[SOURCE: IEC 60050-448:1995, 448-14-32]

3.5
cell block
group of cells connected together in parallel configuration with or without protective devices (e.g. fuse or PTC) and monitoring circuitry

Note 1 to entry: It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

[SOURCE: IEC 62619:2017, 3.8]

3.6
IP Code
coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection

Note 1 to entry: In this document, certain IP Codes can be estimated using procedures in IEC TS 62257-9-5, which provides a simplified and lower-cost alternative to IEC 60529. The procedure in IEC TS 62257-9-5 evaluates protection against ingress of solid foreign objects and water, but not protection against access to hazardous parts.

[SOURCE: IEC 60529, 3.4, modified – note 1 has been added.]

3.7 Component categories

3.7.1
portable
connected in a way that makes a product or subsystem easy for an individual to carry

Note 1 to entry: Products or subsystems are portable when two or more of the main components (energy source, energy storage, and light source) are connected in this way.

[SOURCE: IEC TS 62257-9-5:2018, 3.17]

3.7.2
fixed
designed for permanent or semi-permanent mounting and use in place

Note 1 to entry: Products or subsystems are fixed when the main components (energy source, energy storage, and light source) are designed in this way.

[SOURCE: IEC TS 62257-9-5:2018, 3.18]

3.7.3
separate
without solar module or with a solar module connected to other components via a cable with a length of at least 3 m

Note 1 to entry: The length criterion allows the solar module to collect energy outdoors while the other product components remain indoors.

[SOURCE: IEC TS 62257-9-5:2018, 3.19, modified – the 3 m length specification has been incorporated into the definition.]

3.7.4
integrated, adj
with a solar module integrated into another component or connected to another component (other than a fixed outdoor component) via a cable with a length less than 3 m

[SOURCE: IEC TS 62257-9-5:2018, 3.20, modified – the 3 m length specification has been incorporated into the definition.]

3.8 Electrical quantities

3.8.1
capacity
capacity of a cell or a battery
electric charge which a cell or battery can deliver under specified discharge conditions

Note 1 to entry: The SI unit for electric charge, or quantity of electricity, is the coulomb (1 C = 1 A·s) but in practice, capacity is usually expressed in ampere hours (Ah).

[SOURCE: IEC 60050-482:2004, 482-03-14]

3.8.2
low-voltage disconnect
LVD
battery voltage at which the load terminals of the charge controller are switched off to prevent the battery from reaching a problematically low state of charge (SOC)

Note 1 to entry: This is a specific case of a "load disconnect point" as defined by IEC 62509:2010, 3.11.

[SOURCE: IEC TS 62257-9-5:2018, 3.23, modified – the reference to overdischarge has been removed since an LVD can be designed to terminate the discharge before the battery is completely discharged]

3.8.3
standby loss
quantity of electricity (electric charge), expressed as a fraction of the total battery capacity, drawn from a product's battery with the product switched off over a specific length of time

[SOURCE: IEC TS 62257-9-5:2018, 3.24]

3.8.4
standard operating voltage
standardized voltage corresponding to a typical battery operating point during discharge

[SOURCE: IEC TS 62257-9-5:2018, 3.31]

3.8.5
typical battery discharge voltage
battery voltage corresponding to the "typical operating point" (e.g. the operating point resulting in the average value of power) during discharge

Note 1 to entry: The typical battery discharge voltage is an outcome of the full-battery run time test, while the standard operating voltage depends only on the battery chemistry and number of cells.

[SOURCE: IEC TS 62257-9-5:2018, 3.32]

3.8.6
appliance operating voltage
voltage supplied to an appliance by a port when the appliance is operating at a particular setting and the power control unit battery is at the typical battery discharge voltage

[SOURCE: IEC TS 62257-9-5:2018, 3.33]

3.9 Component categories and types, and related terms

3.9.1
product
complete stand-alone renewable energy product or kit, typically including an energy source, power control unit(s), one or more lights or other appliances, wiring, and other accessories, and sold or distributed as a kit

Note 1 to entry: The product is the unit to which the IEC TS 62257-9-5 test report applies.

Note 2 to entry: The complete definition of a stand-alone renewable energy product is given in IEC TS 62257-9-5:2018, 4.1.1.

3.9.2
appliance
device that performs a specific function providing service to an end user, such as a light, radio, mobile device, or television set

[SOURCE: IEC TS 62257-9-5:2018, 3.26, modified – mobile device has been added to the list of examples.]

3.9.3
mobile device
basic mobile phone, feature phone, smartphone, tablet computer, or similar portable communication and/or computing device having an internal rechargeable battery

Note 1 to entry: Larger portable devices, such as laptop computers, can also be considered mobile devices, but some provisions (e.g. related to charging current and ports) may not be applicable.

Note 2 to entry: A mobile device is an appliance.

[SOURCE: IEC TS 62257-9-5:2018, 3.27, modified – note 2 has been added.]

3.9.4
power control unit
component of a stand-alone renewable energy product that includes a battery and one or more ports plus, typically, the associated battery management, voltage regulation and overload protection components

Note 1 to entry: In the case of a product with a single power control unit, the power control unit is often referred to as the "main unit" or "control box." A power control unit can include appliance functionality such as a light or built-in radio. A portable appliance (such as a light) with internal battery is a power control unit if it includes a port.

[SOURCE: IEC TS 62257-9-5:2018, 3.29]

3.9.5
main unit
component or assembly including an input for connecting the primary energy source (e.g. solar, grid or mechanical charger), a battery, and one or more built-in appliance(s) or port(s)

Note 1 to entry: A power control unit can be a main unit, though a main unit does not necessarily have a port.

Note 2 to entry: A product can contain more than one main unit.

[SOURCE: IEC TS 62257-9-5:2018, 3.30, modified – note 2 to entry has been added.]

3.9.6
port
connector (typically a socket) on a component that can supply power to an appliance

Note 1 to entry: This definition applies when the word "port" is used without qualification in this document. The word "port" can also be used more generally to refer to any socket (receptacle).

[SOURCE: IEC TS 62257-9-5:2018, 3.28, modified – note 1 to entry has been added]

3.9.7
barrel jack
low-voltage DC power socket with a central pin, accepting a cylindrical plug

Note 1 to entry: Some examples of such connectors are described in IEC 60130-10, but many other sizes exist. Barrel jacks are typically described by the length, inner diameter, and outer diameter of the matching plug.

3.9.8
cigarette lighter receptacle
cigar lighter receptacle
low-voltage DC power socket of the kind used for vehicle cigarette/cigar lighters and power outlets

Note 1 to entry: This term encompasses socket types defined by SAE J563 and ISO 4165, and other similar connectors, whether or not they are intended for use with cigarette lighters. Both the lighter receptacle and the power outlet receptacle of SAE J563 are considered cigarette lighter receptacles.

3.10
quality test method
QTM
rigorous set of tests defined in IEC TS 62257-9-5 for off-grid renewable energy products, requiring a relatively large sample size and using randomly procured samples

Note 1 to entry: QTM testing is considered appropriate for qualification for market support programmes, and generating information for third-party-verified specification sheets.

3.11
accelerated verification method
AVM
optional verification pathway defined in IEC TS 62257-9-5 for off-grid renewable energy products to enable expedited entry to markets or market support programmes, including a 2-step process of a verification entry (AVM-VE) test and follow-up test

3.12
plug-and-play product
off-grid renewable energy product in which all electrical connections are made with plug-and-socket connectors and can be made without the use of tools, and no technicians or electricians are necessary to install and operate the system safely and successfully

Note 1 to entry: The adjective "plug-and-play" can also describe connections of this type.

3.13
manufacturer
entity who provided the product for testing (who can be the maker of the product or a supplier, importer, distributor, reseller, etc.)

Note 1 to entry: When referring to a component manufacturer, such as a battery, PV module, or LED manufacturer, this definition does not apply. Instead, the maker of the component is intended.

3.14
advertised value
value stated by the manufacturer in any consumer-facing location, including but not limited to product packaging, a user manual or other documentation included in the packaging, or a website

Note 1 to entry: Phrases such as "advertised current" or "advertised run time" refer to the advertised value of the quantity indicated.

3.15
measured value
value determined as a result of testing, whether by direct measurement or calculation

Note 1 to entry: Phrases such as "measured power" or "measured run time" refer to the measured value of the quantity indicated.

Note 2 to entry: The measured value is compared to the advertised value to determine truth in advertising.

3.16
advertised appliance
appliance not included as part of the product but mentioned in the accompanying advertising material, such as the product packaging or the manufacturer's website

Note 1 to entry: This advertising can be a simple statement that the appliance can be used with the product or an estimate of the run time or service provided by the appliance with a full battery or after a day of solar charging. Methods are provided in IEC TS 62257-9-5 for evaluating these claims even though the appliances are not provided to the test laboratory.

[SOURCE: IEC TS 62257-9-5:2018, 4.1.4, modified – the text has been edited to meet the requirements of the IEC Directives and to identify the document providing the test methods.]

4 Test requirements

4.1 General

All testing specified in this document shall be conducted using the test methods provided in IEC TS 62257-9-5 or in this document. The test laboratory should be qualified to undertake the test methods used. Testing options are described in brief in Table 1 and Table 2. All requirements are described in more detail in 4.2, 4.3, and 4.5.

Table 1 – Summary of test requirements and alternatives – initial testing requirements to determine compliance with Clause 5

Test method	Relevance	Sample size for most tests	Random sampling required?
Quality test method (QTM)	Applicable for any product, especially new products in which all aspects have never been previously tested.	6 (size A) 4 (size B)	Required: sampling from warehouse or retail
Accelerated verification method (AVM)	Alternate to QTM which enables products to achieve initial qualification more quickly. Manufacturer shall meet certain eligibility criteria to use this option.	Initial test: 6 (size A) 4 (size B)	Not required initially: manufacturers can send units directly to lab
		Follow-up test: 2	Required for follow-up testing: sampling from warehouse or retail
Pay-as-you-go (PAYG)	Applicable to fee-for-service or pay-as-you-go (PAYG) enabled versions of products that were previously qualified according the QTM or AVM.	2	Not required
Product families	Used to minimize the testing required for kits configured from sets of interchangeable components sold on a component-level basis or as mix-and-match kits. At least one kit in the family and 50 % of all components shall have been tested according to the QTM or AVM.	6 (size A) 4 (size B)	Required: sampling from warehouse or retail
Similar products	Used to minimize the testing required for products with similar aspects to ones that have already been tested according to the QTM or AVM.	6 (size A) 4 (size B)	Required: sampling from warehouse or retail
Verification of product identicality (VPI)	Used to minimize testing required for products which are purportedly identical to a product that has already been tested according to the QTM or AVM but will be sold under different model numbers or brands.	2	Required: sampling from warehouse or retail
Reference of other standards	Products that have already been tested and found to meet certain outside standards may be exempted from testing certain aspects.	Sampling requirements of the referenced standard apply.	

NOTE 1 Sample sizes for each test are presented in IEC TS 62257-9-5.

NOTE 2 Size A and size B are defined in IEC TS 62257-9-5 and described in this document in 4.2.2.

Table 2 – Summary of test requirements – recurring testing requirements to ensure continued compliance with Clause 5

Test method	Relevance	Sample size for most tests	Random sampling required?
Renewal testing	Required for all products within two years after initial qualification to verify continued compliance with Clause 5.	2 (if aspects have changed or product fails initial testing, a larger sample size can be required)	Required: sampling from warehouse or retail
Market check method (MCM)	Optional test used to verify continued compliance with Clause 5. May be conducted at any time.	2 (if aspects have changed or product fails initial testing, a larger sample size can be required)	Required: sampling from retail

NOTE Sample sizes for each test are presented in IEC TS 62257-9-5.

4.2 Initial testing requirements

4.2.1 General

Initial qualification under the quality, warranty, and performance reporting requirements outlined in Clause 5 requires evaluation according to one or more of the following pathways. Test laboratories conducting initial testing according to IEC TS 62257-9-5 should have demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory.

Regardless of the testing pathway chosen, the dynamic measurement of port performance from IEC TS 62257-9-5 need not be conducted.

NOTE The dynamic measurement of port performance is described in IEC TS 62257-9-5:2018, EE.4.3.

4.2.2 Quality test method

One pathway is to use quality test method (QTM) results according to IEC TS 62257-9-5. Sampling procedures in IEC TS 62257-9-5 shall be followed.

NOTE In IEC TS 62257-9-5:2018, the QTM is defined in Clause 6. Size A products are defined in IEC TS 62257-9-5 as products with peak solar PV power (or similar input power) smaller than or equal to 10 W and size B products are defined as products with peak solar PV power greater than 10 W and smaller than or equal to 350 W. The aspects to be tested and samples sizes for each size of product are presented in the "QTM (size A)" and "QTM (size B)" columns of IEC TS 62257-9-5:2018, Table 14; for size A, this corresponds to a sample size of six (n = 6) for most tests and for size B, this corresponds to a sample size of four (n = 4) for most tests. The sampling procedures are specified in IEC TS 62257-9-5:2018, Annex E.

4.2.3 Accelerated verification method

4.2.3.1 Testing procedure

A second pathway is to use accelerated verification method (AVM) results that are drawn from two rounds of testing as described in IEC TS 62257-9-5 and summarized below:

NOTE 1 The AVM is also described in IEC TS 62257-9-5:2018, Clause 9, but with two different configurations. Only one of these configurations is described below.

a) An AVM-verification entry (AVM-VE) test equivalent to a QTM test with the random sampling requirement of QTM testing waived.

b) Follow-up testing conducted shortly after AVM-VE testing is finished and the product is commercially available in markets. The AVM follow-up test uses a sample size of two and is equivalent to a typical market check method (MCM) primary check test (PCT) as described in IEC TS 62257-9-5. Follow-up MCM testing shall be conducted on commercially available products within six months of the preceding QTM testing. Sampling procedures in IEC TS 62257-9-5 shall be followed.

NOTE 2 In IEC TS 62257-9-5:2018, the MCM is defined in Clause 7. The aspects to be tested and samples sizes are presented in the PCT column of IEC TS 62257-9-5:2018, Table 14.

4.2.3.2 Eligibility requirements and qualification criteria

Only products from companies that meet both of the following eligibility requirements are permitted to receive initial qualification via AVM testing:

a) At least three of the company's products have met the requirements of this document via QTM testing according to IEC TS 62257-9-5, or have met other quality standards that require testing to IEC TS 62257-9-5, such as the Lighting Global Quality Standards. At least one of the products which previously met the requirements is of the same size class (size A or size B as described in 4.2.2) as the product to be tested, and at least one of these products currently meets the requirements of this document (i.e. the validity period specified in 4.3 has not expired).

b) None of the company's products have failed market check testing or retesting carried out according to IEC TS 62257-9-5 (as described in 4.3) in the past two years, with the following two exceptions:

   1) failures to meet requirements that have changed since the last time the product was tested (for instance, if it is the first time a product is undergoing the assessment of DC ports, it could fail for this aspect, but still maintain eligibility for the AVM);

   2) failures for aspects that can be corrected by changing the packaging or advertising (i.e. the correction does not require re-testing to confirm the change), if the failure has been fully corrected and documented with photographs of the printed, corrected consumer-facing materials.

Market entry or programme qualification is typically offered after successful completion of the first round of AVM-VE testing, with the guarantee that the second round of follow-up testing will occur within six months. The AVM option is best managed by a market development programme that can oversee the follow-up testing process and has access to data regarding product failures to assess the eligibility criteria. Such a programme can also use financial measures to ensure the follow-up testing will occur, to confirm changes to printed consumer-facing materials when determining eligibility, and to impose applicable penalties for non-compliance. Governments are encouraged to coordinate with market development programmes to ensure that eligible products, and only eligible products, are offered market entry following the AVM-VE test.

4.2.4 Pay-as-you-go targeted testing

A third pathway is specific to fee-for-service or pay-as-you-go (PAYG) enabled versions of products that were previously qualified according to this document using one of the processes described in 4.2.2 and 4.2.3. These products may qualify using targeted testing, which comprises:

a) visual inspection, including internal assessment;

b) durability testing on any aspects that could have been impacted by the addition of the PAYG option (e.g. new ports or changes to the existing casing);

c) an estimate of the parasitic consumption or additional standby loss due to the addition of the PAYG option;

d) submission of manufacturer declaration indicating:

   1) that the performance of the PAYG-enabled version is equivalent to that of the previously tested non-PAYG product, or specifying how the performance of the PAYG-enabled version differs from the non-PAYG version. In cases where PAYG-enabled versions of products are similar, but not identical to the previously tested non-PAYG version, those aspects which differ shall be tested.

   2) an estimate of the accuracy, precision and drift of the metering;

   3) that the appropriate battery protection remains active and the solar module can charge the battery regardless of whether the system is in an enabled or disabled state. This requirement may be waived if the conditions described in 5.6.2 are met.

The targeted PAYG testing shall be conducted with two samples according to IEC TS 62257-9-5. Samples for targeted PAYG testing may be submitted directly by a manufacturer (or their proxy). If PAYG-enabled versions of products are similar, but not identical to the previously-tested non-PAYG version, those aspects which differ will require testing according to the QTM or AVM and qualify according to this document using one of the processes described in 4.2.2 and 4.2.3.

NOTE In IEC TS 62257-9-5:2018, the PAYG testing method is defined in Clause 10. The aspects to be tested and samples sizes are presented in the IEC TS 62257-9-5:2018, Table 19.

4.2.5 Product families

A product family (set of interchangeable components sold on a component-level basis or as a mix-and-match kit) may receive initial qualification as follows:

a) At least one fully configured system ("kit") shall be tested according to the QTM or AVM and qualify according to this document using one of the processes described in 4.2.2 and 4.2.3. Individual programmes or countries may require additional fully configured systems to be tested.

b) At least half of the models of each product component (PV module, battery or control unit, lighting appliance, etc.) shall be tested. For example, if 5 PV module models are included in a family, at least 3 of those module models shall be tested. The smallest/dimmest and largest/brightest models of each component shall be tested, at a minimum. These components shall be tested for all relevant component-level aspects according to the QTM or AVM and qualify according to this document using one of the processes described in 4.2.2 and 4.2.3. If significant differences (other than size) exist between components in a given category (for example, batteries with different chemistries, PV modules of different types, or components from different manufacturers), these shall be treated as a different component type when calculating the number required to be tested.

When reviewing whether the family meets the requirements of Clause 5, test results for any full kits tested, along with reports for all tested components, should be examined. The test results can be provided in a single test report or in several separate reports.

All products which qualify using this method, regardless of whether the particular kit or configuration was directly tested for initial qualification, may be subjected to market check testing described in 4.3 and shall meet all of the requirements of Clause 5.

EXAMPLE A family comprises 5 different PV module models, 3 different battery/power control units, 10 different types of lighting appliances and 2 radio models. The company configures these components to make 7 different kits (PV – battery combinations), with a large variety of options for the number of light points included. The radios can be included or excluded from any kit.

In this case, at least one full kit would need to be tested according to the QTM or AVM. Additionally, at least the following components would need to be tested according to the applicable component-level tests of the QTM or AVM:

- 3 PV module models (including the highest and lowest power modules)
- 2 battery/power control units (the smallest and largest)
- 5 of the lighting appliances (including the dimmest and brightest)
- both radio models would need to be tested according to the applicable component-level tests of the QTM or AVM.

Individual components that are tested as part of a complete kit count toward the requirement to test 50 % of the components. So, if the tested kit included 1 PV module, 1 battery, 3 different lighting appliances and 1 radio, the remaining components that would require testing are: 2 PV modules, 1 battery/power control unit, 2 lighting appliances and 1 radio.

4.2.6 Similar products

Several variants of a product in which some aspects are identical, and some aspects differ from each other may receive initial qualification as follows:

a) If one version of the product has already been tested or is being tested and is found to qualify according to this document using one of the processes described in 4.2.2 and 4.2.3, those aspects of the product which do not differ from the original version need not be tested.

b) When determining the targeted tests required for the alternate versions, it is important to consider differences in component specification as well as system level effects. For example, if the fully tested product ("A") has a different battery than the variant product ("B") then new tests would be required for the battery, battery durability, charge controller behaviour, full-battery run time, and solar charge tests. If the change in battery also impacts the operating voltage of the lighting appliances (as determined during the full-battery run time test), then new testing would also be required for light output and light distribution. Refer to Annex A for detailed provisions for targeted testing of similar products.

c) In all cases, test results shall be generated that allow for full characterization of the quality and performance of each product. In other words, results for product B may be drawn from a combination of results for product A (where applicable) and new tests of product B, and the sum of these test results shall enable full characterization of product B to provide the information required to assess whether the product meets the requirements listed in Clause 5.

d) All targeted testing shall be conducted according to the QTM or AVM using one of the processes described in 4.2.2 and 4.2.3, above. A product being tested according to the QTM described in 4.2.2 shall not reference results from a product undergoing the AVM described in 4.2.3 until the product undergoing AVM testing has completed the AVM follow-up testing. A product shall not reference results from a product that is found to no longer meet the requirements of Clause 5 through market check testing or renewal testing, as described in 4.3. Similarly, a product shall not reference results from a product that has not completed testing (either QTM, AVM, or renewal testing) in the last two years.

e) Retesting, as described in 4.3, should be conducted for variant products at the same time as retesting of the fully tested product, and shall in all cases begin within six months of the fully-tested product's retest report date.

4.2.7 Verification of product identicality

Verification of product identicality (VPI) testing may be used when two products are identical aside from the model number or branding. If one version of the product has already been tested or is being tested and is found to qualify according to this document using one of the processes described in 4.2.2 and 4.2.3, the second product may be found to qualify by undergoing a visual screening test to confirm that the products are identical and that the second product's packaging also complies with the requirements of this document. A minimum of two samples of the second product shall be procured and sampling procedures in IEC TS 62257-9-5 shall be followed.

Most of the visual screening is conducted on a single sample, while the parts that are usually conducted on 4 or 6 samples are conducted on 2 samples. During the visual screening, the test laboratory shall compare the product under test to the test report of the fully tested product.

In cases where the products are sold or distributed by two separate companies, documents confirming the following are required to use this pathway:

- permission from Company A for the test laboratory to view the test report for the originally tested product. If the laboratory does not have access to the original test report, Company A could need to request that the original laboratory provide the new laboratory with the report. If applicable, a market development programme or similar organization could also provide the original report with permission from Company A.
- permission from Company A for the original test report to be referenced in the visual screening report for the co-branded product.

NOTE 1 Company B could also want to secure permission from Company A to access a copy of the original report to provide to pre-verification of conformity (PVoC) and other customs/programme officials in certain markets.

NOTE 2 Some market development programmes, or other organizations, might choose to not require additional testing for changes to branding and model numbers and instead rely on digital materials and manufacturer declarations to confirm that the products are otherwise identical.

4.2.8 Reference to other standards

Other internationally recognized standards may be referenced in lieu of the tests specified in IEC TS 62257-9-5 for certain aspects, as noted in a) through e). All tests should be conducted at a test laboratory that is properly trained to undertake the test methods and, if applicable for the particular standard, accredited by a recognized accrediting body. Testing shall follow the sampling and sample size requirements of the referenced standard or those of IEC TS 62257-9-5. (If the referenced standard contains no sampling or sample size requirements, then this document does not specify additional requirements; sampling should follow industry practice, if applicable.) All other product aspects shall be tested and found to qualify according to this document using one of the processes described in 4.2.2 through 4.2.6. All aspects may be subject to market check testing described in 4.3 regardless of whether requirements were originally met using other recognized standards.

a) IEC 61215 (all parts) may be referenced in lieu of PV module ingress protection tests (the physical ingress protection test and the water ingress protection test and level of water protection). If the IEC 61215 "robustness of terminations" test was conducted and the cable included with the samples under test is of the type specified by the PV module manufacturer, then the PV module does not need to undergo the mechanical durability – strain relief test. Regardless, the PV module shall be tested according to the photovoltaic module I-V characteristics test of IEC TS 62257-9-5 for use in the solar charge test and energy service calculations.

b) For televisions and radios, IEC 60065 or IEC 62368-1 may be referenced in lieu of conducting the following durability tests. For fans, IEC 60335-2-80 may be referenced in lieu of these tests.

   – physical ingress protection test, and
   – mechanical durability – strain relief, switch, gooseneck, moving part, connector and drop tests.

c) For non-lighting appliances, other appropriate internationally recognized standards may be referenced in lieu of certain appliance tests specified in IEC TS 62257-9-5 at the discretion of the market development programme, government, or other organization using this document.

   NOTE Guidance is provided in IEC TS 62257-9-5:2018, FF.6.3.1, to assist in determining whether to accept alternate test results.

   EXAMPLE A market development programme, government, or other organization could specify the following provisions for acceptance of alternative standards:

   For televisions, fans and refrigerators, test results from Global LEAP testing may be referenced in lieu of the power consumption test, appliance operating voltage range test, and physical ingress protection test.

   The test laboratory would need access to the full Global LEAP test results in order to interpolate between the tested voltages to determine the power consumption at the port voltage for the energy service calculations. If the voltage range presented in the Global LEAP report is narrower than the voltage range of the ports of the product that the appliance will be used with, the voltage range test would need to be conducted for the appliance to ensure it is compatible and will not be damaged by the product. This determination may need to be made after the assessment of DC ports from IEC TS 62257-9-5 is conducted on the product.

   If both Global LEAP test results and IEC 60065/IEC 60335 certifications are provided, only one sample of the appliance would need to be procured to test for functionality and compatibility with the renewable energy product. This sample will also be visually compared to the description of the product in the IEC 60065 and Global LEAP test results. The sample could be submitted directly by a manufacturer (or their proxy). If water protection requirements are to be met by testing rather than labelling, two additional randomly sampled units of the appliance would need to be provided.

d) If a lighting appliance without an internal battery has been tested in accordance with IEC TS 62257-12-1, the results may be referenced in lieu of the following tests:

   – The light output test need not be repeated provided that the appliance operating voltage is within the range of voltages at which relative light output was measured during the input voltage range test of IEC TS 62257-12-1.
   – The physical ingress and water protection test of IEC TS 62257-12-1 may be referenced in place of those same tests in IEC TS 62257-9-5, provided that the IEC TS 62257-12-1 test method defines procedures for estimating or testing the IP Codes for which testing is needed according to the required level of water protection for the renewable energy product.
   – The mechanical durability tests and light distribution test of IEC TS 62257-12-1 may be referenced in place of those in IEC TS 62257-9-5.
   – If the standard operating voltage from IEC TS 62257-12-1 is greater than or equal to the appliance operating voltage from IEC TS 62257-9-5, then the lumen maintenance test need not be conducted. Alternatively, if the standard operating voltage from IEC TS 62257-12-1 is greater than or equal to the standard operating voltage from IEC TS 62257-9-5 and there is no DC-DC converter between the battery and the port to which the light is to be connected, then the lumen maintenance test need not be conducted.

– In some cases, the lighting appliance will still need to undergo the appliance voltage range test, depending on the prior test results and the performance of the ports on the renewable energy product.

e) If a lithium iron phosphate battery has previously been tested according to IEC 61427-1, the results may be referenced in lieu of the battery durability storage test in IEC TS 62257-9-5, as specified in 5.6.4.

4.3 Recurring testing requirements

Products shall be retested two years after the date of completion of the QTM testing. If the product has remained unchanged since QTM testing, renewal testing shall consist of a market check method (MCM) primary check test (PCT) as described in IEC TS 62257-9-5 with a sample size of two for all applicable tests.

If the product has changed since QTM testing, testing according to the QTM of IEC TS 62257-9-5 shall be conducted on all aspects that have changed and all aspects that could be impacted by the changes, as described in 4.2.6. All other aspects shall undergo testing with a sample size according to the PCT to confirm the product continues to meet the requirements in Clause 5. In all cases of renewal testing, the sampling procedures in IEC TS 62257-9-5 shall be followed.

In either case, to minimize the testing required, tests for some aspects may be referenced or omitted as described in 4.2.5, 4.2.6, and 4.2.8. In addition, some PV module tests are not required for recurring testing, as specified in 5.5.5.1. Tests referenced according to 4.2.8 shall follow any recurring testing requirements of the referenced test and need not be retested every two years.

When reviewing whether the product meets the requirements of Clause 5, test results from original QTM or AVM testing and the new renewal testing should be available for comparison and to confirm that the product did originally undergo an initial qualification test.

EXAMPLE If a product was originally tested according to the QTM and completed testing on 31 January 2016, it would need to undergo a renewal test by 1 February 2018. If the design of the product had not changed in the two years, the renewal test report would show results for only 2 samples. If the report indicated that the product continued to comply with the requirements of Clause 5, the results would remain valid for another two years. Another renewal test could be conducted in January 2020 to further extend the results.

Furthermore, market check testing according to the MCM in IEC TS 62257-9-5 may be used to verify that a product, after being shown to meet the quality and warranty requirements through QTM testing, continues to do so.

4.4 Retesting of non-conforming products

In cases where products tested according to 4.2 or 4.3 are found not to meet all of the quality requirements of Clause 5, the market development programme, government, or other organization using this document may allow for targeted retesting of the product after improvements have been made. When determining retesting requirements, the provisions of 4.2.6 and Annex A shall be observed. If the issue can be corrected by changes to the packaging or consumer-facing materials, the organization may choose to allow submission of photographic evidence that consumer-facing materials have been improved to assess compliance with the requirements of Clause 5.

4.5 General testing requirements applicable to all testing pathways

4.5.1 General

For any product, regardless of which pathway described in 4.2 is used for testing, one set of test results shall fully characterize the product's performance on the highest (brightest) light output setting or configuration, as applicable. If a product includes only one lighting appliance, but offers multiple light output settings, the light output aspects (luminous flux, CCT, and CRI) shall be measured on at least two settings. If a product includes multiple lighting appliances, the light output aspects shall be measured for the highest (brightest) setting of each distinct lighting appliance type individually. The power consumption of all lighting appliances on all settings shall be measured individually.

For appliances used individually or in combination, the full-battery run time and any relevant run times after solar, electromechanical, or grid charging shall be evaluated according to the energy service calculations described in IEC TS 62257-9-5.

NOTE 1 In IEC TS 62257-9-5:2018, the energy service calculations are defined in Annex GG. An advertised value of daily energy service (e.g. watt-hours per day) is evaluated using the example usage profile (IEC TS 62257-9-5:2018, Table GG.4) if the combination of appliances used to obtain the advertised energy service is not specified.

For the example usage profile defined in IEC TS 62257-9-5 daily energy service, full-battery run time, and run time after solar, electromechanical, and/or grid charging shall be reported by the test laboratory, but need not be included on the product packaging or documentation. In the example usage profile, if there are both included and advertised appliances of a given type, use only the included appliances of that type. Otherwise, use the advertised appliance or set of advertised appliances with the highest power consumption of each type.

The only aspect of the light distribution test that is required is the vertical and horizontal full width half maximum (FWHM) angles. This aspect shall be measured at a 1 m distance from the centre of the light source. Measurements not used in this calculation need not be made.

If a component has two or more built-in LED arrays that cannot be operated simultaneously, the deep discharge protection shall be tested and found to meet the requirements of 5.6.1 for each array. The deep discharge protection can be tested using the charge controller behaviour test or the full-battery run time test. If the charge controller behaviour test is used, the full-battery run time test shall be conducted on the brightest array and need not be conducted for the other arrays.

NOTE 2 This requirement overrides the requirement in IEC TS 62257-9-5 to perform the full-battery test for each array.

NOTE 3 Using the charge controller behaviour test when the full-battery run time test is not required can reduce the time required for testing. However, for arrays with passive deep discharge protection, the charge controller behaviour test cannot be performed without first completing the full-battery run time test.

For televisions with automatic brightness control enabled by default, power consumption testing shall be done with automatic brightness control enabled. If automatic brightness control is enabled, the illuminance at the automatic brightness control sensor shall be 12,0 lx ± 2,4 lx.

4.5.2 Exception for accessory lights

A lighting appliance is an accessory light if its advertised luminous flux is 15 lm or less, unless it is the only light included with the product and is one of the core functions of the product (i.e. is not simply an indicator LED). Accessory lights are considered non-lighting appliances and need not be assessed for light output aspects (luminous flux, CCT, CRI, and light distribution) or lumen maintenance. However, if an accessory light is suspected to have a luminous flux greater than 15 lm, it may be tested to confirm the actual light output and, if found to exceed 15 lm, may be subject to the requirements for lighting appliances.

5 Quality requirements

5.1 General

The quality standards are benchmarks that set a baseline level of quality, durability, and truth in advertising to protect consumers of off-grid lighting products. The quality standards are divided into the six main categories described in 5.2 through 5.8: truth in advertising, lumen maintenance, health and safety, battery requirements, quality and durability, and consumer information.

If a product fails to meet any requirement of this document or of IEC 62257-9-5 at any point during testing, even if the failure does not occur during the specific test used to evaluate that requirement, the product is considered not to meet the requirement. For example, if a switch stops functioning on a product while its luminous flux is being measured, the product would fail for functionality. An exception may be made if the failure could reasonably have been caused by handling, disassembly, or modifications to the product that are not representative of ordinary use.

In certain cases, where products are designed for special applications, certain requirements may be waived, altered, or strengthened at the discretion of the market development programme or government that is utilizing the requirements. Any deviations from the requirements listed in this document shall be noted in the test report and any other verification materials. If it is evident from the design and construction of the stand-alone renewable energy product that a particular test or standard is not applicable, the test is either not made or reasonable adjustments may be made to apply the test to the product. Any modifications shall provide a level of accuracy equivalent to the original method and shall be fit for the intended use. All modifications shall be documented in the test report. The need for additional detailed requirements to cope with new situations should be brought promptly to the attention of the appropriate committee.

A brief summary of requirements is presented in Table 3. This table is to be used as a guide; the complete set of requirements is specified in the remainder of Clause 5.

Table 3 – Summary of quality requirements

Category	Metric	Sub-clause	Size
Truth in advertising	All numeric aspects are accurate. All advertised features are functional.	5.2.1, 5.2.2	All
	Performance reporting requirements: manufacturer name, product name, light output, solar run time, a statement regarding device charging, warranty terms, and component specifications	5.2.3	Size A
	Performance reporting requirements: manufacturer name, product name, PV power, solar run time profile, a statement regarding battery replacement, warranty terms, and component specifications	5.2.3	Size B
	Advertisements for pay-as-you-go (PAYG) products are truthful and products are capable of accurately metering service	5.2.4	All
	Advertisements for included appliances are accurate	5.2.5	All
	Ingress protection advertisements are accurate	5.2.6	All
Ports requirements	Ports requirements include: appliance voltage compatibility, truth in advertising, and ports functionality	5.3	All
Lumen maintenance	Actual or estimated relative light output at 2 000 h is ≥ 90 % of the initial light output	5.4	All
Health and safety	AC-DC power supplies carry a recognized consumer electronics safety certification	5.5.1	All
	Hazardous substances: batteries do not contain mercury or cadmium	5.5.2	All
	Product passes an overload protection test	5.5.3	All
	All wires, cables and connectors are appropriately sized	5.5.4	All
	All PV modules meet additional visual screening and durability tests	5.5.5	All
	All PV modules with maximum power greater than 10 W at STC pass the hot spot endurance test of IEC 61730-2 or IEC 61215-2 or the partial shading test defined in Annex B of this document	5.5.5.8	Size B
	Products with a maximum solar PV power greater than 240 W, open-circuit voltage greater than 35 V, or short-circuit current greater than 8 A are subject to additional safety requirements	5.5.6	Size B
Battery requirements	Battery chemistry is stated and supported by documentation	5.6.1	All
	All batteries are protected by an appropriate charge controller	5.6.2	All
	Lithium-based batteries meet a safety standard and have overvoltage protection for individual cells	5.6.3	All
	After battery durability test, capacity loss does not exceed 25 %	5.6.4	All
Quality and durability	Physical ingress protection requirements vary by component category	5.7.2.2	All
	Water protection requirements vary by component category	5.7.2.3	All
	Components are subject to a drop test depending on their weight, expected use and advertisements	5.7.3	All
	The system and any included appliances are rated "good" or "fair" for workmanship quality as defined in IEC TS 62257-9-5	5.7.4	All
	Switch, gooseneck, connector and moving parts durability: Items expected to be used regularly remain functional after 1 000 cycles; those used only during installation remain functional after 100 cycles	5.7.5	All
	Cables attached to an included component are subject to a strain relief test	5.7.6	All
	All outdoor cables are outdoor-rated and UV resistant	5.7.7	Size B
	PV overvoltage requirement: If the battery is disconnected or isolated, the system is not damaged, and the load terminals maintain a voltage that is safe for their intended uses	5.7.8	All
	Miswiring requirement: If improper or reversed connections can easily be made, they cause no damage to the system or harm to the user	5.7.9	All
	Additional requirements apply to products with non-plug-and-play connectors	5.7.10	All

Category	Metric	Sub-clause	Size
Consumer information	Warranty requirement: minimum period of 1 year	5.8.1	Size A
	Warranty requirement: minimum period of 2 years for the system and included lights, and 1 year for other included appliances	5.8.1	Size B
	All products or separately packaged components state the date of manufacture	5.8.2	All
	A user manual is included that presents instructions for installation, use, and troubleshooting of the system	5.8.3	Size B
	Information regarding component replacement is included along with a consumer-facing statement about battery replacement	5.8.4	Size B

5.2 Truth in advertising

5.2.1 General

Specific requirements regarding the accuracy of advertised performance and functionality are provided in 5.2.3 through 5.2.6 and assessed according to the test methods in IEC TS 62257-9-5.

All numeric aspects from IEC TS 62257-9-5, such as light output, run time, time to charge, and PV power, shall deviate no more than 15 % from advertised values (though it is always acceptable if actual performance is better than advertised). If a range is provided, the best rating shall be within the 15 % tolerance.

NOTE In most cases, "better" than advertised implies that the measured quantity is greater than the advertised value. For example, a measured run time that is longer than advertised or a light output that is brighter than advertised would be considered better than the advertised value. In some cases "better" implies that the measured quantity is less than the advertised value. For instance, if a product advertised the time required to fully charge the battery, a measured value that was less than the advertised value would be considered better than the rating.

In general, the percent deviation from a target value is calculated using the following formula:

$$D = 100\,\% \cdot \frac{x_{\text{target}} - x_{\text{meas}}}{x_{\text{target}}}$$

where:

D is the percent deviation in a numeric value;

x_{target} is the target value;

x_{meas} is a measured value or the average of the measured values for each sample.

All advertised features shall be functional. Any rating or description of the product that appears on the packaging, inside the package and in any other consumer-facing medium (internet, etc.) shall be truthful and accurate. Statements shall not mislead buyers or end users about the features or utility of the product.

Some claimed features or ratings are outside the scope of IEC TS 62257-9-5. The market development programme, government, or other entity using this document may determine an appropriate method to evaluate these claims.

5.2.2 Assessment of run time values

5.2.2.1 Background

IEC TS 62257-9-5 defines multiple types of run time:

a) Appliance full-battery run time: this is the run time of a single appliance with battery from a full charge of its own internal battery. This value is measured in the full-battery run time test or appliance full-battery run time test, or estimated in the appliance power consumption test.

b) Full-battery run time: this is the run time when the main unit (3.9.5) battery is fully charged and used to power an appliance or combination of appliances. This value is calculated in the energy service calculations.

c) Solar run time: this is the run time for an appliance or combination of appliances expected in one day of solar charging, including any use or charging of the appliance during the day. This value is calculated in the energy service calculations.

d) Electromechanical and grid run time: this is the run time after the main unit battery is charged by the electromechanical charger or the grid.

If a run time is advertised, the run time should be stated in such a way that the intended interpretation is clear to the consumer.

NOTE 1 In IEC TS 62257-9-5:2018, the interpretation of full-battery run time according to a) and b) above is described in more detail in GG.4.1.1.

NOTE 2 Solar run time can be greater than full-battery run time because it includes daytime use or charging, which is not limited by the capacity of the main unit battery.

NOTE 3 Solar run time and full-battery run time are typically greater than appliance full-battery run time because it is assumed that the appliance could be recharged multiple times from the energy stored in the main unit battery. Electromechanical and grid run time can also be greater than appliance full-battery run time.

NOTE 4 For mobile devices, "run time" refers to the number of full charges of the mobile device battery, not the duration of operation.

A full-battery run time result for main units is also measured in the full-battery run time test. This measurement is made with a specified combination of appliances, which does not necessarily correspond to any advertised combination.

5.2.2.2 Interpretation of advertised values

If a run time is advertised, it is assumed to be for the setting with the greatest power consumption (e.g. for a light, the brightest setting), unless otherwise stated.

NOTE In IEC TS 62257-9-5, radios and televisions are tested under specified operating conditions, which are considered the only "setting" for the appliance.

If a full-battery run time (in the sense of 5.2.2.1 b)) for a given appliance or combination is measured in the full-battery run time test and also calculated in the energy service calculations, the result of the energy service calculations shall take precedence unless there is a specific technical reason to prefer the full-battery run time test result (e.g. if one of the assumptions made in the energy service calculations is shown to be invalid for the product).

In general, if a run time is advertised and it is not clear to which of these types it refers, the advertisement should be interpreted in the way that is least favourable to the product. In specific cases:

a) If only "run time" is stated, or an unclear phrase such as "run time on a single charge," compare the advertised value to the minimum of the measured values of full-battery run time, solar run time, and (for appliances with batteries) appliance full-battery run time.

b) If only "full-battery run time" or the equivalent is stated, compare the advertised value to the lesser of the measured values of full-battery run time and (for appliances with batteries) appliance full-battery run time.

c) A run time value advertised for multiple appliances shall assume simultaneous use, not sequential use. For example, if a product includes three lights, and each light can be used for 4 h, an appropriate advertised value would be 4 h, not 12 h, for three lights.

d) If any advertised run time for an appliance with battery, expressed in units of time (not full charges), exceeds the appliance full-battery run time as defined in 5.2.2.1 a), the meaning of the run time should be communicated in a way that is meaningful to a typical user (e.g. "radio solar run time: 20 h if radio is charged twice from main battery").

e) If, due to assumed daytime use, any solar run time (5.2.2.1 c)) for an appliance exceeds the full-battery run time (5.2.2.1 b)) for that appliance, the requirement for daytime use should be communicated in a way that is meaningful to a typical user (e.g. "television solar run time: 8 h, including daytime use").

For lighting appliances, run time shall be expressed in units of time. For non-lighting appliances with batteries (including accessory lights as defined in 4.5.2), run time may be expressed in units of time, number of full charges, or as a percentage of a full charge. (Run time for lighting appliances may be expressed this way if it is also given in units of time.) Any run time expressed relative to a full charge shall be evaluated as for mobile devices.

5.2.2.3 Run times for advertised appliances

Run times may be specified for advertised appliances (3.16). Any such statement of run time shall clearly indicate that these appliances are not included with the product. Further, the assumed power (or, if run time is specified in terms of full charges, the battery capacity) of the advertised appliances shall be presented and shall be representative of actual appliances that can be found in the market.

5.2.3 Information and performance reporting requirements

5.2.3.1 Required content

The performance reporting requirements differ for size A and size B products. Size A and size B are defined in IEC TS 62257-9-5 and described in 4.2.2.

a) For all products, the manufacturer name and a uniquely identifiable product name or model number shall be presented as described in 5.2.3.2.

b) All PV modules that are not integrated into other components shall include a clear and indelible label on the PV module that provides the following information:

   – name, registered trade name or registered trademark of manufacturer;
   – type or model number designation;
   – serial number (unless included in a kit and marked on another component);
   – date and place of manufacture; alternatively, serial number allowing to trace the date and place of manufacture;
   – maximum system voltage;
   – open-circuit voltage (V_{oc});
   – short-circuit current (I_{sc});
   – maximum power (P_{mpp}).

   All electrical ratings shall be compared to measurements made at standard test conditions (1 000 W/m^2, 25 °C, air mass index 1,5 according to IEC TS 61836), but ratings at other test conditions (NMOT, etc.) may be included in addition to those at STC.

c) For all components, whether packaged with a kit or included as part of a product family, the following performance metrics shall be advertised to enable consumers and distributors to compare products and make educated choices. All component specifications shall be provided on the packaging or user manual. If the component is packaged with the kit, the information shall be presented on the packaging or user manual of the kit. If the component is packaged separately from the kit, the information shall be presented on the packaging or

user manual of the component. Where indicated, specifications shall also be provided on the component.

- PV modules (those that are not integrated into other components): maximum power, open-circuit voltage, short-circuit current.
- Batteries: battery chemistry, battery capacity in mAh, Ah, or Wh, and nominal voltage (battery capacity and nominal voltage shall also be marked on the battery)
- Lighting appliances with batteries (excluding main units): luminous flux (or brightness) in lumens and the appliance full-battery run time (5.2.2.1 a)) for the brightest setting
- Lighting appliances without batteries: luminous flux (or brightness) in lumens
- Appliances without batteries (including lighting appliances): power in watts and nominal operating voltage or voltage range
- Appliances with batteries (including lighting appliances): power in watts, nominal charging voltage or voltage range, battery chemistry, battery capacity in mAh, Ah, or Wh, and nominal battery voltage (battery capacity and nominal voltage shall also be marked on the battery)

The requirements for lighting appliances do not apply to accessory lights as defined in 4.5.2.

d) For size A products, four additional elements are required and shall be presented as described in 5.2.3.2:

- Luminous flux in lumens (may also be described as "light output" or "brightness");
- Daily solar run time in hours;
- Basic warranty terms as described in 5.7.1 (note that warranty terms may be included on a user agreement or warranty card that is easily accessed prior to purchase, rather than on the packaging);
- For products that offer mobile phone charging or other auxiliary services (such as a radio), a note that qualitatively describes the impact of mobile phone charging and other auxiliary services on product performance. This statement need not be quantitative; it is intended to ensure that the consumer is aware of the trade-off between using the available stored energy for lighting or other services. A statement such as, "mobile phone charging can reduce the daily runtime of the lights," or "charging mobile phones or using the radio will result in shorter run times for the lights," is acceptable.

NOTE "Auxiliary services" refers to appliances, whether included or advertised, that can be powered by the product, but for which an advertised daily solar run time is not presented on the packaging.

The luminous flux and solar run time shall be reported for the brightest setting. For products with multiple lighting appliances, including those with their own batteries (often referred to as torches, portable lamps, or lanterns), the brightest setting is the simultaneous use of all included lighting appliances on their brightest settings. The luminous flux of all lighting appliances shall be reported, either separately or as a single total value. The solar run time for the "brightest setting" shall include all the lighting appliances included in the product; products with multiple batteries can have multiple values of solar run time, one for each battery.

The name of the metric or a pictorial representation and the units shall be included, for example, "Light output on high: 75 lm" or "Brightness on highest setting: 75 lumens." A number without the units or an appropriate description is not acceptable. An advertised value without a setting name is assumed to be for the solar run time on the brightest setting and shall be evaluated as such.

Manufacturers may also present comparative measures of brightness, though they shall also report the value in lumens. In cases where manufacturers or distributors choose to provide comparative measures of brightness in addition to reporting the value in lumens, comparisons shall be standardized to reflect the light output as reported in lumens. Allowable equivalents include:

- 1 candle or 1 kerosene wick lamp = 10 lm
- 1 hurricane lamp = 40 lm
- Incandescent lamp (bulb) = 900 lm (this is based on a 60 W lamp)

– Compact fluorescent (CFL) lamp (bulb) = 900 lm (this is based on a 13 W lamp)

EXAMPLE 1 A 45 lm product could advertise that it is "brighter than 4 candles" or "as bright as a hurricane lamp."

e) For size B products four additional elements are required and shall be presented as described in 5.2.3.2:

– PV module power in watts

– One solar run time profile for all of the included light points on high and any other included appliances provided on the packaging or in the user manual. This run time profile may also include advertised appliances as specified in 5.2.2.3. Unless otherwise stated in the advertisement, default values from IEC TS 62257-9-5 for the percentage of daytime and night-time use and charging of appliances shall be used when assessing the advertised solar run time profile, except that the night-time percentage for lights without batteries shall be 100 %. Additional run time profiles may also be presented.

NOTE In IEC TS 62257-9-5:2018, daytime and night-time use percentages are defined in Table GG.6.

EXAMPLE 2 An example of a solar run time profile is: "After a day of solar charging, you can use the main lights on high for 4 h, the torch for 8 h, and the TV for 3 h." The information can also be given in tabular or graphical form.

– A clear statement regarding battery replacement as described in 5.8.4

– Basic warranty terms as described in 5.8.1 (note that warranty terms may be included on a user agreement or warranty card that is easily accessed prior to purchase, rather than on the packaging).

For all products, solar run time and daily energy service, if advertised, shall be based on a solar resource of 5 kWh/m^2. Additional solar run time and energy service values based on alternative values of solar resource may be advertised; the solar resource in kWh/m^2 used to calculate any such alternative values shall be clearly indicated.

5.2.3.2 Design requirements

The manufacturer may choose how to present the required performance metrics, mobile-charging information, identifying information (manufacturer name, product name and/or model number), and warranty terms, so long as the presentation adheres to the content requirements in 5.2.3.1 and the following design requirements:

a) All information shall be presented in a clear, unambiguous manner. Elements shall not be misleading.

b) The information shall have at least the same prominence as the other messages on the packaging.

c) The label or information shall be sized such that:

1) The text is at least 10-point font;

2) Any graphics are clearly visible.

d) There shall be sufficient contrast between the text or graphics and background to be clearly legible.

The information shall be placed on the outside of the package in at least one prominent location, with the following two exceptions: the warranty terms may be included on a warranty card or user agreement rather than on the packaging, but shall be accessible prior to purchase, and the solar run time profile for size B products may be included in a user manual. In cases where products are exclusively installed by the company's trained and authorized technicians and the product packaging is not designed to be consumer-facing, the required elements may instead be included in a prominent location in a user agreement or other documentation to be reviewed by the consumer prior to purchase. All information shall be available to customers prior to sale.

It is strongly recommended that:

e) The text and graphic elements should be simple and understandable;

f) The information should be presented graphically and/or using an appropriate language for the region(s) where the product will be sold.

5.2.4 Fee-for service or pay-as-you-go (PAYG) metering requirements

The PAYG system should be capable of accurately metering service to customers so they reliably get the service that is paid for. If there are both pay-as-you-go (PAYG) and non-PAYG versions of a product, each shall be truthfully advertised with respect to energy services provided. These aspects are primarily assessed through manufacturer declaration and measurement of parasitic consumption of the PAYG metering system, as described in 4.2.4. In cases where the PAYG version of the product is fully tested, the parasitic consumption of the PAYG metering system is not measured separately, but is included in the standby loss measurement for the product, which impacts the run time estimates for the product.

The market development programme, government, or other entity using this document may specify additional market check tests to assess the performance of the PAYG system in regions where the service is functional.

5.2.5 Included appliances requirements

Included appliances are subject to truth-in-advertising requirements for performance claims. Relevant tests are listed in IEC TS 62257-9-5 and include light output, battery test, appliance power consumption, full-battery run time, solar charge test, and energy service calculations.

NOTE In IEC TS 62257-9-5:2018 relevant appliance tests are listed in Table FF.1.

5.2.6 Assessment of ingress protection advertisements

Any advertised IP Code may be evaluated, and, if evaluated, shall be accurate. Evaluation of IP Codes shall be performed according to IEC 60529 or IEC TS 62257-9-5, except that the modified IPX4 method from IEC TS 62257-9-5 shall not be used for this purpose. This requirement may be met by manufacturer-supplied documentation of test results from a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory. Unless otherwise specified, the sampling requirements of 5.7.2.1 do not apply to tests required by this subclause that are not required by 5.7.2.

EXAMPLE A component of a product undergoing a QTM test is required by 5.7.2 to meet IP21. The package claims that the component meets IP67. The testing for IP21 would require random sampling according to IEC 62257-9-5, but the testing for IP67 would not.

NOTE IEC TS 62257-9-5 does not include procedures to evaluate all possible IP Codes.

As described in 5.7.2, technical protection assessed according to IEC TS 62257-9-5 may be used to provide protection equivalent to IPX4, IPX3, or IPX1.

Components that contain sensitive electronics and are advertised using the following terms shall meet the IP Codes listed below, evaluated according to IEC 62257-9-5 (if applicable) or IEC 60529:

- waterproof, or similar: IPX7
- weatherproof, or similar: IP64
- splashproof, or similar: IPX4
- rainproof, protected from heavy rain, or similar: IPX3 (or IPX1 plus technical protection)
- water resistant, rated for outdoor use, or similar: IPX1 (or technical protection)
- dustproof, protected from dust, or similar: IP5X

Diodes and screw terminals are not considered sensitive electronics, but any printed circuit board is considered sensitive.

User documentation or markings on the product or packaging shall not supersede the minimum requirements by component form factor described in 5.7.2. (For example, a fixed outdoor component is required to meet the requirements of Table 9 even if it is only claimed to be "water resistant" and even if it includes an appropriate warning to install in a sheltered area.)

If a component that would otherwise be considered a fixed indoor component has advertising that includes words or pictures depicting that the product is for use outdoors, camping, boating, or similar, the component shall be subject to the IP requirements for portable integrated products described in 5.7.2 (including 5.7.2.1). If a component is advertised to be permanently mounted outdoors (including on a boat), the component shall meet the fixed outdoor requirements described in 5.7.2 (including 5.7.2.1).

If a component is advertised to be used on the water in conditions where it is likely to be submerged, the component shall meet IPX7.

5.3 Ports requirements

5.3.1 General

The requirements of 5.3 apply to products that include output ports to power appliances or mobile devices (see 3.9.6) and are assessed using IEC TS 62257-9-5. Ports that are intended primarily for a function other than providing power (i.e. data ports or input ports) are not expected to meet these requirements. To be exempted from testing, these ports shall be labelled on the port, packaging, or user manual that the port is "not for charging" or similar. The laboratory may check the functionality of these ports (e.g. by connecting a compatible device), and any port so tested shall be functional.

NOTE In IEC TS 62257-9-5:2018, the ports tests are described in Annex EE.

Each tested sample shall meet the requirements of 5.3.4, 5.3.5 and 5.3.6 (i.e. no failures are permitted).

In 5.3.5, 5.3.6.3.1, and 5.3.6.4.1, ports are required to provide a voltage within specified limits over a specified range of current or power, based on the advertised current or power rating. If both current and power ratings are advertised, each evaluation shall be performed twice, once using the current rating and once using the power rating, and the port shall meet the requirements in both cases.

Separate current (or power) ratings may be specified for functionality and for overcurrent protection. If separate ratings are given, the term "advertised current (or power)" in 5.3.5, 5.3.6.3.1, and 5.3.6.4.1 refers to the rating for functionality.

EXAMPLE 1 If the port voltage for a USB port drops below 4,5 V at 0,5 A, the following language could be used: "The USB port can supply 1,5 A, but some mobile devices might not charge if the load exceeds 0,5 A."

EXAMPLE 2 Consider a 12 V port that can reliably provide 12 V at 3 A and has overcurrent protection that activates at 6 A. In this example, the port cannot sustain 12 V at currents above 3 A, and a typical 12 V, 6 A appliance might not work properly at a reduced voltage. A current rating for this situation could state: "the port can supply 6 A, but some appliances might not function properly if the load exceeds 3 A."

The voltage at the maximum current (or power) required by 5.3.5, 5.3.6.3.1, and 5.3.6.4.1 may be determined by linear interpolation. However, if the relationship between voltage and current (or power) appears to be nonlinear on the interval containing the maximum current (or power), and the voltage at one endpoint of this interval is less than the required minimum value, one or more additional measurements should be taken in this interval to determine whether the port meets the requirement.

5.3.2 Voltage converters

If a product includes an accessory that converts one port type into another by changing the voltage (e.g. an adapter that plugs into the 12 V port and provides a 5 V USB output), the output(s) of the accessory shall be tested as a separate port or ports and shall undergo the output overload protection test and assessment of DC ports. Such accessories need not be included in the PV overvoltage test.

5.3.3 Ports with multiple output voltages

If any port has multiple output voltage settings (e.g. a laptop computer power supply that is adjustable to multiple voltages between 9 V and 24 V), at least two settings shall be tested, subject to the following provisions:

a) 5 V or 12 V settings shall be tested and shall comply with 5.3.6.

b) If specific settings are used for the included or advertised appliances, these should be tested.

c) Otherwise, the maximum and minimum settings should be tested.

Each selected setting is tested as a separate port, including the output overload protection test and assessment of DC ports.

5.3.4 Appliance voltage compatibility requirements

5.3.4.1 General

Except as specified in 5.3.4.2, included appliances shall function when connected to ports and shall not be damaged or present a safety hazard over the entire voltage range of the port as assessed in the appliance operating voltage range test or the assessment of DC ports of IEC TS 62257-9-5. Appliances shall function at all tested voltages, where "function" is defined as providing the expected service (e.g. lights turn on, television displays images and sound) for appliances without internal batteries, and is defined as charging for appliances with internal batteries.

NOTE In IEC TS 62257-9-5:2018, the appliance operating voltage range test is described in Clause FF.8. Alternatively, the voltage compatibility can be assessed using steps in EE.4.2. See IEC TS 62257-9-5:2018, EE.4.2.1.3, for additional information.

5.3.4.2 Exception

When tested at the minimum voltage, the appliance need not function if the behaviour is described in the user manual and the description is written in a way that is meaningful to a typical user; for example: "The television may not work when the battery is low." A single statement may be used to meet the requirements of this exception and the exceptions defined in 5.3.6.3.2 or 5.3.6.4.2. For example, if the user manual states that the USB port turns off when the battery is low, it is not necessary to add an additional statement that a USB radio cannot charge when the battery is low.

5.3.5 Truth-in-advertising requirements

Advertised port voltage ranges are subject to truth-in-advertising requirements. Compliance is assessed using the evaluation of advertising claims described in IEC 62257-9-5. Each tested sample is evaluated individually, and all samples shall meet these requirements.

If a voltage range is advertised, the following requirements shall be met at all simulated battery voltages, except that the voltage may fall below the lower limit at the low-battery voltage if this behaviour is clearly described in the user manual or in the same place where the voltage range is stated.

a) For 5 V ports, the port voltage shall not be less than the advertised minimum voltage, minus a tolerance of 1 %, when the port is operating at up to 95 % of the advertised current (or power), or, if there is no advertised current (or power), up to 0,5 A.

b) For all other ports, including 12 V ports, the port voltage shall not be less than the advertised minimum voltage, minus a tolerance of 1 %, when the port is operating at up to 95 % of the advertised current (or power), or, if there is no advertised current (or power), at all measured current (or power) values except the highest measured value for each simulated battery voltage level.

c) For all ports, the port voltage shall not exceed the advertised maximum voltage, plus a tolerance of 1 %, under any test conditions.

NOTE 1 In IEC TS 62257-9-5:2018 the assessment of advertised voltage ranges is described in EE.4.5.2 a).

If both current and power ratings are advertised, whichever is least favourable to the product shall be used to evaluate the advertised voltage specification.

A product may advertise a minimum voltage, a maximum voltage, both, or neither. In addition, a nominal port voltage is frequently advertised. If a single voltage value is specified for a port with no further description, it should be interpreted as a nominal port voltage. Nominal port voltages are not subject to a truth-in-advertising requirement, but should be accurate.

Any port power and current specifications, if provided, shall be accurate. If a current or power rating is advertised in association with a port, the port shall be able to provide at least 95 % of the advertised current or power value at the typical battery discharge voltage.

NOTE 2 In IEC TS 62257-9-5:2018 the assessment of advertised current and power specifications is described in EE.4.5.2 b).

Power output of ports shall be sufficient to power appliances that are advertised but not included. Advertised appliances with batteries that charge from 5 V ports meeting the requirements of 5.3.6.4 shall be excluded from this assessment.

NOTE 3 In IEC TS 62257-9-5:2018 the evaluation of claims regarding capability to power appliances is described in EE.4.5.2 c).

5.3.6 Functionality requirements

5.3.6.1 Dynamic measurement not required

There are no requirements for dynamic port performance for any type of port, and the dynamic measurement need not be conducted.

NOTE In IEC TS 62257-9-5:2018 the dynamic measurement is described in EE.4.3.

5.3.6.2 Non-standard connectors

Ports with a connector type that is not commonly used for 12 V or 5 V ports need not meet the requirements of 5.3.6.3 or 5.3.6.4, provided that the consumer-facing advertising or documentation states that generic user-supplied or off-the-shelf appliances cannot be used and no adapter that converts the port to a commonly used connector type (without changing the voltage) is included or described. The following receptacle types are not eligible for this exception unless modified so that standard or conventional plugs cannot be inserted:

- any receptacle type defined by any version of the USB standard;
- a barrel jack (see 3.9.7) of any dimensions;
- a cigarette lighter receptacle (see 3.9.8).

Additional exceptions to the requirements are given for 12 V ports in 5.3.6.3.2 and for 5 V ports in 5.3.6.4.2.

5.3.6.3 Functionality requirements for 12 V ports

5.3.6.3.1 Basic requirements

All ports advertised or reasonably expected to provide 12 V shall have a steady-state voltage no greater than 15 V under any conditions. Such ports shall meet the following minimum steady-state voltage requirements:

a) If there is a consumer-facing advertised current (or power) value, the port voltage shall be no less than 10,5 V when the port is operating at up to 95 % of the advertised current (or power) value, at all simulated battery voltages. The port shall function at all simulated battery voltage levels, but there is no current or power requirement except as specified in 5.3.5.

b) If there is no advertised current (or power) value, the port voltage shall be no less than 10,5 V at all measured current (or power) values except the highest measured current (or power) for each simulated battery voltage level. The port shall function at all simulated battery voltage levels, but there is no current or power requirement except as specified in 5.3.5.

A port is reasonably expected to provide 12 V if any of the following are true (this is not an inclusive list):

- The port is a type defined by an industry standard or convention for use with 12 V systems, including but not limited to cigarette lighter receptacles.
- The product includes an adapter allowing such connectors to be used with the port (without changing the voltage), or such an adapter is separately advertised by the manufacturer.
- The port is advertised to work with one or more DC appliances (other than included lighting appliances).
- The nominal port voltage (whether advertised or not) is between 10,5 V and 15 V, or the range of measured port voltages overlaps with this range.

5.3.6.3.2 Exceptions

When the power control unit battery is at the low-battery voltage, the port voltage may drop below 10,5 V or the port may turn off if the feature or behaviour is described in the user manual and the description is written in a way that is meaningful to a typical user; for example: "Some appliances might not work when the battery is low."

Ports that would otherwise be reasonably expected to provide 12 V, but meet all of the following criteria, need not comply with the lower voltage limit:

a) The port is not a cigarette lighter receptacle (see 3.9.8) and no adapter to convert the port to a cigarette lighter receptacle is included or advertised.

b) One of the following is true:

   1) The consumer-facing documentation and advertising materials, including but not limited to the packaging, user manual, and manufacturer's website, do not imply that the port can be used with any appliances other than the included lighting appliances or depict such use, or

   2) There is a prominent consumer-facing statement, meeting the requirements of 5.2.3.2, clearly stating that the port can be used only with manufacturer-supplied appliances, whether included or sold separately. No other consumer-facing information shall contradict this statement.

Ports that meet a) and b) need not comply with the upper voltage limit if there is a warning, meeting the requirements of 5.2.3.2 or 5.7.2.3.2.1 b), clearly stating that user-supplied appliances can be damaged if connected to the port.

NOTE The following do not meet the requirements of b) above:

- There is a statement that some user-supplied 12 V appliances might not work correctly, or similar wording, but not explicitly stating that the product cannot be used with such appliances.

- The consumer-facing documentation and advertising describes or depicts the use of the port with included or manufacturer-supplied non-lighting appliances, such as a fan or radio, but does not explicitly state that the product can only be used with these appliances

5.3.6.4 Functionality requirements for 5 V ports

5.3.6.4.1 Basic requirements

All ports with a USB form factor and all 5 V ports advertised or reasonably expected to be used for mobile phone charging (including barrel plugs) shall meet the requirements below. These requirements are based on the USB Battery Charging Specification Revision 1.2 (USB Implementers Forum, 2012), with some modifications to address common charging requirements in the stand-alone renewable energy product market. The market development programme, government, or other entity using this document may define exceptions to these requirements; the manufacturer shall present clear justification for any exceptions.

a) USB ports shall be able to provide at least 0,5 A at all simulated battery voltages.

b) Voltage requirements when the port is operating at a current less than or equal to 0,5 A or 95 % of the advertised current (or a power less than or equal to 95 % of the advertised power), whichever is greater:

   1) Minimum steady-state voltage: 4,5 V at all simulated battery voltages except the low-battery voltage; 4,25 V at the low-battery voltage.

   2) Maximum steady-state voltage: 5,5 V

c) Voltage requirements when the port is operating at a current (or power) greater than the current (or power) specified in b):

   1) No minimum steady-state voltage requirement

   2) Maximum steady-state voltage: 5,5 V

5.3.6.4.2 Exceptions

In the special case that a product has at least two USB ports and at least one of these ports meets all the requirements of 5.3.6.4.1, the other port may be designed to provide a voltage that exceeds 5,5 V. The maximum steady-state voltage of this port shall not exceed 6,0 V under any test conditions and shall comply with all other requirements of 5.3.6.4.1. The user manual shall include a description of the difference between the two ports, indicate which port is higher voltage, provide a way to identify each port, and state that not all devices will be compatible with the higher voltage port.

The minimum steady-state voltage requirement at the low-battery voltage, specified in 5.3.6.4.1 b) 1), may be waived if the port behaviour is described in the user manual in a way that is meaningful to a typical user. If this requirement is met, the port may turn off at the low-battery voltage or operate with an output voltage less than 4,25 V.

EXAMPLE If the port does not function when the battery is low, the following language could be used: "When the battery is low, the USB port will turn off, but the lights will continue to work."

5.3.6.5 Ports powered directly from a PV module

Ports that are powered directly from a PV module (without a battery) can be tested by supplying power to the PV input using the apparatus from the solar charge test of IEC TS 62257-9-5 to simulate the PV module performance at TMOT (50°C and 1 000 W/m^2). All functionality requirements that would normally apply at the typical battery discharge voltage shall apply under these conditions. These ports can also be tested using natural sunlight or a solar simulator meeting the requirements of IEC 60904-9 class BBB.

If the product advertises that a mobile phone or other appliance can be charged directly from the PV module, the PV module output should be considered a "port" and should be evaluated in accordance with this subclause.

5.4 Lumen maintenance

When tested according to IEC TS 62257-9-5, the lumen maintenance of all lighting appliances that are required to be assessed for light output aspects shall meet one of the following requirements:

- at 2 000 h, average relative light output of all samples shall be greater than or equal to 90 % of the initial light output with only one sample allowed to fall below 85 %, or
- at 1 000 h, all samples shall maintain greater than or equal to 95 % of the initial light output.

The lumen maintenance requirement may be assessed using a 2 000 h test or the expedited method using LM-80-08 data. If the 2 000 h test is used, and the pass/fail determination is made at 1 000 h, the test may be terminated at 1 000 h or may continue to 2 000 h with no further verdict.

The LM-80 test is intended as a way to expedite products entering the market and shall not be used for renewal or market check method (MCM) tests.

For products that undergo 500 h tests (LM-80 tests, renewal tests, MCM primary check tests, accelerated verification method (AVM) tests), all samples at 500 h shall maintain greater than or equal to 95 % of initial light output. If a product fails the 500 h test, it shall be retested with additional samples for the full 2 000 h. The number of samples required for the retest depends on the product size categories described in 4.2.2. Size A products shall be retested with six samples and size B products shall be retested with four samples.

NOTE In IEC TS 62257-9-5:2018 the 2 000 h test is described in Clause J.4 and the LM-80 test is described in Clause J.6.

5.5 Health and safety

5.5.1 AC-DC power supply safety

Any included AC-DC power supply shall carry a recognized consumer electronics safety certification with accompanying valid documentation.

NOTE UL and CE markings are common electronic safety approval markings found on AC-DC power supplies relevant to off-grid lighting products. The UL and CE markings on these AC-DC power supplies typically indicate compliance with the UL 1310 and IEC 60950-1, IEC 62368-1, or IEC 60335-2-29 safety standards, respectively. Other safety approval markings, such as China Compulsory Certificate (CCC) and TÜV, are also found on AC-DC power supplies relevant to stand-alone renewable energy products. CCC and TÜV markings on these AC-DC power supplies indicate compliance with the GB 4943 and IEC 60950-1 safety standards, respectively, though IEC 60950-1 is being replaced by IEC 62368.

A test certificate and/or test report shall be provided showing that the included AC-DC power supply has been tested against the appropriate safety standards and that the test results are current and valid. The certificate or report shall be prepared by a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory.

5.5.2 Hazardous substances

Batteries shall not contain mercury or cadmium at levels greater than trace amounts (0,0005 % mercury and 0,002 % cadmium by weight).

NOTE This requirement is generally assessed through manufacturer-supplied information. Batteries that are not nickel cadmium (NiCd) typically meet this requirement. This requirement is harmonized with Directive 2006/66/EC of the European Parliament and of the Council of the 6 September 2006 on batteries and accumulators and repealing Directive 91/157/EEC (the European Commission Battery Directive).

5.5.3 Circuit and overload protection

All ports shall pass the output overload protection test of IEC 62257-9-5. Ports shall include overcurrent protection to prevent irreversible damage to the system. The overload protection device shall either completely cut off power to the port, or the circuitry shall limit the current such that even when the load resistance is decreased, the current remains below a safe value which does not damage the system.

The overload protection shall be easily resettable or replaceable by the user, or shall automatically reset. If replaceable fuses are used for circuit protection, sizes shall be labelled on the product and listed in the user manual, and, if fuses are replaceable by the user, at least one spare fuse shall be included with the product. Included appliances need not meet these requirements, unless they have ports that are intended to provide power. To be exempted from testing, a statement that the port is "not for charging" or similar shall be included at the port, or on the packaging or user manual.

NOTE In IEC TS 62257-9-5:2018 the overload protection test is described in DD.4.2.

Ports that are powered directly from a PV module (without a battery) can be tested under the conditions defined in 5.3.6.5.

5.5.4 Wiring and connector safety

For all products, all wires, cables and connectors shall be appropriately sized for the expected current and voltage, and all connectors and wire joints shall be robust. This includes that all external cords provided with the product shall be capable of carrying the electric currents present during normal operation without exceeding 50 °C ± 3 °C (measured at 25 °C ± 3 °C ambient temperature). This requirement is primarily assessed using a declaration from the manufacturer.

NOTE 1 In IEC TS 62257-9-5:2018, the required manufacturer declaration is described in D.3.3.3.

NOTE 2 This requirement overrides the direction in IEC TS 62257-9-5 to require the manufacturer declaration only for Size B products and includes an additional required declaration that all connectors and wire joints shall be robust.

5.5.5 Additional tests for PV modules

5.5.5.1 General

All PV modules (unless otherwise noted) shall meet the requirements of 5.5.5. The sample sizes and renewal requirements for these tests are given in Table 4. For renewal tests as described in 4.3, AVM follow-up tests as described in 4.2.3.1 b), or market check method (MCM) tests (as described in IEC 62257-9-5), these tests are required only if specified in Table 4 or if the PV module has changed.

Table 4 – Sample size and renewal requirements for PV tests

Subclause	Sample size	Required for renewal, AVM follow-up, or market check method (MCM) tests	Provision of IEC 61730 (all parts) sufficient to meet requirements
5.5.5.2 Wiring inspection	Same as IEC 62257-9-5 visual screening	yes	no
5.5.5.3 Visual screening	Same as IEC 62257-9-5 visual screening	yes	no
5.5.5.4 Durability of markings and sharp edges	1	no	yes
5.5.5.5 Screw connections	1	no	yes
5.5.5.6 Breakage	1	no	yes
5.5.5.7 Bending or folding	1	no	no
5.5.5.8 Hot-spot endurance (size B products only)	1	no	yes

Outside test results to IEC 61730 (all parts) or IEC 61215 (all parts) may be provided to meet some of these requirements. Such testing shall be conducted at a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory. For such testing, the sampling requirements of IEC TS 62257-9-5 do not apply, and sample sizes shall be as specified in the referenced standard.

NOTE The requirements of 5.5.5.4, 5.5.5.5, 5.5.5.6, and 5.5.5.8 are fulfilled by any PV module that has met the requirements of IEC 61730 (all parts).

Subclauses 5.5.5.4 through 5.5.5.8 reference procedures in Annex B and Annex C. These procedures, as well as the contents of 5.5.5.2 and 5.5.5.3, are intended to be added to a future version of IEC TS 62257-9-5. If the most recent version of IEC TS 62257-9-5 includes one of the referenced procedures, the procedure in IEC TS 62257-9-5 shall take precedence and the procedure in this document shall not be used.

5.5.5.2 Wiring inspection

If the most recent version of IEC TS 62257-9-5 includes a wiring inspection procedure for PV cables, that procedure shall be used. Otherwise, the following procedure shall be used.

The conductors connecting the PV module to the main unit (3.9.5) shall be sized to safely carry the maximum short circuit current of the module. The conductor diameter shall be measured using an appropriate instrument (e.g. callipers, micrometer, or wire gauge); for multi-stranded conductors, multiple measurements should be made to determine an average diameter for the bundle, or an individual strand may be measured and then the result multiplied by the number of strands. Examples of maximum ratings are given in Table 5. The determination of whether the wire is sized safely is ultimately at the test laboratory's discretion.

Table 5 – Examples of maximum current ratings

Wire size American wire gauge (AWG)	Wire size mm^2	Example current rating A
18	0,82	11,4
16	1,31	14,7
14	2,08	20,5
12	3,31	24,6
10	5,26	32,8
NOTE The example maximum ratings are referenced from ANSI/NFPA 70:2017, Table 310.15(B)(16), assuming multi-conductor insulated cable at an ambient temperature of 50 °C and a conductor temperature of 90 °C. These values are provided for general guidance. To provide strict safety requirements, the insulation temperature limit, thickness, thermal conductivity, air convection and temperature should all be taken into account. Further, these values only take into account the current-carrying capacity. To minimize voltage drop, good practice warrants the use of larger diameter conductors (for example, the use of 2,5 mm^2 wire to carry 7 A).		

5.5.5.3 Visual screening

During the visual screening described in IEC TS 62257-9-5, any of the following visual defects identified in the PV module shall be included in the deficiency score calculated during the internal inspection. These deficiencies are not classified as functionality deficiencies and should be treated similarly to soldering, wiring, and fixture deficiencies. If any hazards or immediate safety issues are present, these safety issues should be treated similarly to those identified during the internal inspection and the product's workmanship quality shall be noted as poor.

a) broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;

b) bubbles or delaminations forming a continuous path between the electric circuit and the edge of the module;

c) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the operation of the module would be impaired:

d) loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired;

e) module markings (label) are no longer attached or the information is unreadable.

NOTE 1 In IEC TS 62257-9-5:2018 the deficiency score and workmanship quality is described in F.4.3.c).

NOTE 2 Guidance regarding deficiencies that could pose safety issues for PV modules was derived from IEC PAS 62257-10 and IEC 61730-2.

If the visual screening procedure in a future version of IEC TS 62257-9-5 contradicts the requirements of this subclause, the requirements of IEC TS 62257-9-5 shall take precedence.

5.5.5.4 Durability of markings and sharp edges

All PV modules that are not integrated into other components shall meet the requirements of the following tests as described either in IEC 61730-2 or in a future version of IEC TS 62257-9-5, or in Clauses C.2 and C.3 of this document.

a) Durability of markings.

b) Sharp edge test.

5.5.5.5 Screw connections

Any PV modules with screw connections intended to be used at the time of installation shall meet the requirements of the screw connection test defined in IEC 61730-2, a future version of IEC TS 62257-9-5, or Clause C.4 of this document.

5.5.5.6 Breakage

All PV modules that are not integrated into portable components (i.e. modules that are not subject to the drop test described in IEC TS 62257-9-5) shall pass the module breakage test of IEC 61730-2 or the impact test described in a future version of IEC TS 62257-9-5 or Clause C.5 of this document.

5.5.5.7 Bending or folding

All PV modules that are designed or advertised to be flexible or foldable shall pass a bending or folding test described in a future version of IEC TS 62257-9-5 or in Clause C.6 of this document, except that modules that are mounted or integrated into a component in a way that they would not be flexed or folded during installation or use do not need to undergo this testing, regardless of whether the module itself is flexible or foldable.

5.5.5.8 Hot-spot endurance (size B products only)

All modules with rated power (at STC) greater than 10 W shall pass one of the following hot-spot endurance tests:

a) the hot-spot endurance test of IEC 61730-2 or IEC 61215-2;

b) the partial shading test specified in a future edition of IEC TS 62257-9-5; or

c) if the most recent edition of IEC TS 62257-9-5 does not specify a partial shading test, the partial shading test for photovoltaic modules described in Annex B of this document.

5.5.6 Requirements for systems with large PV modules or arrays

If a product includes a PV module or array with maximum power greater than 240 W, open-circuit voltage greater than 35 V, or short-circuit current greater than 8 A, the module and other components in the system, as appropriate depending on the design of the product, are subject to the following additional requirements:

a) PV modules shall meet the requirements for class II modules in IEC 61730 (all parts).

b) All components intended to be directly connected to the output of the PV module shall meet the requirements of IEC 62109-1 or UL 1741. Typically, this requirement applies to the main control unit.

c) Any component intended to be connected to an electrical output of components to which b) applies shall meet the requirements of IEC 62109-1 or another applicable standard (e.g. UL 1741 or the relevant part of IEC 60331) assessing protection from fire and electric shock, unless the circuit to which the component is connected meets the requirements of IEC 62109-1 or another applicable standard for protection in case of direct contact.

If a product is intended to be used with multiple PV modules in series or parallel, regardless of whether the PV modules are included with the kit, requirements a) through c) shall apply if the total power, open-circuit voltage, or short-circuit current of the combination can exceed 240 W, 35 V, or 8 A respectively.

If outside test results are provided to meet this requirement, the testing shall be conducted at a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory.

5.6 Battery requirements

5.6.1 Provision of battery specification sheets

A battery specification sheet from the battery manufacturer, showing at a minimum acceptable deep discharge protection and overcharge protection thresholds, shall be provided for all batteries. Additionally, companies shall declare the battery chemistry and provide a safety data sheet (SDS) or similar documentation to support the declaration for all batteries in the system. For lithium-based batteries, the declaration of the chemistry shall state the specific materials used, such as "lithium cobalt oxide" or "lithium iron phosphate." A generic term such as "lithium-ion" is not sufficient.

5.6.2 Battery charge control

All batteries shall be protected by an appropriate charge controller that prolongs battery life and protects the safety of the user. All tested samples shall meet the requirements outlined below. Charge control is evaluated according to IEC TS 62257-9-5. Included appliances with batteries shall also meet these requirements.

The deep discharge protection voltage measured according to IEC TS 62257-9-5 shall not be less than the minimum value given in Table 6 or the value specified by the battery manufacturer, whichever is less. The deep discharge protection voltage for nickel-metal hydride batteries shall not exceed the maximum value given in Table 6 or the value specified by the battery manufacturer, whichever is greater.

The overcharge protection voltage measured according to IEC TS 62257-9-5 shall not exceed the maximum value given in Table 7 or the value specified by the battery manufacturer, whichever is greater. The overcharge protection voltage for lead-acid batteries shall not be less than the minimum value given in Table 7 or the value specified by the battery manufacturer, whichever is less. The test laboratory should discontinue the test if the cell temperature exceeds the value given in IEC TS 62257-9-5 or the value specified by the manufacturer, whichever is greater.

The following exceptions are permitted for nickel-metal hydride (NiMH) batteries:

- For NiMH batteries with only one cell in series, there is no requirement for deep discharge protection voltage.
- If the product meets the requirements of the passive overcharge protection test of IEC TS 62257-9-5, there is no overcharge protection voltage requirement. (There is no passive overcharge protection test for any other battery type.)

Components with output ports shall have active deep discharge protection. Passive deep discharge protection is permitted for components without ports.

NOTE 1 In IEC TS 62257-9-5:2018, charge control is evaluated in accordance with Annex S, Annex M and/or Clause FF.9. Passive overcharge protection is defined in IEC TS 62257-9-5:2018, S.4.4.

Table 6 – Default battery deep discharge protection voltage specifications

Battery type	Deep discharge protection voltage V/cell		
	Recommended	Minimum	Maximum
Lead-acid	≥ 2,00	1,95	--
Lithium-ion	≥ 3,00	2,95	--
Lithium iron phosphate	≥ 2,50	2,45	--
Nickel-metal hydride	= 1,00	0,95	1,10
NOTE The recommended values for lead-acid batteries correspond to a depth of discharge (DoD) of approximately 50 %, which is recommended to improve the cycle life of the battery. In practice, the recommended level of deep discharge will vary according to the design of the battery and the desired cycle life. The recommended values for other battery types are designed to protect the battery from damage.			

Table 7 – Default battery overcharge protection voltage specifications

Battery type	Overcharge protection voltage V/cell		
	Recommended	Minimum	Maximum
Lead-acid	= 2,40	2,35	2,45
Lithium-ion	≤ 4,20	--	4,25
Lithium iron phosphate	≤ 3,65	--	3,70
Nickel-metal hydride	≤ 1,45	--	1,50

For PAYG systems, appropriate battery protection shall remain active regardless of whether the system is in an enabled or disabled state. To avoid damage to a battery during long-term periods of non-payment disabled system status, the solar module shall be able to charge the battery even if the product is in a disabled state. This requirement may be waived for products using lithium-based batteries if the product is designed to protect the battery from damage when not charged for extended durations (i.e. up to one year). The design shall also ensure the product can still safely charge when payment is made, and the charging system is reconnected. The preventive measures shall address both the discharge to operate the product and the self-discharge of the battery and shall prevent the battery from being charged if it has been discharged to an unsafe voltage.

NOTE 2 Allowing a lithium cell to discharge below 0 % state of charge can cause the anode's copper foil to dissolve and redeposit, forming conductive bridges from the anode to the cathode. If the damaged cell is then recharged, these bridges can cause internal short circuits that can initiate thermal runaway leading to explosion. Recharging a lithium cell after it has discharged below 0 % can be unsafe.

5.6.3 Specific requirements for lithium-based batteries

5.6.3.1 Safety standards

All lithium batteries, including those in appliances, shall meet the requirements of a standard for safety during use. Test reports shall cover both the individual cell and the fully assembled battery pack. Test reports shall be prepared by a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory.

a) Batteries used in portable applications shall meet either IEC 62133-2, UL 62133, or the combination of UL 1642 and UL 2054. For this purpose, portable applications are defined as easily hand-carried devices (such as torches/flashlights, battery-powered radios, mobile phones and tablets). Any components that would be subject to the drop test as described in Figure 2 shall be considered portable applications.

b) Batteries that are not intended to be used in portable applications (i.e. used in stationary applications), but are used in a component with a mass 18 kg or less shall meet either:

   1) the requirements of a) or

   2) the requirements of both of the following:

      i) either the *United Nations Recommendations on the transport of dangerous goods: manual of tests and criteria* or IEC 62281, and

      ii) either IEC 62619 or UL 1973

c) Batteries used in a component with a mass greater than 18 kg shall meet the requirements of IEC 62619 or UL 1973.

The 18 kg mass threshold includes the battery and any housing or component in which it is integrated, but does not include external system components (e.g. a separate solar module included with the system).

NOTE 1 The 18 kg threshold is derived from the scope of IEC 61960-3:2017.

NOTE 2 The United Nations Recommendations on the transport of dangerous goods: manual of tests and criteria is often referenced as UN 38.3.

5.6.3.2 Overvoltage protection for individual cells

All lithium batteries, including those in appliances, shall have overvoltage protection for individual cells or cell blocks (see 3.5). This protection may be part of the battery pack or the component in which the battery is installed. The overvoltage protection limit for an individual cell shall be as specified by the battery manufacturer. In the absence of manufacturer-specified values, the overcharge protection voltage in Table 7 may be used.

NOTE 1 The product of the individual-cell overvoltage protection limit (specified by the battery manufacturer) and the number of cells or cell blocks in series can be greater than the maximum charging voltage for the battery pack. For example, for a four-cell battery pack, the maximum charging voltage could be 14,2 V (3,55 V per cell) and the overvoltage protection voltage could be 3,8 V. (These values are presented as an example and are not intended as a recommendation.)

The requirement for individual-cell overvoltage protection may be assessed through manufacturer declaration. To the degree possible, the results of the visual screening should be used to verify that the appearance of the battery pack and circuitry is generally consistent with the declaration.

NOTE 2 There is no test procedure to evaluate individual-cell overvoltage protection in IEC TS 62257-9-5:2018.

EXAMPLE 1 The following case would suggest that the battery pack and circuitry are not consistent with the declaration, so it is possible the battery does not meet the requirements of this clause: Consider a product with a lithium-ion battery having four cells in series. If the manufacturer's declaration states that individual cell protection is provided on the main unit PCB, but there are only two wires connecting the PCB and battery, then individual cell protection cannot be on the PCB as described. It could be internal to the battery pack or absent entirely.

EXAMPLE 2 In this case, the battery pack and circuitry are not consistent with the declaration, and the battery cannot meet the requirements of this clause: Consider the same product as example 1, but the manufacturer states that the individual cell protection is internal to the battery pack. However, the test report states that the battery pack does not contain an internal PCB. In this case, there cannot be individual cell protection, and the product is not as described.

5.6.4 Battery durability

5.6.4.1 Requirements

The following batteries shall meet the battery durability requirement:

- Batteries in main units (3.9.5);
- Batteries that supply power to lighting appliances other than accessory lights as defined in 4.5.2.

For these batteries, the average capacity loss shall not exceed 25 %. If the sample size is at least four, no more than one sample shall have a capacity loss greater than 35 %, following the battery durability storage test as defined in IEC TS 62257-9-5. If the sample size is less than four, no sample shall have a capacity loss exceeding 35 %.

NOTE In IEC TS 62257-9-5:2018 battery durability is evaluated according to Annex BB.

5.6.4.2 Exceptions

The following batteries need not meet the requirements of 5.6.4.1:

- Flooded lead acid batteries that are shipped dry.
- Lithium iron phosphate batteries that have been tested according to and meet the requirements of the type tests specified in IEC 61427-1, provided that the testing is conducted at a laboratory that has demonstrated competence, metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025 by an ILAC MRA signatory.

NOTE In IEC 61427-1:2013, the type tests are listed in 9.1.

5.7 Quality and durability

5.7.1 General

All applicable quality and durability requirements are extended to PAYG components, such as remote-entry keypads, integrated circuits, and any other hardware systems that are included with the product.

All applicable quality and durability requirements are extended to appliances included with the product. As noted in 4.2, some quality and durability requirements may be waived for non-lighting appliances that can be proven to meet other relevant standards.

5.7.2 Physical and water ingress protection

5.7.2.1 Testing and sampling requirements

IP Codes may be estimated according to IEC TS 62257-9-5. All testing to meet the requirements of 5.7.2 shall be performed on samples that have been obtained according to the sampling requirements of IEC TS 62257-9-5.

NOTE IEC 60529 does not have a random sampling requirement. Therefore, this requirement generally cannot be satisfied by a manufacturer-provided IEC 60529 test report.

5.7.2.2 Physical ingress protection

All components that contain electronics or electrical connections shall meet the requirements in Table 8.

Table 8 – Physical ingress protection requirements

Component category as defined in 3.7	Required physical ingress protection level
Fixed outdoor	IP5X
All PV Modules	Either IP3X, or IP2x plus technical protection
Others	IP2X

5.7.2.3 Water protection

5.7.2.3.1 Water protection requirements

All components that contain electronics or electrical connections shall meet the requirements in Table 9.

As shown in Table 9, the component category will place the product or component into one of five protection levels: no protection, occasional rain, frequent rain, permanent rooftop installation for PV modules, or permanent outdoor exposure. There are three different water protection compliance pathways to meeting the required protection level for each component category:

- The most straightforward alternative is to meet the IP Code appropriate for the category.
- In a second alternative, the totality of the product's design and construction as it relates to protection from water is evaluated to determine if the technical protection level is equivalent to that of a product with the required level of water protection. The process of determining whether a component has adequate technical protection to meet a given protection category is described in IEC TS 62257-9-5.

  NOTE 1 In IEC TS 62257-9-5:2018 the process for determining the technical level of water protection is described in Annex V.

- In the third alternative, clear messages to the consumer about the degree of protection from water are presented in a water protection warning label as described in 5.7.2.3.2.

NOTE 2 Component categories are defined in 3.7. As specified in 3.7.3, the PV module cable of a portable separate component is at least 3 m in length.

Table 9 – Water protection requirements

Component category	Required water protection level
Fixed indoor [a]	No requirement
Portable separate	Occasional rain, which requires meeting one of: • IPX1, or • technical protection, or • a warning label
Portable integrated	Frequent rain, which requires meeting one of: • IPX3, or • IPX1 plus technical protection, or • IPX1 plus a warning label, or • technical protection plus a warning label
Fixed outdoor	Permanent outdoor exposure, which requires meeting IPX5
PV modules	Permanent rooftop installation, which requires meeting one of: • modified IPX4 as defined in IEC 62257-9-5, or • IEC 61215 (all parts), or • technical protection

[a] Remote controls that do not include built-in lights or radios and are associated with fixed-indoor components need not meet water ingress requirements even if the remote control is portable.

5.7.2.3.2 Water protection warning label

5.7.2.3.2.1 General

If an option is chosen that requires a warning label, the warning label messages shall meet the following requirements.

The overall requirement is that the communication strategy shall be designed and implemented so that a typical user understands both the degree of protection from water for the product and what they should do to maintain the product in an instance of water exposure. This information can be included as a label or be printed on the packaging or in the user manual.

Further, contradictory information (e.g. that the product is resistant to water, is waterproof or can be used outdoors) shall not be included on the packaging or in any marketing materials of other media. This includes all written, graphical, internet, and spoken information.

The general design requirements are as follows:

a) The basic, unambiguous messages shall accurately describe:
   1) the degree of protection the product is afforded by its enclosure and other systems (e.g. "designed for indoor use" or "should not be exposed to rain"), and
   2) steps a consumer should take to drain or dry the product if it does get wet.
b) The labels or instructions shall have at least the same style and prominence as the other messages on the packaging or in the users' instructions. The following requirements shall be followed:
   1) The instructions or label shall be placed in at least one prominent location on the packaging, in the users' manual, or on other information inside the package, such as the warranty card.
   2) The instructions or label shall include both graphical and text elements.
   3) The text and graphic elements shall be simple and understandable.
   4) The instructions or label shall be in an appropriate language for the intended market. It is strongly recommended to include one label in English (or the "official" language of the country, e.g. French or Hindi in many areas) and another in a regionally common language (as appropriate).
   5) Use sufficient contrast between the text and graphics with the background so that the text and graphics are clearly legible.
   6) The label or instructions shall be sized such that:
      i) the text is at least 10 point font;
      ii) the graphic elements are clearly visible;
      iii) the size of the label is at least 10 cm^2;
      iv) the label is conspicuous and takes up at least 2,5 % of the area of the surface of the packaging where it appears.

5.7.2.3.2.2 Recommended consumer label placement

The label or instruction should be placed on the outside of the package in at least one prominent location. The bottom of the box or package is not prominent. This is not a requirement, but it is strongly suggested to appropriately inform consumers before the sale.

5.7.2.3.2.3 Example label

An example label is shown in Figure 1; each manufacturer is encouraged to design their own label or instruction but it is permitted to use the one provided herein.

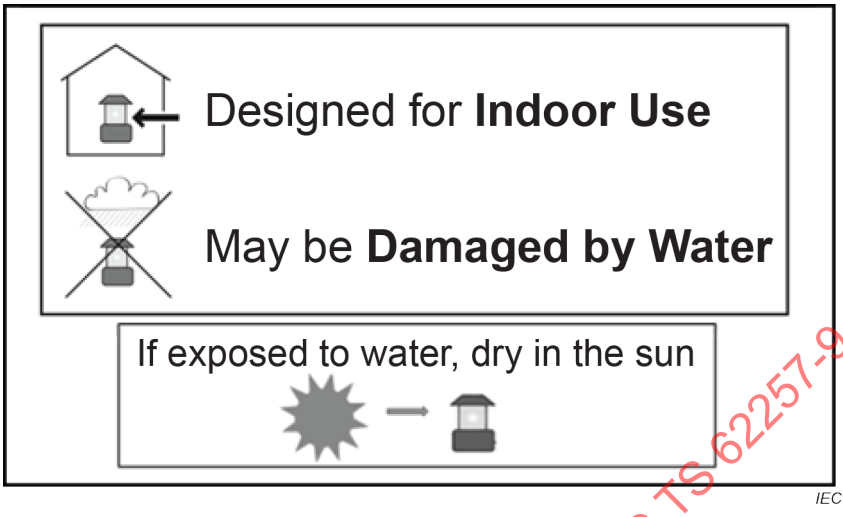
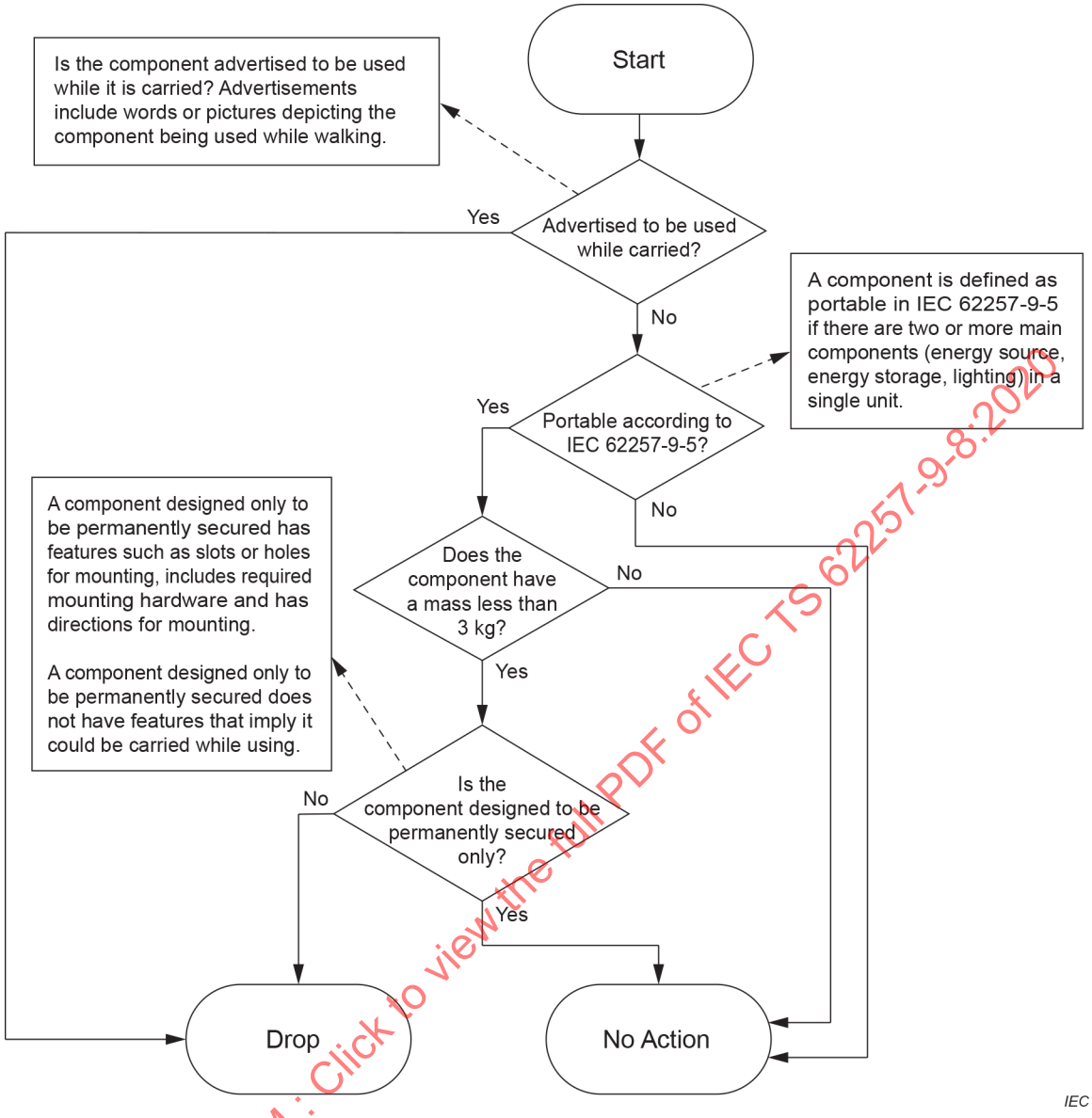


Figure 1 – Example water protection warning label or instruction

5.7.3 Drop test requirements

All components advertised or designed to be used while carried shall pass the drop test described in IEC TS 62257-9-5. Other components shall be subject to the drop test in accordance with the decision rules described in Figure 2. Passing thresholds are described below. Fixed-indoor components that are designed to be permanently secured are not subject to the drop test.



Handles on components that are not considered "portable" according to IEC 62257-9-5 or on components with a mass of 3 kg or more are assumed to be included to allow ease of installation or relocation of the component only. If these components are not advertised to be used while carried, they need not undergo the drop test.

Figure 2 – Decision process to determine whether or not a component is subject to the drop test

At least five out of six samples of lighting components (other than accessory lights as defined in 4.5.2) shall be functional after the drop test. If fewer than six samples are tested, all samples shall remain functional. Regardless of sample size, no dangerous failures are permitted. Dangerous failures are defined as those which can expose the user to physical harm, such as harmful chemicals, heat (e.g. from an electrical short or fire), or sharp materials (e.g. broken glass).

For the purpose of the drop test, lighting components are defined as lighting appliances, components containing a built-in lighting appliance, and power control units used to power a lighting appliance.

Sample sizes required for the drop test are defined in IEC TS 62257-9-5 and are based on the type of test and type of component.

For non-lighting appliances (including accessory lights as defined in 4.5.2) and power control units that do not supply power to lighting appliances, the modified drop test requiring only two drops per sample shall be used as described in IEC TS 62257-9-5. For tests with a sample size of four to six, all but one sample shall be functional after the test. For sample sizes less than four, all tested samples shall be functional. Regardless of sample size, no dangerous failures are permitted.

NOTE 1 Non-lighting appliances include components such as battery-powered radios, fans, razors and accessory lights.

NOTE 2 In IEC TS 62257-9-5:2018 the drop test is defined in Annex W and the specific requirements for the modified drop test for portable non-lighting appliances are described in W.4.1.5 a) 2).

NOTE 3 Although power control units are included in these requirements, power control units without built-in appliances that are not advertised to be used while carried typically will not be tested as the decision process in Figure 2 will typically result in "no action" for these components.

5.7.4 Soldering and electronics quality

The system and any included appliances shall be rated "good" or "fair" for workmanship quality as defined in IEC TS 62257-9-5. No more than one sample shall fail to function when initially evaluated.

NOTE In IEC TS 62257-9-5:2018 the workmanship quality assessment is defined in F.4.3.5.

5.7.5 Switch, gooseneck, connector, and moving parts durability

These tests are conducted according to IEC TS 62257-9-5. Mechanisms expected to be used regularly shall be functional after 1 000 cycles on all tested samples. Mechanisms expected to be used primarily during installation shall be functional after 100 cycles on all tested samples.

Most switches and connectors are considered to be intended for regular use. Mechanisms expected to be used primarily during installation are limited to only a few cases, such as:

- A safety disconnect switch or circuit breaker that is turned on after installation and only turned off for maintenance.
- Connectors dedicated to lighting appliances that are specifically designed and explicitly stated to be for permanent installation and are not intended to be relocated after installation.
- A moving part that will be fixed in place during installation so that it cannot be moved again.

5.7.6 Strain relief durability

All cables attached to any included component, e.g. PV module or light point, shall pass a strain relief test in accordance with IEC TS 62257-9-5.

5.7.7 Outdoor cable durability (size B products only)

For size B products, all included outdoor cables shall be outdoor-rated and UV resistant. Outdoor cables are defined as any cables intended to be used outdoors, such as the cable to the PV module or cables connecting components that are installed outdoors. Compliance is primarily determined based on manufacturer declarations and documentation provided by the manufacturer, though market check testing may be used to verify any claims.

As part of the testing process, manufacturers are required to sign a declaration form that includes the following statement: "All cables intended to be used outdoors, such as cables connecting the PV module, are appropriately protected against UV radiation and water ingress."

Manufacturers are also required to provide supporting documentation. Approved documentation includes one or more of the following:

a) Certifications indicating that the cable meets a recognized PV cable standard such as IEC 62930, EN 50618, UL 4703, UL 854, or an equivalent standard.

b) Certifications indicating that cables have been evaluated for outdoor use and are resistant to damage from sunlight and water exposure. For instance, the cable is UL listed, and the listing indicates that the cable is suitable for use outdoors. Other similar listings can also be appropriate.

c) Independent laboratory test results indicating that the cable jacket material is resistant to damage from sunlight and water exposure

   1) For sunlight resistance: UL 44:2018, 5.15.2; ISO 4892; the sunlight resistance test of UL 1581; the weather (sunlight) resistance test of UL 2556; HD 605/A1; or an equivalent test method.

   2) For water resistance: some form of wet/damp heat testing, such as that described in IEC 60068-2-78, UL 493, ISO 4892, or an equivalent test method.

d) Cable specification sheets confirming that the cable jacket material is appropriate for use outdoors, which includes being resistant to damage from both sunlight and water exposure. This documentation can include material specification sheets from the cable manufacturer, polymer masterbatch information, technical publications detailing polymer weather resistance, and/or technical specifications for polymer additives used to protect the material from outdoor exposure damage.

   The following are examples of acceptable cable jacket materials and additives:

   1) Thermoplastic materials

      i) PVC with ≥ 2,5 % by weight carbon black additive.

      ii) Polyethylene with ≥ 2,5 % by weight carbon black additive.

      iii) PVC or polyethylene with an approved UV-resistant polymer additive

      iv) PVC or polyethylene with independent laboratory test results indicating that the cable jacket material is resistant to damage from sunlight

   2) Thermoset (cross-linked) materials

      i) Styrene-butadiene rubber (SBR)

      ii) Silicone rubber

      iii) Ethylene propylene diene monomer (EPDM) rubber

   3) Thermoplastic elastomers (TPE), also called thermoplastic rubbers (TPR)

   4) Additives for polymers, such as octabenzone, formulated to protect the jacket material from damage due to sunlight exposure. These additives should be used according to the manufacturer's directions. These additives meet the requirement for sunlight exposure, but resistance to damage from water exposure shall be addressed using another measure.

NOTE 1 The cable jacket is the outermost layer of material of an insulated wire or multi-conductor cable. The jacket can be separate from individual wire insulations, or it can serve as both the insulation and the outer jacket. The jacket is exposed to sunlight and water when the cable is used outdoors.

NOTE 2 In IEC TS 62257-9-5:2018 the required manufacturer declaration is described in DD.3.3.3.

NOTE 3 Size B is defined in IEC TS 62257-9-5 and described in this document in 4.2.2.

5.7.8 PV overvoltage requirement

The product shall have sufficient protection from PV overvoltage as determined by the PV overvoltage protection test of IEC TS 62257-9-5. For ports with a nominal port voltage of 5 V, the allowable port voltage limit shall be no less than 6,0 V, notwithstanding any lower limit listed in IEC TS 62257-9-5. Allowable port voltage limits for 6 V and 12 V ports are as listed in IEC TS 62257-9-5. If the allowable port voltage limit for a port is not listed in IEC TS 62257-9-5, the allowable port voltage limit shall be 1,316 7 times the nominal voltage of the port (e.g. the limit for a 9 V port would be 11,85 V).

NOTE 1 In IEC TS 62257-9-5:2018 the PV overvoltage protection test is described DD.4.3. This test is used to verify that if the battery is disconnected or isolated, the system will not be damaged, the PV open-circuit voltage will not be present on load terminals, and the load terminals will maintain a voltage that is safe for their intended uses.

NOTE 2 The constant 1,316 7 is the ratio of maximum allowable voltage to nominal voltage defined in IEC TS 62257-9-5 for 6 V and 12 V ports.

The PV overvoltage protection requirement is not applicable to ports that are powered directly from a PV module (without a battery).

5.7.9 Miswiring protection requirement

The product should be designed to prevent improper connections. The product shall pass the miswiring protection test of IEC TS 62257-9-5. (If, during the miswiring test procedure, no possible incorrect connections are identified, the product is considered to pass the test.)

NOTE In IEC TS 62257-9-5:2018 the miswiring protection test is described DD.4.1. This test is used to ensure that the user interface is designed to prevent improper connections. The test also assesses cases in which improper or reversed connections can easily be made and ensures that they cause no damage to the system or harm to the user.

5.7.10 Requirements specific to systems with non-plug-and-play connections

All products other than plug-and-play products (3.12) shall meet the requirements of this subclause.

All electrical connections, other than permanently installed connections made at the time of installation, shall be made using plug-and-socket connectors without the use of tools. Permanently installed connections that are made at the time of installation may be made with screw terminals, spring or lever-actuated terminals, quick disconnect (blade) terminals, or similar methods, provided that the following requirements are met:

- The connection is straightforward to make, provides a good quality electrical connection, and does not require technical expertise to make, such as wrapping wire in a specific direction, soldering, or crimping in the field. For example, the following connections shall not be used:
  - Alligator (crocodile) clips;
  - Connections made in the field that require soldering or crimping;
  - Screw terminals or binding posts in which the wire is wrapped around the screw and held in place with the screw head or nut, rather than being clamped between two plates or washers. For instance, some binding posts have a hole to insert the wire; in others the wire needs to be wrapped around the post. The latter type requires slightly more care to make a good connection; those that require wrapping the wire are therefore not permitted.
  - Twist-on wire connectors (wire nuts) or wires twisted together.
- Adequate instructions are provided for making each type of connection, including:
  - A list of all required tools.
  - Sufficient instructions, including illustrations, to make each type of connection so that it will be safe and reliable.
- After installation, all terminals, other than connections on the charge controller, shall be insulated so that no live electrical parts can be contacted or shall be enclosed in a way that the component would meet IP2X (i.e. a 12,5 mm probe cannot enter the enclosure where the terminals are located). In the case of battery terminals, only one terminal is required to be insulated.
- Connectors on charge controllers need not be enclosed or insulated, but shall be designed in a way to minimize the potential for short-circuiting, such as with plastic dividers. Additionally, the leads from the battery to the charge controller shall have short circuit protection, which will be assessed by inspection. This protection shall be located as close to the battery as practical.

  Overcurrent protection for the PV module or array shall meet the requirements of IEC 60364-7-712:712.43 unless all of the following criteria are met:

  - The potential maximum current from all sources (the entire array) does not exceed the ampacity of the conductors.
  - The battery or load is incapable of back-feeding power to the array.
  - The array has no more than two identical modules (or series-connected strings of identical modules) wired in parallel.
- All terminals for loads are considered ports and are subject to the ports and protection tests and standards, which include overload protection (5.5.3) and PV overvoltage (5.7.8). The entire product is subject to the miswiring test and requirements (5.7.9).
- Adequate strain relief shall be provided for all screw terminal connections. The method for providing strain relief shall be clearly described in the installation instructions and, if any equipment or devices are required (other than commonly available tools such as flat or Phillips screwdrivers, pliers, wire cutters, or manual wire strippers), these shall be included with the kit. Easily disconnected terminals, like blade terminals, are only permissible if enclosed in a way that the consumer cannot easily access the terminals during normal use.
- A means is provided and described in the instructions to identify wires or cables in order to avoid incorrect connections (e.g. colour coding or labelling of wires).
- Any required tools other than commonly available tools (e.g. flat or Phillips screwdrivers, pliers, wire cutters, manual wire strippers) shall be included with the kit. Alternatively, for kits that are exclusively installed by the company's trained and authorized technicians, tools need not be included in the kit, but documentation shall be submitted confirming that the necessary tools are supplied to the installing technicians.
- All required materials (e.g. wire and terminals) are provided with the kit, supplied to the installing technician, or adequately specified to allow the installer to select the correct materials to make the connection. Note, for most kits, the required wire shall be included with the kit. For systems that are exclusively installed by the company's trained and authorized technicians, wire need not be included and sold with each kit. If wire is not included with the kit, the company shall provide a sufficient sample of the wire they provide to their installers for testing; the length of the sample may be specified by the test lab and shall be sufficient to perform all of the required tests. The wire shall be accompanied by a declaration stating that the sample is representative of the wire used in the field and that the wire is appropriately sized for the system. The declaration and user or installation manual shall also specify the wire type and maximum distance for all wires in the system. The testing laboratory shall test the product using the minimum distance of wire for the lumen maintenance test and the maximum distance of wire for all other tests in IEC TS 62257-9-5.
- All connectors or terminals shall be appropriate for the wire type and size, number of wires, current, voltage, and installation location. If terminals are for indoor use only, this limitation shall be clearly indicated in the installation instructions. Connectors shall be used within their design limits. The company shall provide specifications for connectors from the connector manufacturer upon request.

NOTE In most cases, these connections are not considered to be "sensitive electronics," and therefore the physical and water ingress protection requirements in accordance with IEC TS 62257-9-5:2018 are as follows:

- For connectors in junction boxes on the back of PV modules: IP3x, or IP2x with technical protection
- For connectors permanently installed outdoors: IP55
- For connectors used indoors: no protection necessary (IP00)

5.8 Consumer information

5.8.1 Warranty requirements

All products shall carry a warranty that is accurately specified and consumer-facing. The following requirements shall be followed when presenting and offering the warranty:

- For size A products:
  - The minimum warranty period from the time of purchase by the end user shall be at least one year.

  - The warranty shall cover the entire product, including the battery.
- For size B products:
  - The minimum warranty period from the time of purchase by the end-user shall be at least two years for the main system, including the PV module, control box, cables and lights and the system battery. Batteries included within appliances shall have a warranty period of at least one year. The battery warranty is assumed to include a capacity retention figure of at least 80 % at two years, benchmarked to the advertised battery capacity.
  - All lighting appliances that include their own batteries (including pico-power lights) and all non-lighting appliances, USB charging adaptors and similar accessories shall have a warranty period of at least one year.
- For all products:
  - The warranty shall cover, at a minimum, manufacturing defects that impede operation under normal use and early component failure.
  - The consumer-facing warranty information shall explain how the consumer can access the warranty (e.g. return the product to point of purchase/distributor/service centre, call or SMS a number, etc.) and how the warranty will be executed (e.g. repair, replacement, etc.), and should advise the customer to inquire about the warranty terms prior to purchase.
  - The consumer-facing warranty shall be available to the consumer in writing in a way that enables the end user to verify and understand the terms of the warranty prior to purchase. The written information should be in a regionally appropriate language. Consumer-facing warranties may be included on the product box or on a user agreement or warranty card that is easily accessed prior to purchase.
  - The presentation of the warranty information shall meet the design requirements in 5.2.3.2.

Note that this is a minimum requirement, and manufacturers and distribution partners are encouraged to exceed the basic protection offered in these terms to differentiate their products in the market.

NOTE Size A and size B are defined in IEC TS 62257-9-5 and described in this document in 4.2.2.

5.8.2 Date of manufacture

All products shall be labelled with the date of manufacture; alternatively, a serial number assuring traceability of date of manufacture may be provided (i.e. the date need not be discernible to consumers, only to those who are able to interpret the code). The date of manufacture shall be reported with a precision of at least the month and year. If components are packaged separately, each component shall carry these component-specific markings. The label may be on the product or the packaging.

5.8.3 User manual requirements (size B products only)

For size B products a user manual shall be included with the product. The user manual shall present instructions for installation, use, and troubleshooting of the system. Installation instructions shall include appropriate placement and installation of the PV module. Basic electrical safety and system maintenance shall also be covered. Installation and operation instructions should be presented using language and graphics that can be understood by the typical consumer.

At a minimum, the operation manual shall contain graphical and/or written guidance on the following:

- Connecting the PV module to the unit for charging.
- Instructing the user not to shade the PV module.
- Facing the PV module surface toward sun.

- Making all required permanent connections.
- Connecting all advertised appliances.
- Interpreting the battery state-of-charge indicator or other instructions related to determining and understanding the battery state-of-charge.
- If any pre-use steps are necessary for the product to properly function (e.g. fully charge battery before initial use, insert supplied fuse, how to operate the PAYG system), these shall be clearly described.

If the business model of a company is to exclusively install products using trained and authorized technicians, then the product need not have consumer-facing installation instructions. In this case, the manufacturer shall provide the training manual or instructions given to the technicians, which shall contain the elements listed in this subclause. The product shall still include a user manual covering basic operation instructions for the consumer.

NOTE Size B products are defined in IEC TS 62257-9-5 and described in this document in 4.2.2.

5.8.4 Component replacement methods (size B products only)

Size B products shall include information regarding component replacement that meets at least one of the following three options:

a) State that components can be replaced and provide any specifications necessary for a PV module, battery, light, or fuse to function with the system (in addition to the required information outlined in 5.2.3.1 c)). The purpose of this option is to enable a user or technician to be able to reasonably find a replacement if a key component of the system fails, OR

b) Provide directions as to how the consumer can get components, including the battery, replaced at service centres, OR

c) Include a clear consumer-facing statement that the batteries and other components are not replaceable.

If the component replacement requirement is met by including a consumer-facing statement, the statement shall meet the design requirements described in 5.2.3.2.

Detailed instructions or descriptions regarding replacing components may be included on packaging, in the user manual or user agreement.

Regardless of which option is used to meet the component replacement requirement, as required in 5.2.3.1 e), all size B products shall display a clear consumer-facing statement regarding the battery replacement that meets the design requirements described in 5.2.3.2. Acceptable phrases are:

- Battery is field replaceable
- Battery may be serviced by manufacturer
- Battery is not replaceable

Similar phrases may be accepted at the discretion of the market development programme, government, or other entity using this document.

NOTE Size B products are defined in IEC TS 62257-9-5 and described in this document in 4.2.2.

Annex A
(normative)

Testing of similar products

A.1 General

The following provides additional direction when determining which aspects should be assessed when testing two products that are similar, but not the same, as described in 4.2.6. This guidance is not comprehensive, but covers topics that are not intuitive or clearly described in IEC TS 62257-9-5. Note that the individual test procedures often include additional prerequisites that are not specified here and are to be observed; this list does not supersede the test prerequisites defined in IEC TS 62257-9-5.

Throughout Annex A, "product A" refers to the fully tested product and "product B" refers to the variant product. Product B shall not reference results from a product that is found to no longer meet the requirements of Clause 5 through market check testing or renewal testing, as described in 4.3. Similarly, product B shall not reference results from a product that has not completed testing (either QTM (4.2.2), AVM (4.2.3), or renewal testing (4.3)) in the last two years.

A.2 Guidelines

A.2.1 Visual screening

All products shall undergo the visual screening described in IEC TS 62257-9-5.

A.2.2 Lumen maintenance and light output

The following provisions apply to the lumen maintenance and light output aspects:

a) If product B uses the same LED but fewer units of that LED, and the current through each LED is not more than in the previously tested product A, the lumen maintenance of product B need not be tested.

b) If product B uses the same LED but with a lower drive current than in the previously tested product A, the lumen maintenance of product B need not be tested.

c) If the LED(s) used in product B has a different CCT or CRI, but has the same LED product number as that of the previously tested product A, the lumen maintenance of product B need not be tested. To qualify for this provision, the LED(s) in product B shall be from the same LED manufacturer, the same LED series/family, and the same LED package type. The LED(s) in product B shall also be from an equal or higher luminous flux bin/group/rank as the LED(s) in product A.

d) If the LED package uses more LEDs or a higher drive current than in the previously tested product A, or the LEDs have a different product number or manufacturer than in product A, the lumen maintenance of product B shall be tested.

   Exceptions may be made in cases where a company is switching LED manufacturers for a range of products. In these instances, if the new LEDs are "equivalent" to the old LEDs, it can be appropriate to only fully test the lighting characteristics (lumen maintenance and light output) for a selection of the new products. Equivalence is determined by comparing the physical dimensions, thermal resistance (junction to solder pad), forward voltage, maximum power rating, maximum current rating, luminous flux rating, CRI rating, and CCT rating of the old and new LEDs. When choosing which products to test, preference should be given to products likely to have the worst-case thermal characteristics and at least one of each new LED model should be tested. The LED power or current (per LED), dimensions of the LED array, dimensions of the enclosure, and prior LED case temperature measurements may be used to determine the worst-case thermal situation. If the new LEDs are not "equivalent" for certain aspects or testing of the selected products indicates a

significant difference in performance, further testing shall be performed to assess all impacted products.

e) Light output shall be tested if the light output is expected to be less than the previously tested product or if the advertised light output of the new product is more than what was advertised for the previously tested product.

f) If the same lighting appliance is included in both products A and B, the light output, lumen maintenance, CCT, CRI, and light distribution need not be tested for product B if the drive current and voltage are the same for both products. The voltage to consider is the typical battery discharge voltage for built-in appliances and the appliance operating voltage for removable appliances as defined in IEC TS 62257-9-5.

A.2.3 Charge controller testing

If any change is made that could impact the full-battery run time of a product, the charge controller behaviour test shall be performed for product B, even if the battery and charge controller are the same for both products A and B. However, the standby loss measurement need not be repeated unless the changes could affect the standby loss.

A.2.4 PV modules

If the PV modules included with products A and B are produced by different manufacturers, the photovoltaic module I-V characteristics test and the solar charge test shall be performed for product B unless the specifications and performance (including the IV curves) of the two modules can be proven to be nearly identical. All PV modules shall undergo the visual screening and safety testing as required in 5.5.5 and 5.5.6.

A.2.5 Battery durability testing

In the case of lithium-based batteries, if the batteries in products A and B are the same cell type (including the same battery manufacturer, same chemistry, same size, and same capacity), but a different number of cells or configuration (i.e. 2 cells in parallel or series in one product and one cell in the other product), the battery durability test need not be performed for the battery in product B.

A.2.6 Connector durability testing

If product B includes an additional cable that uses the same connector and receptacle as those tested on product A, the mechanical durability – connector test need not be repeated for product B, though the new cable shall be tested for functionality.

A.2.7 Battery testing, full-battery run time, solar run time, and energy service calculations

If the batteries are the same in product A and B, the battery samples that underwent prior battery capacity testing may be used for the full-battery run time test of product B. If these samples are unavailable or the batteries are different, new battery samples will need to be cycled according to the battery capacity test and undergo the full-battery run time test.

NOTE In IEC TS 62257-9-5:2018, the full-battery run time and solar charge tests require cycling of the batteries per the battery capacity test under certain circumstances. According to IEC TS 62257-9-5:2018, any change that could affect the full-battery run time of a product will require retesting the full-battery run time using batteries that have already been cycled during the battery capacity test.

This requirement could be changed in a future version of IEC TS 62257-9-5. If this change is made, it could be possible, for some battery types, to perform the full-battery run time test without repeating the battery capacity test.

If any change is made that could impact the solar run time, but not the full-battery run time (such as a change to the PV module), the solar charge test shall be repeated. In some cases retesting of the battery capacity is required, depending on the battery chemistry:

a) For lithium-based and NiMH batteries, the full-battery run time test and battery capacity test need not be performed for product B. If the originally tested battery samples that underwent battery capacity and full-battery run time testing for product A are available and in good condition, these should be used for the new solar charge test for product B; however, if necessary, new samples may be used for the solar charge test for product B, while results are referenced from prior tests of product A for the battery capacity and full-battery run time aspects of product B.

b) For lead-acid batteries, samples shall be cycled according to the battery capacity test procedure prior to the solar charge test of product B.

If the batteries in products A and B are produced by different battery manufacturers, but are otherwise the same (have the same rated battery capacity, battery chemistry, and voltage) the battery capacity test shall be conducted. If the measured capacity of the battery in product B is at least 90 % of the capacity of the previously tested battery, the full-battery run time test need not be conducted for product B.

Any changes to the inputs to the energy service calculations (e.g. full-battery run time, solar run time, port performance, charging efficiencies, or power consumption that could result in changes to the performance metrics of more than 15 % shall require use of the energy service calculations to recalculate the product performance in terms of run time and daily energy availability (in Wh/day).

A.2.8 Miswiring protection

The miswiring test shall be conducted if any changes have been made to the ports, connectors, system voltage, or voltage regulation of the ports, unless product B has no possible incorrect connections.

A.2.9 Output overload

The output overload test shall be conducted if any changes have been made to the ports, system voltage, or voltage regulation of the ports.

A.2.10 PV overvoltage

The PV overvoltage test shall be conducted if any changes have been made to the PV module voltage, ports, system voltage, or voltage regulation of the ports.

A.2.11 Assessment of DC ports

The assessment of DC ports shall be conducted if any changes have been made to the system voltage or voltage regulation of the ports. Physical changes to the ports can also trigger retesting depending on the change.

A.2.12 Power consumption and charging efficiency

In cases where a previously tested removable appliance is included with a different power control unit, if the ports of the power control unit do not require retesting, the power consumption and charging efficiency of the appliance need not be retested.

A.2.13 Voltage range

In cases where a previously tested removable appliance is included with a different power control unit, if the ports of the power control unit do not require retesting, the appliance voltage compatibility or appliance operating voltage range need not be retested for that appliance.

If an appliance has undergone the operating voltage range test with a different main unit, but the ports are not the same, the previous results may be used if the minimum and maximum voltages for the new product are fully included in the corresponding voltage ranges from the previous testing (i.e. the new minimum voltage in each step is less than or equal to the minimum voltage from previous testing and the new maximum voltage in each step is greater than or equal to the maximum voltage from previous testing).

A.2.14 Changes to firmware or software

On occasion, companies make changes to a product's performance by changing the firmware or software without making any hardware changes. In these cases, a clear declaration from the manufacturer should provide details of the process, the firmware/software version, and details of the expected impact on the product's performance. If performance changes are expected, A.2.2 through A.2.13 shall be used to determine what retesting, if any, is required.