

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**

IECNORM.COM : Click to view the full PDF of IEC TS 62257-9-8:2025



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2025 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IECNORM.COM : Click to view the full PDF IEC 60251-9-8:2025

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 978-2-8327-0057-0

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

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	9
3 Terms and definitions	10
3.1 Terms related to photometric tests	11
3.7 Component categories	12
3.8 Electrical quantities.....	13
3.9 Component categories and types, and related terms	14
3.10 Types of connections and connecting devices.....	15
4 Test requirements.....	17
4.1 General.....	17
4.1.1 Overview	17
4.1.2 Product sizes.....	18
4.2 Initial testing requirements	20
4.2.1 General	20
4.2.2 Quality test method.....	20
4.2.3 Accelerated verification method	20
4.2.4 Pay-as-you-go targeted testing	21
4.2.5 Product families.....	22
4.2.6 Similar products.....	22
4.2.7 Verification of product identity	23
4.2.8 Reference to other standards.....	24
4.3 Recurring testing requirements	25
4.4 Retesting of non-conforming products	26
4.5 General testing requirements applicable to all testing pathways.....	26
4.5.1 General	26
4.5.2 Exception for accessory lights	26
4.5.3 Accessories with batteries	27
5 Quality requirements	27
5.1 General.....	27
5.2 Truth in advertising	29
5.2.1 General	29
5.2.2 Assessment of run time values	30
5.2.3 Information and performance reporting requirements	32
5.2.4 Fee-for service or pay-as-you-go (PAYG) metering requirements	36
5.2.5 Included appliances requirements.....	36
5.2.6 Assessment of ingress protection advertisements.....	37
5.2.7 Evaluation of advertised charging time	37
5.3 Ports requirements.....	38
5.3.1 General	38
5.3.2 Voltage converters.....	39
5.3.3 Ports with multiple output voltages	39
5.3.4 Appliance voltage compatibility requirements.....	39
5.3.5 Truth-in-advertising requirements	40
5.3.6 Functionality requirements.....	41

5.4	Lumen maintenance.....	45
5.5	Health and safety.....	45
5.5.1	AC-DC power supply safety	45
5.5.2	Hazardous substances	46
5.5.3	Overload protection	46
5.5.4	Wiring and connector safety	46
5.5.5	Additional tests for PV modules	47
5.5.6	Requirements for systems with large PV modules or arrays	48
5.6	Battery requirements.....	49
5.6.1	Provision of battery specification sheets	49
5.6.2	Battery charge control	49
5.6.3	Specific requirements for lithium-based batteries.....	51
5.6.4	Battery durability	53
5.6.5	Authentication of battery documents	53
5.7	Quality and durability	54
5.7.1	General	54
5.7.2	Physical and water ingress protection.....	54
5.7.3	Drop test requirements	57
5.7.4	Soldering and electronics quality	58
5.7.5	Switch, gooseneck, connector, and moving parts durability.....	58
5.7.6	Strain relief durability.....	59
5.7.7	Outdoor cable durability (size B products only)	59
5.7.8	PV overvoltage requirement.....	60
5.7.9	Miswiring protection requirement	61
5.7.10	Requirements specific to systems with non-plug-and-play connections	61
5.8	Consumer information.....	63
5.8.1	Warranty requirements.....	63
5.8.2	Date of manufacture.....	64
5.8.3	User manual requirements (size B products only)	65
5.8.4	Component replacement methods (size B products only).....	65
5.8.5	Port information requirements.....	66
Annex A (normative)	Testing of similar products	69
A.1	General.....	69
A.2	Guidelines	69
A.2.1	Visual screening	69
A.2.2	Lumen maintenance and light output	69
A.2.3	Charge controller testing.....	70
A.2.4	PV modules	70
A.2.5	Battery durability testing	70
A.2.6	Connector durability testing	70
A.2.7	Battery testing, full-battery run time, solar run time, and energy service calculations	71
A.2.8	Miswiring protection.....	71
A.2.9	Output overload	71
A.2.10	PV overvoltage	71
A.2.11	Assessment of DC ports	71
A.2.12	Power consumption and charging efficiency.....	72
A.2.13	Voltage range	72
A.2.14	Changes to firmware or software	72

Annex B (informative) List of documentation to solicit	73
B.1 General.....	73
B.2 Documentation to request	73
Bibliography.....	75
Figure 1 – Example water protection warning label or instruction	56
Figure 2 – Decision process to determine whether or not a component is subject to the drop test	57
Figure 3 – Example labelling for a product with four ports having a combined current limit of 3,5 A and a separate port having a current limit of 8 A. The five ports together can supply a total of 11,5 A.....	67
Figure 4 – Example labelling for a product with five ports having a combined current limit of 8 A and a subset of four ports having a combined current limit of 3,5 A	67
Table 1 – Summary of test requirements and alternatives – Initial testing requirements to determine compliance with Clause 5	18
Table 2 – Summary of test requirements – recurring testing requirements to ensure continued compliance with Clause 5	18
Table 3 – Summary of quality requirements	28
Table 4 – Renewal requirements and acceptable alternative test procedures for PV tests	47
Table 5 – Default battery deep discharge protection voltage specifications	50
Table 6 – Default battery overcharge protection voltage specifications.....	50
Table 7 – Summary of battery safety testing requirements of 5.6.3.1 through 5.6.3.2	52
Table 8 – Physical ingress protection requirements	54
Table 9 – Water protection requirements	55

IECNORM.COM : Click to view the full PDF of IEC TS 62257-9-8:2025

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RENEWABLE ENERGY OFF-GRID SYSTEMS –

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

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

This second edition cancels and replaces the first edition issued in 2020. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Removed the PV module wiring inspection, partial shading test, and visual screening and durability tests for photovoltaic modules. Applicable tests are now referenced from IEC TS 62257-9-5.
- b) Increased the interval for recurring testing from two years to three years.

- c) Tightened the truth-in-advertising tolerance for numerical aspects other than luminous flux from 15 % to 10 %.
- d) Revised consumer information requirements to allow more flexibility and remove requirements for information that is not known to be valuable to consumers.
- e) Simplified and reorganized the requirements for 12 V and 5 V ports, and allow non-standard output voltages if clearly marked.
- f) Added requirements for ports with USB fast charging support.
- g) Revised the requirements for non-plug-and-play products to allow connectors that require special tools or training in products installed by trained technicians.
- h) Clarified cell- and pack-level safety requirements for single-cell lithium batteries.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
82/2292/DTS	82/2321/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62257 series, published under the general title *Renewable energy off-grid systems*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

The IEC 62257 series 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.

This series provides 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.

This series is 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 series 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 10,5 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 companies, distributors, and other stakeholders to describe these products. Many of these systems meet the definition of type T₂I (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;
- Companies 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 OFF-GRID SYSTEMS –

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 the IEC 62257 series 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 products 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 and installed as a kit, included as a part of a 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, and systems that include PV modules (or combinations of PV modules) with open-circuit voltage greater than 35 V that meet 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 IEC 62109-1. 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 or 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.

This document includes provisions related to safety; however, it is not intended to be a comprehensive safety standard. In particular, this document is not intended to be used as an alternative to safety standards such as IEC 62368-1 or the IEC 60335 series for appliances such as radios and televisions that are included with stand-alone renewable energy products. Nor is it intended to replace the safety requirements of IEC 62281 or UN 38.3 for battery safety during transport, or safety requirements of IEC 61730-1 and IEC 61730-2 for PV modules intended for use outside the context of stand-alone renewable energy products.

This document does not address electromagnetic compatibility (EMC). Field experience has not shown EMC to be a major concern in typical applications of stand-alone renewable energy products within the scope of this document. In applications where EMC is a concern (e.g. systems that include medical devices), the standards relevant to the specific application should be referenced.

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 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60335-2-29, *Household and similar electrical appliances – Safety – Part 2-29: Particular requirements for battery chargers*

IEC 60364-7-712:2017, *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 60598-1, *Luminaires – Part 1: General requirements and tests*

IEC 61215-1, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

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

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, *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 cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

IEC TS 62257-9-5:2024, *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: Laboratory evaluation of lamps and lighting appliances for off-grid electricity systems*

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

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

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 62790, *Junction boxes for photovoltaic modules – Safety requirements and tests*

IEC TS 63163, *Terrestrial photovoltaic (PV) modules for consumer products – Design qualification and type approval*

ISO 4892 (all parts), *Plastics – Methods of exposure to laboratory light sources*

ANSI/CAN/UL 9540, *Energy Storage Systems and Equipment*

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

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

UL 62133-2, *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, Section 38.3: Lithium batteries (UN 38.3)*

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_v

density of incident luminous flux with respect to area at a point on a real or imaginary surface

$$E_v = \frac{d\Phi_v}{dA}$$

where Φ_v is luminous flux and A is the area on which the luminous flux is incident

Note 1 to entry: The illuminance is expressed in lux ($\text{lx} = \text{lm} \cdot \text{m}^{-2}$).

[SOURCE: IEC 60050-845:2020, 845-21-060, modified – Notes 1, 2, and 4 have been omitted.]

3.1.2

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

LED

light emitting diode

solid state device embodying a p-n junction, emitting incoherent optical radiation when excited by an electric current

[SOURCE: IEC 60050-845:2020, 845-27-050, modified – The notes have been omitted.]

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 in a battery connected together in parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device (PTC)) and monitoring circuitry

Note 1 to entry: The cell block 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 62619:2022, 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 60529:1989, 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 62257-9-5:2024, 3.18]

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 62257-9-5:2024, 3.19]

3.7.3

separate

without PV module or with a PV 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 PV module to collect energy outdoors while the other product components remain indoors.

[SOURCE: IEC TS 62257-9-5:2024, 3.20, modified – the 3 m length specification has been incorporated into the definition.]

3.7.4

integrated

with a PV module incorporated into another component or connected to another component (other than a fixed outdoor component) via a cable with a length less than 3 m

Note 1 to entry: The length of the cable is insufficient for the PV module to collect energy outdoors while the other product components remain indoors.

[SOURCE: IEC TS 62257-9-5:2024, 3.21, modified – the 3 m length specification has been incorporated into the definition.]

3.7.5 component

<of a product> constituent part of a product which cannot be physically divided into smaller parts as part of normal installation and use

Note 1 to entry: Examples of components include main units, power control units, appliances, PV modules, external batteries, and cables.

[SOURCE: IEC 60050-151:2001, 151-11-21, modified – "device" has been replaced with "product" and "without losing its particular function" with "as part of normal installation and use," and the note has been added.]

3.8 Electrical quantities

3.8.1 capacity

<for batteries or battery cells> electric charge which a battery or battery cell 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 60050-482:2020, 482-03-14]

3.8.2 standby loss

current drawn from a product's battery with the product switched off

[SOURCE: IEC TS 62257-9-5:2024, 3.25]

3.8.3 standard operating voltage

standardized voltage corresponding to a typical battery operating point during discharge

[SOURCE: IEC TS 62257-9-5:2024, 3.31]

3.8.4 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 62257-9-5:2024, 3.32]

3.8.5 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 62257-9-5:2024, 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 62257-9-5:2024, 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 62257-9-5:2024, 3.26]

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 62257-9-5:2024, 3.27]

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 62257-9-5:2024, 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 62257-9-5:2024, 3.30]

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 62257-9-5:2024, 3.28]

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.

3.9.9

foldable module

PV module that is separated into distinct PV sections nominally of the same size and connected by a section that can be folded and does not contain cells, but has the interconnecting busbars

[SOURCE: IEC TS 63163:2021, 3.2, modified – the phrase "that can be folded" has been added.]

3.10 Types of connections and connecting devices

The terms listed in 3.10 are mainly applicable to non-plug-and-play products.

3.10.1

flat quick-connect termination

electrical connection consisting of a male tab and a female connector which can be inserted and withdrawn with or without the use of a tool

Note 1 to entry: Flat quick-connect terminations are sometimes called "blade terminals"

[SOURCE: IEC 60050-442:1998, 442-06-07, modified – the note has been added.]

3.10.2

clamping unit

part(s) of the terminal necessary for the mechanical clamping and the electrical connection of the conductor(s), including the parts which are necessary to ensure the correct contact pressure

[SOURCE: IEC 60050-442:1998, 442-06-12]

3.10.3

screwless-type terminal

terminal for the connection and subsequent disconnection of two or more conductors, the connection being made directly or indirectly by means of springs, wedges, or the like

[SOURCE: IEC 60050-442:1998, 442-06-11]

3.10.4

screw-type terminal

a terminal for the connection of two or more conductors in which the connection is made, directly or indirectly, by means of screws or nuts of any kind

[SOURCE: IEC 60050-442:1998, 442-06-19, modified – the definitions of “screw-type clamping unit” (442-06-19) and “screw-type terminal” (442-06-18) have been combined, as the distinction is not required in this document.]

3.10.5

insulation piercing connecting device

IPCD

connecting device for the connection and disconnection of a conductor or the interconnection of two or more conductors, the connection being made by piercing, boring through, cutting through, removing or making ineffective in some other manner the insulation of the conductors without previous stripping

[SOURCE: IEC 60050-442:1998, 442-06-33]

3.10.6

twist-on connecting device

TOCD

connecting device which is twisted on the ends of two or more conductors

[SOURCE: IEC 60050-442:1998, 442-06-36]

3.11

quality test method

QTM

rigorous set of tests defined in IEC TS 62257-9-5 for off-grid renewable energy products 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.

3.12

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

3.13

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.

3.14

company

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

3.15

advertised value

value stated by the company 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.

[SOURCE: IEC TS 62257-9-5: —,3.37]

3.16

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.

3.17

advertised appliance

appliance not included as part of the product but mentioned in the accompanying advertising material, such as the product packaging or the company'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 62257-9-5:2024, 4.1.4, modified – the text has been reformulated as a terminological entry and the reference to IEC TS 62257-9-5 has been added.]

4 Test requirements

4.1 General

4.1.1 Overview

All testing specified in this document shall be conducted using the test methods provided in the most recent version of IEC TS 62257-9-5. 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.

Annex B contains a list of information and documentation that should be requested from the company to facilitate successful application of the provisions of this document.

**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.	2	Required: sampling from warehouse or retail
Accelerated verification method (AVM)	Alternate to QTM which enables products to achieve initial qualification more quickly. The company shall meet certain eligibility criteria to use this option.	Initial test: 2	Not required initially: companies 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 in accordance with the QTM or AVM.	2	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 in accordance with the QTM or AVM.	2	Required: sampling from warehouse or retail
Verification of product identity (VPI)	Used to minimize testing required for products which are purportedly identical to a product that has already been tested in accordance with 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 4.1.2.			

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 three years after initial qualification to verify continued compliance with Clause 5.	2 (if aspects have changed or product fails initial testing, additional testing 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, additional testing can be required)	Required: sampling from retail preferred, though warehouse sampling may be used
NOTE Sample sizes for each test are presented in IEC TS 62257-9-5.			

4.1.2 Product sizes

In this document, products with rated maximum PV power at STC less than 10,5 W are referred to as “size A,” while products with rated maximum PV power at STC greater than or equal to 10,5 W are referred to as “size B.”

If a product has multiple PV modules that can be connected electrically, then the product size is determined by the maximum rated power of the array formed by the connected modules. If a product has multiple PV modules, but they cannot be connected electrically, then the product size is determined by the PV module with the greatest maximum power at STC.

The size classification is determined by the rated performance of the PV module, not the actual performance. However, if the measured power of the PV module at STC when measured at the PV junction box differs from the 10,5 W threshold by more than the truth-in-advertising tolerance, the module may be required to be reclassified and required to meet the requirements of the other category. If the measured power of the PV module submitted as size B is less than 9,45 W, the module will be reclassified as size A and obligated to meet the requirements of size A products. If the measured power of the PV module submitted as a size A module exceeds the 10,5 W threshold, but the company chooses to maintain the size A rated value as the advertised value, the product will not be reclassified unless the rating appears to be intentionally misleading to influence the size classification.

EXAMPLE 1 A product includes a PV module rated 10 W, so is submitted as a size A product. However, upon testing, the PV module maximum power at STC is determined to be 12 W. This product may still be considered size A if the company does not increase the rated power of the PV module. If the company instead chooses to increase the rated power to more than 10,5 W, this product would be reclassified as a size B product and would need to meet the requirements for size B products. If the measured power of the module had been substantially higher than 10,5 W, the market development programme, government, or other organization using this document can choose to require the product to be reclassified.

EXAMPLE 2 A product is rated 11 W so is submitted for evaluation as a size B product. However, the maximum power at STC is 9,4 W. This product would need to change its advertised rating to be less than 10,5 W and would be reclassified as a size A product because its measured power is less than 9,45 W. The product would need to provide the performance reporting requirements for size A products and would no longer need to meet the requirements of size B products.

If a product does not have a PV module, its size is determined by the maximum power output of the power source (e.g. AC/DC power supply or electromechanical generator). If the product does not include a power source (e.g. it is powered directly from the utility grid or from an external DC power supply that is not included), the size is determined by the maximum power consumption of the product from the energy source.

EXAMPLE 3 A product contains two 10 W PV modules that are connected in parallel by plugging into them a combiner cable, which is then plugged into a socket on the main unit. This is a size B product because the total array power is 20 W.

EXAMPLE 4 A product contains two 10 W PV modules that are both plugged into separate sockets on a main unit to simultaneously provide power to a battery. Inside the main unit, the two connectors are connected in series or parallel. This is also a size B product; the two modules are electrically connected even though the connection is made inside the main unit.

EXAMPLE 5 A product contains two 10 W PV modules that are plugged into separate sockets on a main unit as in Example 2. However, the input from each PV module is internally connected to a separate maximum power point tracking circuit. This is still considered a size B product; the two modules function together as an array to charge a single battery even though they are not directly connected in series or parallel.

EXAMPLE 6 A product includes two lamps with batteries, each of which can be separately charged by a 6 W PV module. The PV modules cannot be connected together. This is a size A product because the maximum power of the largest module is 6 W.

EXAMPLE 7 The product described in Example 4 includes a combiner cable so that both PV modules can be used to charge a single lamp at a higher rate. This is now a size B product because the PV modules can now be connected, even if the user retains the option to use them separately.

EXAMPLE 8 A product includes a 10 W PV module that connects to a main unit. In addition, the product includes a battery-powered LED lamp with an integrated PV module of 1 W. This product is size A because the PV modules cannot be connected electrically.

EXAMPLE 9 The battery-powered lamp of Example 6 is now equipped with a micro-USB power input that allows it to be charged either from a USB port on the main unit or from its integrated PV module. This is still a size A product because the two PV modules are not intended to be used simultaneously as a single PV array.

EXAMPLE 10 A product includes an 8 W PV module that charges a main unit. In addition, the main unit has a second PV input socket. The user can separately purchase a second 8 W module to supply more energy to the system. This is a size A product because the second PV module is not included with the product.

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 in accordance with one or more of the following pathways. Test laboratories conducting initial testing in accordance with 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.

4.2.2 Quality test method

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

NOTE In IEC TS 62257-9-5:2024, the QTM is defined in Clause 6. The sampling procedures are specified in IEC TS 62257-9-5:2024, 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 as follows:

NOTE 1 The AVM is also described in IEC TS 62257-9-5:2024, Clause 10.

- 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 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 62257-9-5:2024, the MCM is defined in Clause 8. The aspects to be tested and samples sizes are presented in the PCT column of IEC TS 62257-9-5:2024, Table 3.

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 in accordance with 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 defined in 4.1.2) 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 renewal testing carried out in accordance with IEC TS 62257-9-5 (as described in 4.3) in the past three 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 in accordance with 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 company 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.

After testing, if the new standby loss measurement is greater than the old standby loss measurement, the energy service calculations of IEC TS 62257-9-5 shall be performed using the new standby loss measurement. All other inputs to the calculations shall be taken from the previously qualified product. This calculation may be performed either by the test laboratory or by the market development programme, government, or other entity using this document. All advertised run time and energy service parameters for the product under test shall meet the truth-in-advertising requirements of 5.2.1 based on the updated energy service calculations.

The targeted PAYG testing shall be conducted with two samples in accordance with IEC TS 62257-9-5. Samples for targeted PAYG testing may be submitted directly by a company (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 in accordance with the QTM or AVM and qualify in accordance with this document using one of the processes described in 4.2.2 and 4.2.3.

NOTE In IEC TS 62257-9-5:2024, the PAYG testing method is defined in Clause 11. The aspects to be tested and samples sizes are presented in the IEC TS 62257-9-5:2024, Table 8.

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 in accordance with the QTM or AVM and qualify in accordance with 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 or dimmest and largest or brightest models of each component shall be tested, at a minimum. These components shall be tested for all relevant component-level aspects in accordance with the QTM or AVM and qualify in accordance with 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 companies), 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, shall meet all of the requirements of Clause 5. Compliance with requirements that are not assessed during initial qualification may be assessed through market check testing as described in 4.3.

EXAMPLE A family comprises 5 different PV module models, 3 different 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 in accordance with the QTM or AVM. Additionally, at least the following components would need to be tested in accordance with the applicable component-level tests of the QTM or AVM:

- 3 PV module models (including the highest and lowest power modules)
- 2 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 in accordance with 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 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 in accordance with this document using one of the processes described in 4.2.2 and 4.2.3, those aspects of the product which differ from the original version shall 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 in accordance with the QTM or AVM using one of the processes described in 4.2.2 and 4.2.3. A product being tested in accordance with 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 three years.
- e) Renewal testing, as described in 4.3, should be conducted for variant products at the same time as renewal testing of the fully tested product, and shall in all cases begin within six months of the fully-tested product's renewal test report date.

4.2.7 Verification of product identity

Verification of product identity (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 in accordance with 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 2 samples are conducted on both 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 company 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 4.2.8 a) through 4.2.8 g). 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 in accordance with 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 61215-1 and IEC 61215-2 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). The PV module shall be tested in accordance with 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) If the PV cable included with the samples under test is of the type specified by the PV module manufacturer, the test of cord anchorage from IEC 62790 may be used instead of the mechanical durability – strain relief test from IEC TS 62257-9-5. An IEC 61730-1, UL 61730-1, or IEC 61215-2 test report or certificate may be accepted as evidence of compliance if it can be determined that the relevant test was conducted. Junction boxes with integrated connectors are exempt from the cord anchorage test of IEC 62790; modules having such junction boxes shall undergo the mechanical durability – strain relief test of IEC TS 62257-9-5.
- c) 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.
- d) For lighting appliances and components containing built-in lighting appliances, IEC 60598-1 may be referenced in lieu of the mechanical durability – strain relief test of IEC TS 62257-9-5.
- e) 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 62257-9-5:2024, 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 can be referenced in lieu of the power consumption test, appliance operating voltage range test, and physical ingress protection test.

The test laboratory requires 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, conduct the voltage range test for the appliance to ensure it is compatible and will not be damaged by the product. This determination can be conducted 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, or IEC 62368-1 certifications are provided, procure only one sample of the appliance 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, IEC 60335, or IEC 62368-1 and Global LEAP test results. The sample could be submitted directly by a company (or their proxy). If water protection requirements are to be met by testing rather than labelling, provide two additional randomly sampled units of the appliance.

- f) 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 results may be referenced 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 based on 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 may be omitted. 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 may be omitted.
 - 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.
- g) If a lithium iron phosphate battery has previously been tested in accordance with 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 three years after the date of completion of the QTM testing to confirm the product continues to meet the requirements in Clause 5. If the product's PV module has remained unchanged since QTM testing, renewal testing may be conducted as described in IEC TS 62257-9-5 with a sample size of two for all applicable tests.

If the product's PV module has changed since QTM testing, all applicable PV tests included in the QTM of IEC TS 62257-9-5 shall additionally be conducted. 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. Tests referenced in accordance with 4.2.8 shall follow any recurring testing requirements of the referenced test and are exempt from the recurring testing requirement imposed by this document.

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 in accordance with the QTM and completed testing on 31 January 2025, it would need to undergo a renewal test by 1 February 2028. If the report indicated that the product continued to comply with the requirements of Clause 5, the results would remain valid for another three years. Another renewal test could be completed before the end of January 2029 to further extend the results.

Furthermore, market check testing in accordance with 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 in accordance with 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 digital materials or 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 or electromechanical charging shall be evaluated in accordance with the energy service calculations described in IEC TS 62257-9-5.

NOTE In IEC TS 62257-9-5:2024, 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 62257-9-5:2024, 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 either solar or electromechanical charging, or both, shall be reported by the test laboratory, but may be omitted from the product packaging and 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 light distribution test of IEC TS 62257-9-5 is optional.

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 $12,0 \text{ lx} \pm 2,4 \text{ lx}$.

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 testing of light output aspects (luminous flux, CCT, and CRI) and lumen maintenance for these appliances may be omitted. 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, shall be subject to the requirements for lighting appliances.

4.5.3 Accessories with batteries

A component with battery may be omitted from the energy service calculations (and therefore does not require the FBRT and power consumption tests) if:

- a) The component is only used as an accessory, such as a remote control, keyboard, or mouse, for another component, and
- b) the battery capacity of the component, in terms of energy (Wh), is not more than 10 % of the battery capacity of the main unit from which it is charged.

The power consumption of accessories without batteries, such as mice and keyboards, is typically included in the power consumption of the component with which the accessory is used. In this case, the power consumption test can be omitted for these components. For example, if a computer includes a USB keyboard without batteries, the keyboard will be connected to the computer when the computer's power consumption is measured in accordance with IEC TS 62257-9-5, so there is no need to separately measure the power consumption of the keyboard.

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: company name, product name, light output, solar run time, a statement regarding device charging, and component specifications	5.2.3	Size A
	Performance reporting requirements: company name, product name, solar run time profile, 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 1 000 h is ≥ 95 % 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 safety and durability tests	5.5.5	All
	All PV modules with maximum power greater than 100 W at STC pass the hot spot endurance test of IEC 61730-2, UL 61730-2, or IEC 61215-2 or the partial shading test of IEC TS 62257-9-5	5.5.5.4	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 and no hazards or safety issues are present	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
	Port information requirements include providing the current and voltage ratings for each port, clearly labelling any ports not intended to supply power, and additional requirements for ports advertising USB fast charging	5.8.5	All

5.2 Truth in advertising

5.2.1 General

Specific requirements regarding the accuracy of advertised performance and functionality are provided in 5.2.2 through 5.2.7 and assessed in accordance with the test methods in IEC TS 62257-9-5.

In general, truth in advertising is determined by applying the following rules in order:

- It is always acceptable if actual performance is better than advertised;
- Statements regarding port performance are assessed in accordance with 5.3;
- Luminous flux (light output) shall deviate no more than 15 % from advertised values;
- All other numeric aspects from IEC TS 62257-9-5, such as run time, time to charge, and PV power, shall deviate no more than 10 % from advertised values;
- If a range is advertised, the entire range shall comply with the rules in 5.2.1 a) to 5.2.1 d).

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.

EXAMPLE 1 The calculated solar run time is 10,5 h and the advertised value is 12 h. The deviation from the advertised value is 12,5 % in the direction that is unfavourable to the user, so the requirement is not met. In this example, any calculated solar run time $\geq 10,8$ h is acceptable, even if it exceeds the advertised value by more than 10 %.

EXAMPLE 2 The advertised luminous flux is 100 lm. The requirement is met for any measured value ≥ 85 lm.

EXAMPLE 3 The solar run time is advertised as "8 h to 10 h" and the measured value is 8,1 h. This is not acceptable even though the measured value is within the advertised range, because the measured value deviates from the high end of the range (10 h) by 19 %, which is greater than the permitted 10 %.

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. The solar run time can be less than the full-battery run time if the solar energy is not sufficient to charge the battery or greater than the full-battery run time if appliances are used during the day while the battery is charging.
- d) Electromechanical run time: this is the run time after a stated amount of electromechanical work input. This can be less than the full-battery run time if the battery is not fully charged.

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 62257-9-5:2024, the interpretation of full-battery run time in accordance with 5.2.2.1 a) and 5.2.2.1 b) 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 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.

Run time after grid charging is characterised by the full-battery run time together with the grid-charge time.

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, televisions, computer monitors, and computers 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 (if applicable), electromechanical run time (if applicable), 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 (3.17). Any such statement of run time shall clearly indicate that these appliances are not included with the product. For each advertised appliance for which run time is presented, the assumed power (or, if run time is specified in terms of full charges, the battery capacity) of the appliance 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 (4.1.2).

- a) For all products, the company name and a uniquely identifiable product name or model number shall be presented as described in 5.2.3.2.
- b) All products shall have a method of indicating to the consumer what components and appliances are included with the product. The description of contents shall be on the packaging, user manual, user agreement, or separate documentation presented at the time of purchase as described in 5.2.3.2. The market development programme, government, or other entity using this document may accept alternative methods to describe the contents of a product. Products in product families (4.2.5) often use the same packaging and user manual across an entire product line with different configurations of components and appliances. A set of checkboxes that are manually marked to indicate which (and how many) of the potential components are included is an acceptable way to indicate product contents. Other similar alternatives that clearly indicate to the consumer what is included may be accepted at the discretion of the entity using this document. If a company uses the same packaging for multiple different products and any images or specifications on the packaging differ from what might be included in a specific product, a note shall be present on the packaging to warn customers that the contents may vary and directing them to how they can learn what is included with the specific product.

EXAMPLE 1 Warning messages could include: "Contents may vary, see details in the user manual", or "Run times may vary, see details on included documentation" or "Included lights and run times may vary. Look on the back to see what is included in your kit."

- c) All PV modules that are not integrated into other components (including PV modules with a cable length less than 3 m, even though they are classified as "integrated" in 3.7.4) shall include a clear and indelible label on the PV module that provides the following information:
 - name, registered trade name or registered trademark of company;
 - type or model number designation;
 - open-circuit voltage (V_{oc});
 - short-circuit current (I_{sc});
 - maximum power (P_{mpp});
 - for flexible modules, the minimum radius of curvature (or, if the module can be bent in multiple directions, the minimum radius of curvature for each direction).

All electrical ratings shall be compared to measurements made at standard test conditions (1 000 W/m², 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.

- d) 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 in the user manual. If the component is packaged with the kit, the information shall be presented on the packaging or in the user manual of the kit. If the component is packaged separately from the kit, the information shall be presented on the packaging or in the 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. For size B products, the PV power shall be presented as described in 5.2.3.2;
 - 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 (including lighting appliances built into main units): luminous flux (or brightness) in lumens;

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

e) For size A products, the following 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;
- For products that offer mobile phone charging or other auxiliary services (such as a radio or torch), a note that describes the impact of mobile phone charging and other auxiliary services on product performance. This statement may be qualitative; it is intended to ensure that the consumer is aware of a 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.

Alternatively, instead of a qualitative statement, one or more quantitative solar run time profiles as specified in f) may be provided.

NOTE 1 "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 lights on their brightest setting. The luminous flux and solar run time may be presented in any of the following ways:

- 1) A single value of luminous flux and combination solar run time reported for the main lighting (all lights that are powered directly from main unit(s))
- 2) A single value of luminous flux and combination solar run time reported for all included lighting appliances, including lighting appliances with their own batteries (often referred to as torches, portable lamps, or lanterns).
- 3) Luminous flux and solar run time reported for each lighting appliance individually
- 4) Additional luminous flux or solar run time values may be reported for appliances used separately or in combination, provided that each run time value is clearly associated with the corresponding luminous flux value. Misleading or ambiguous advertisements that misrepresent the relationship between the luminous flux and run time are not permitted.

EXAMPLE 2 An advertisement showing the luminous flux of the main lighting unit and the luminous flux of a torch and only presenting the run time of the main lighting unit would not be acceptable because the run time does not consider the energy needed to power the torch. Ensure the advertisement clearly depicts that the user will only receive the advertised run time if only the main lighting is used.

Products with multiple batteries can have multiple values of solar run time, one for each battery.

f) For size B products, the additional elements specified by either option 5.2.3.1 f) 1) or option 5.2.3.1 f) 2) are required and shall be presented as described in 5.2.3.2:

- 1) One solar run time profile stating solar run times for all of the included light points on high and the included or advertised appliance having the greatest power consumption, when used in combination. Other appliances (included or advertised) may be included in this profile, but are not required.
- 2) Two solar run time profiles:
 - i) The solar run time for the included light points on high, used in combination;
 - ii) Separately, the solar run time for the included or advertised appliance having the greatest power consumption, used individually.

Advertised appliances included in combinations may be generic types (e.g. television, portable radio, 20 cm fan) or specific products. If specific appliances are advertised, sufficient information, such as a model number or distinctive product name, shall be provided so that the end user can identify the appliance. If generic appliances are advertised, the power consumption from IEC TS 62257-9-5 should be used to determine which appliance has the greatest power consumption. If two appliances have equal rated power consumption, either may be advertised.

If a run time profile includes advertised appliances, the requirements of 5.2.2.3 shall be met. 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 2 In IEC TS 62257-9-5:2024, daytime and night-time use percentages are defined in Table GG.6, and generic appliance power consumption is defined in Table HH.1.

EXAMPLE 4 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.

- g) The requirement to report solar run time is modified for products without PV modules. These modifications apply to size A and size B products.
 - 1) For products charged from grid (utility) power or an external DC power supply (such as USB), full-battery run time shall be reported instead of solar run time. In addition, the time required for a full charge from the grid or DC power supply shall be stated.
 - 2) For products with electromechanical charging, the run time from a specified quantity of electromechanical charging shall be stated. The description of the electromechanical run time shall provide sufficient information for the user to understand the amount of mechanical work input required.
- h) For all metrics presented in accordance with 5.2.3.1 a) through g), 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 run time value without a setting name is assumed to be for the solar run time on the brightest setting and shall be evaluated as such.
- i) Companies may also present comparative measures of brightness, though they shall also report any values required by 5.2.3.1 d) through f). In cases where companies 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 3 A 45 lm product could advertise that it is "brighter than 4 candles" or "as bright as a hurricane lamp."

For all products, solar run time and daily energy service, if advertised, shall be based on a solar resource of 5 kWh/m². Additional solar run time and energy service values based on alternative values of solar resource may be advertised; the solar resource in kWh/m² used to calculate any such alternative values shall be clearly indicated.

Additional consumer information requirements for all products are given in 5.8.

5.2.3.2 Design requirements

5.2.3.2.1 General

The company may choose how to present the required performance metrics, mobile-charging information, identifying information (company name and either product name, model number, or both), 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 or other location where the information is presented.
- c) The label or information shall be sized such that:
 - 1) The font size requirements of 5.2.3.2.3 are met;
 - 2) Any graphics are clearly visible.
- d) There shall be sufficient contrast between the text or graphics and background to be clearly legible.

It is strongly recommended that:

- a) The text and graphic elements should be simple and understandable;
- b) The information should be presented either graphically or using an appropriate language for the region(s) where the product will be sold, or both.

5.2.3.2.2 Location requirements

Any information that is subject to the requirements of 5.2.3.2 shall be accessible prior to purchase. Accessible prior to purchase means that:

- a) The information may be printed on the packaging or on a document inside the packaging, if the packaging can be opened prior to purchase;
- b) If the information is inside the packaging, it shall be possible to open the packaging and access the information without altering the packaging, unless the information in its entirety is legible from the exterior of the packaging (note, tape or a seal that can be cut or easily removed to open the package is acceptable);
- c) If information is provided inside the packaging as in 5.2.3.2.2 b), but the packaging is taped shut or otherwise sealed prior to purchase, companies shall work with distributors and retailers to ensure the information can still be presented to the customer prior to purchase. This could be by allowing the customer to open the box prior to purchase or could include providing an extra copy of the materials that the retailer can share with customers prior to purchase. Compliance with this clause will be primarily assessed through MCM testing or market observations. If products observed in the market do not have the required information available prior to purchase, the product is considered to no longer meet this requirement.
- d) The information shall be included on or in the packaging in physical, human-readable form. Information available only on a website, brochure, catalogue, or other documentation not included on or in the packaging shall not be sufficient to meet this requirement.

EXAMPLE The following examples meet the requirement:

- Information is presented on the outside of the packaging;
- Information is presented in a user manual or on a warranty card included in a cardboard box that is not sealed and can be opened by a retail store employee to show the materials to a prospective customer;
- Information is presented in a user manual in a cardboard box that the distributor has sealed with tape. To ensure customers still have access to information that might inform their purchase, the retailer has a copy of the user manual available for customers to review prior to purchase.
- Information is presented on a cardboard insert in a plastic clamshell container. All the required information is visible from the outside of the packaging;

- Information is presented on a user manual inside a plastic clamshell container that can be opened and resealed without damage. The packaging must be opened to read the information, but the manual can be accessed and put back in place without damage.

The following examples do not meet the requirement:

- Information is presented in a user manual inside a cardboard box that is sealed with tape and the retailer will not allow the box to be opened and no copies of the materials are available to review;
- A statement “2 year warranty; see example.com or scan the QR code for complete user manual and warranty details” is printed on the packaging;
- Information is presented on a user manual inside a plastic clamshell container that cannot be opened without cutting the plastic, and the information is not visible from outside the packaging.

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.

5.2.3.2.3 Font size requirements

When required information is presented in the Latin alphabet, the font used shall have a cap height of at least 2,2 mm. The cap height is the height of flat capital letters (for example, X or H), measured from the baseline. Cap height may be measured with a type scale, ruler, calliper, or other instrument. For materials submitted electronically that include a scale reference, the cap height may be determined by inspection using the appropriate software.

This dimensional measurement may be omitted if the information is legible and the other requirements of 5.2.3.2 are met.

The term “cap height” is not applicable to scripts other than the Latin alphabet. For other writing systems criteria should be determined that provide an equivalent level of legibility.

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 company 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.

Instructions for using the pay-as-you-go system shall be provided in the user manual (if present), in a user agreement, or in another location in or on the packaging.

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 62257-9-5:2024 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 in accordance with 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. Lighting appliances and components that contain built-in lighting appliances may alternatively be evaluated in accordance with IEC 60598-1. This requirement may be met by company-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 in accordance with 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 in accordance with 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 in accordance with IEC 62257-9-5 (if applicable), IEC 60529, or IEC 60598-1:

- 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-type 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.

5.2.7 Evaluation of advertised charging time

Advertised solar charging time (i.e. the time required to charge the product from the PV module), if present, shall be compared to the solar charging time calculated in the energy service calculations of IEC TS 62257-9-5. If the statement of solar charging time specifies which batteries are included in the time estimate, only these batteries shall be included in the calculation. Otherwise, the calculation shall include the main unit battery and all batteries in included appliances charged from that main unit.

The number of batteries included in the calculation can exceed the number of ports available to charge the batteries simultaneously. In this case the realistically achievable charging time can be greater than that calculated according to the IEC TS 62257-9-5 procedure. In this situation, the consumer-facing description of charging time shall not be physically impossible due to a limited number of charging ports.

Advertised grid charging time (i.e. the time required to charge the product from the AC grid or a DC power source not included with the product) shall be compared to the result of the grid charge test of IEC TS 62257-9-5. If the product is advertised to be charged using a DC power source not included with the product, sufficient information shall be provided for the user to identify the correct power source. The following information shall be considered sufficient:

- a) For USB inputs, if the product can be charged within the advertised time using a power supply limited to 5 V and 0,5 A, no consumer-facing information is required. The product shall be tested using a DC power supply set to 5 V and 0,5 A.
- b) If a current greater than 0,5 A is needed in order to charge the product within the advertised time, the current (A or mA) or power (W) shall be stated. The product shall be tested using a DC power supply set to 5 V and the advertised current (or the advertised power divided by 5 V).
- c) If a USB power supply that supports fast charging is needed in order to charge the product within the advertised time, the power (W) and fast-charging protocol (e.g. USB Power Delivery) shall be stated. The product shall be tested with a power supply meeting the advertised specifications.
- d) For other DC inputs, the input voltage and current shall be specified.
- e) If a specific type or model of power source is advertised for use with the product, the laboratory may charge the product using the advertised power source or a DC power supply meeting the company-provided specifications. The company may provide the power source to the laboratory without random sampling.

The power source information shall be specified in the same location as the statement of charging time (e.g. if the charging time is advertised on the packaging, the power source shall also be specified on the packaging).

NOTE In IEC TS 62257-9-5, the grid charge test is performed if the product includes an AC-DC power supply or if charging time from an external DC power source (e.g. a user-supplied USB power adapter) is advertised.

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 as specified in 5.8.5.2. 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 62257-9-5:2024, 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, 5.3.6.2.2, and 5.3.6.3.2, 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, 5.3.6.2.2, and 5.3.6.3.2 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."

If there are multiple identical ports the term "advertised current (or power)" refers to the current or power that can be supplied by a single port with no loads applied to additional ports. (See 5.8.5 for consumer information requirements for identical ports.)

The voltage at the maximum current (or power) required by 5.3.5, 5.3.6.2.2, and 5.3.6.3.2 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.

Consumer information requirements for ports are specified in 5.8.5.

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 may be omitted from 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 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 62257-9-5:2024, the appliance operating voltage range test is described in Clause FF.8.

5.3.4.2 Exception

When tested at the minimum voltage, the appliance may be non-functional 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 5.3.6.2.3 or 5.3.6.3.3. 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

5.3.5.1 Advertised voltage ranges

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 all ports, the port voltage shall not be less than the advertised minimum voltage, minus a tolerance of 10 %, when the port is operating at up to 90 % of the advertised current (or power).
- b) For all ports, the port voltage shall not exceed the advertised maximum voltage, plus a tolerance of 10 %, under any test conditions.

NOTE In IEC TS 62257-9-5:2024 the assessment of advertised voltage ranges is described in EE.4.3.2 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.

5.3.5.2 Advertised power and current specifications

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 90 % of the advertised current or power value at the typical battery discharge voltage.

NOTE In IEC TS 62257-9-5:2024 the assessment of advertised current and power specifications is described in EE.4.3.2 b).

5.3.5.3 Advertised appliance compatibility

Power output of ports shall be sufficient to supply power to appliances that are advertised but not included at the appropriate voltage range as specified in 5.3.6. Advertised appliances with batteries, including mobile devices, that charge from 5 V ports meeting the requirements of 5.3.6.3 shall be excluded from this assessment.

NOTE In IEC TS 62257-9-5:2024 the evaluation of claims regarding capability to power appliances is described in EE.4.3.2 c).

5.3.6 Functionality requirements

5.3.6.1 Non-standard connectors

Ports with a connector type that is not commonly used for 12 V or 5 V ports may be exempted from the requirements of 5.3.6.2 or 5.3.6.3, 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 5.3.6.2.3 and for 5 V ports in 5.3.6.3.3.

5.3.6.2 Functionality requirements for 12 V ports

5.3.6.2.1 Applicability

The provisions of 5.3.6.2 apply to all ports advertised or reasonably expected to provide 12 V, except those with non-standard connectors as described in 5.3.6.1. A port is reasonably expected to provide 12 V if any of the following are true (this is not an inclusive list):

- a) 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.
- b) The product includes or advertises an adapter allowing connectors described in 5.3.6.2.1 a) to be used with the port (without changing the voltage).
- c) The port is advertised to work with one or more DC appliances (other than included lighting appliances), unless all advertised DC appliances have specified voltages outside the range of 10,5 V to 15 V. For example, if the product advertises that it can power a fan, the port would be considered a 12 V port. However, if the product advertises that it can power a 6 V fan, the port would not necessarily be considered a 12 V port unless one of the other listed items apply.
- d) 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.

NOTE For nominal voltages less than 12 V, see 5.3.6.2.3.2 for an exception to the lower voltage limit.

5.3.6.2.2 Basic requirements

All 12 V ports as defined in 5.3.6.2.1 shall meet the following steady-state voltage requirements:

- a) The port voltage shall be no greater than 15 V under any conditions.
- b) The port voltage shall be no less than 10,5 V when the port is operating at up to 90 % 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.

The 10 % tolerance for truth in advertising does not apply to the 10,5 V and 15 V values in 5.3.6.2.2 a) to 5.3.6.2.2 b).

5.3.6.2.3 Exceptions

5.3.6.2.3.1 Low-battery exception

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." (See 5.3.4 for related requirements for included appliances.)

If a port meets the requirements for one of the exceptions defined in 5.3.6.2.3.2, and the port continues to function normally when the power control unit is at the low-battery voltage, the statement related to low-battery functionality may be omitted. However, if the port turns off or enters a distinct low-battery operating mode when the battery is low, both the statement of 5.3.6.2.3.1 and any consumer-facing information required by 5.3.6.2.3.2 shall be present.

5.3.6.2.3.2 Exceptions to lower voltage limit

The port voltage may drop below 10,5 V if the requirements of 5.3.6.2.3.2 a), 5.3.6.2.3.2 b), or 5.3.6.2.3.2 c) are met:

a) **Lighting port exception:** Both of the following are true:

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

NOTE 1 Option 5.3.6.2.3.2 a) is intended for ports that are used only to power the included lights, where there is no implication that the port can power any other appliances and likely no user expectation of such a capability. These ports are often described as "lamp ports" or "light ports" and are often (but not exclusively) found on relatively small Size A products.

b) **Non-standard voltage exception:** The following information is clearly marked on the product packaging or user manual, meeting the requirements of 5.2.3.2:

- 1) A nominal voltage less than 12 V;
- 2) A statement that user-supplied 12 V appliances may not be compatible with the port or system.

EXAMPLE 11,1 V port – it is possible that it is not compatible with user-supplied 12 V appliances.

NOTE 2 Option 5.3.6.2.3.2 b) is intended for ports where the output voltage range overlaps with that of a 12 V port, but the voltage drops below the 10,5 V limit at higher currents, including ports powered directly from a battery composed of three 3,7 V lithium-ion cells in series. Such ports may be capable of powering a variety of small 12 V appliances, as well as larger appliances that can operate over a wider voltage range, but may not be able to power large appliances such as televisions and refrigerators that require a tighter voltage tolerance.

c) **Proprietary port exception:** 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 company-supplied appliances, whether included or sold separately. No other consumer-facing information shall contradict this statement.

NOTE 3 Option 5.3.6.2.3.2 c) is more restrictive than option 5.3.6.2.3.2 b) and is intended for ports that cannot supply a voltage in the range of 10,5 V to 15 V under typical operating conditions.

Notwithstanding these exceptions, the requirements of 5.3.4 and 5.3.5.3 shall be met.

5.3.6.2.3.3 Exceptions to upper voltage limit

The port voltage may exceed 15 V if the port meets the criteria of 5.3.6.2.3.2 a) or 5.3.6.2.3.2 c) and 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.

5.3.6.3 Functionality requirements for 5 V ports

5.3.6.3.1 Applicability

The provisions of 5.3.6.3 shall apply to all ports with a USB form factor and all ports advertised or reasonably expected to be used for mobile phone charging at a nominal voltage of 5 V (including barrel plugs), except those with non-standard connectors as defined in 5.3.6.1.

For fast-charging USB ports, the requirements of 5.3.6.3.2 do not apply except as stated in 5.3.6.5.2.

5.3.6.3.2 Basic requirements

All 5 V ports as defined in 5.3.6.3.1 shall meet the requirements in the following list. 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 company 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 90 % of the advertised current, whichever is greater, or a power less than or equal to 90 % 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 5.3.6.3.2 b).
 - 1) No minimum steady-state voltage requirement
 - 2) Maximum steady-state voltage: 5,5 V

The 10 % tolerance for truth in advertising does not apply to these voltage values (4,5 V, 4,25 V, and 5,5 V). Additional provisions for ports with fast-charging functionality are given in 5.3.6.5.

5.3.6.3.3 Exceptions

The minimum steady-state voltage requirement at the low-battery voltage, specified in 5.3.6.3.2 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."

5.3.6.4 Ports powered directly from a PV module

Ports that are powered directly from a PV module (without a battery) are tested in IEC TS 62257-9-5 by simulating the PV module performance at TMOT (50 °C and 1 000 W/m²). All functionality requirements that would normally apply at the typical battery discharge voltage shall apply under these conditions.

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.

5.3.6.5 USB fast charging

5.3.6.5.1 Applicability

During the assessment of DC ports, all USB ports having any of the following advertised characteristics shall be tested for USB fast charging in accordance with the assessment of DC ports in IEC TS 62257-9-5:

- a) Support for fast charging of mobile devices (or similar terms, such as “quick” or “rapid” charging, or “will charge faster”);
- b) Support for USB Power Delivery or another specific fast-charging protocol, such as Qualcomm® Quick Charge™;
- c) A power rating greater than or equal to 15 W or an advertised voltage greater than 6 V.

Ports not meeting the criteria in 5.3.6.5.1 a) to 5.3.6.5.1 c) may be tested if requested by the company.

NOTE The test procedure for USB fast charging in IEC TS 62257-9-5:2024 is specified in EE.4.2.5.4.3.

5.3.6.5.2 Requirements

Ports with detected fast-charging support shall meet the following requirements:

- a) The steady-state output voltage for the 5 V fixed voltage source mode shall meet the requirements of 5.3.6.3, except with the maximum current offered by the port used in place of the advertised current. This requirement is applicable at all simulated battery voltages.
- b) The following requirements are applicable only when the power control unit is powered at the typical battery discharge voltage:
 - 1) When a load that does not support fast charging is connected, the port shall meet the voltage requirements of 5.3.6.3 at a current of 0,5 A.
 - 2) The maximum power output shall be no less than 90 % of the advertised value in at least one of the operating modes.
 - 3) If multiple fast-charging protocols are supported (e.g. USB Power Delivery and a proprietary protocol), each protocol tested shall comply with 5.3.6.5.2 b) 2), unless different power ratings for each protocol are clearly advertised in a way that is meaningful to a typical user.

EXAMPLE 1 A USB Type-C port is rated 20 W and is capable of supplying 15 W at 5 V or 20 W at 9 V using USB Power Delivery. This port meets the requirements in 5.3.6.5.2. (The port is not expected to supply the rated power at every possible voltage, only at the highest voltage.)

EXAMPLE 2 A USB Type-C port is rated 40 W and is capable of supplying 20 W using USB Power Delivery, or 40 W using a proprietary fast-charging protocol for compatible smartphones. This port does not meet the requirements because it cannot supply the rated power using USB Power Delivery.

EXAMPLE 3 The port of Example 2 is advertised as “20 W fast charging, or up to 40 W with compatible Brand X smartphones.” This port meets the requirement because the difference in power between the two protocols is clearly explained.

- 4) The steady-state output voltage for each fixed voltage source mode other than 5 V shall meet the requirements of the specifications for the supported fast-charging protocols, if such specifications are publicly available. In the specific case of USB power delivery, the permitted tolerance is $\pm 5\%$ (v_{SrcNew} , IEC 62680-1-2:2022, Table 7-24).
 - 5) Any specific protocols (e.g. USB Power Delivery) or modes (e.g. PPS) that are advertised in consumer-facing locations shall be functional.
- c) Advertised voltage ranges for fast charging are not assessed as described in 5.3.5.1, but should be accurate.

For USB power delivery SPR modes, and other modes supported by the test laboratory, these requirements are assessed by testing in accordance with the assessment of DC ports in IEC TS 62257-9-5. For other modes that cannot be evaluated by the test laboratory, evidence of compliance shall be supplied by the company. This evidence can include component data sheets or third-party test reports or certificates.

NOTE Because there is no universally accepted definition of “fast charging” or “fast-charging protocol,” this document does not contain a requirement for ports advertised or described as “fast charging” to support a specific fast-charging protocol. The intent of this document is to ensure that the maximum power of the port is specified accurately and that the voltages supplied by the port will allow mobile devices to charge correctly without damage.

5.4 Lumen maintenance

All lighting appliances that are required to be assessed for light output aspects shall meet one of the following requirements:

- a) the relative light output of all samples tested shall be at least 95 % at 1 000 h, measured with the lumen maintenance test of IEC TS 62257-9-5, or
- b) the estimated relative light output of all samples tested shall be at least 90 % at 2 000 h, estimated with the alternate method using ANSI/IES LM-80 data defined in IEC TS 62257-9-5.

The alternate method using ANSI/IES LM-80 data shall not be used for market check method (MCM) tests.

For products that undergo 500 h tests (LM-80 tests, MCM primary check tests, and 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 1 000 h.

NOTE In IEC TS 62257-9-5:2024 the lumen maintenance test is described in Annex J.

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 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 62368-1 safety standards, respectively.

Either a test certificate or test report, or both, 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.

The AC input plug on an AC-DC power supply that meets this requirement is exempt from the switch and connector test of IEC TS 62257-9-5. However, the DC output connector on an AC-DC power supply is subject to the test.

5.5.2 Hazardous substances

Batteries shall not contain mercury or cadmium at levels greater than trace amounts (0,000 5 % mercury and 0,002 % cadmium by weight).

NOTE This requirement is generally assessed through company-supplied information. Batteries that are not nickel cadmium (NiCd) typically meet this requirement. This requirement is harmonized with Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries.

5.5.3 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.

The output overload protection test may be omitted for ports on appliances that are not intended to provide power and meet the requirements of 5.8.5.2.

NOTE In IEC TS 62257-9-5:2024 the output 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 5.3.6.4.

5.5.4 Wiring and connector safety

5.5.4.1 Conductor sizing and robustness

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 $50\text{ °C} \pm 3\text{ °C}$ (measured at $25\text{ °C} \pm 3\text{ °C}$ ambient temperature). This requirement is primarily assessed using a declaration from the company.

5.5.4.2 Prohibited connector types

Connectors typically used for AC mains power supplies shall not be used except for AC power inputs meeting the requirements of 5.5.1. Connectors in this category include, but are not limited to:

- Appliance couplers specified in IEC 60320 (all parts) and commonly used variants (for example, the non-standard polarized form of the C7/C8 plug and socket, sometimes referred to as C7P/C8P);
- AC plugs or receptacles specified by national, regional, or international standards such as those described in IEC TR 60083;
- AC plugs and receptacles specified by ANSI/NEMA WD 6 (typically used in North America);
- Plugs, socket-outlets, and couplers specified in IEC 60309 (all parts).

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 renewal requirements and alternative test procedures 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 – Renewal requirements and acceptable alternative test procedures for PV tests

Subclause	Renewal testing required?	Alternative test procedure
5.5.5.2 Wiring inspection	yes	none
5.5.5.3 Bending or folding	no	Bending: IEC 61215-2 MQT 22 or IEC TS 63163 CMQT 10.15 for category 2 products Folding: IEC TS 63163 CMQT 10.16 for category 2 products
5.5.5.3.2 Hinged PV modules	yes	none
5.5.5.4 Hot-spot endurance (products >100 W only)	no	IEC 61215-2 MQT 09; IEC 61730-2 MST 22; UL 61730-2 MST 22, or IEC TS 63163 CMQT 10.5

Outside test results to the alternative test procedures listed in Table 4 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 visual screening and sharp edge tests from IEC TS 62257-9-8:2020 have been incorporated into the visual screening of IEC TS 62257-9-5 and are no longer a separate procedure.

5.5.5.2 Wiring inspection

All cables connecting photovoltaic modules to other components shall pass the photovoltaic module wiring inspection of IEC TS 62257-9-5. This includes PV cables with a length less than 3 m, but excludes any wires or cables that are internal to other components (such as appliances or main units).

5.5.5.3 Bending or folding

5.5.5.3.1 General

All PV modules that are designed or advertised to be flexible or foldable modules (3.9.9) shall pass the bending or folding test of IEC TS 62257-9-5, unless the module is mounted or integrated into a component such that it cannot be flexed or folded during installation or use.

Alternatively:

- Flexible modules may be tested using the bending test (MQT 22) of IEC 61215-2 or the bending test of IEC TS 63163 for category 2 products;
- Foldable modules may be tested using the folding test of IEC TS 63163 for category 2 products.

5.5.5.3.2 Hinged PV modules

PV module assemblies consisting of two PV modules connected by a hinge or flexible material that do not meet the definition of foldable modules per 3.9.9 shall pass the gooseneck and moving part test of IEC TS 62257-9-5. This requirement shall be assessed in renewal testing per 4.3.

5.5.5.4 Hot-spot endurance (products >100 W only)

All modules with rated power (at STC) greater than 100 W shall pass one of the following hot-spot endurance tests:

- a) the hot-spot endurance test of IEC 61730-2, UL 61730-2, or IEC 61215-2, or
- b) the partial shading test of IEC TS 62257-9-5.

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 61730-1 and IEC 61730-2 or UL 61730-1 and UL 61730-2.
- b) All components intended to be directly connected to the output of the PV module shall meet the requirements of one of the following standards. Typically, this requirement applies to the main control unit.
 - IEC 60335-2-29
 - IEC 62109-1
 - ANSI/CAN/UL 9540
- c) Any component intended to be connected to an electrical output of components to which 5.5.6 b) applies shall meet the requirements of IEC 62109-1 or another applicable standard (e.g. UL 1741 or the relevant part of IEC 60335) assessing protection from fire and electric shock, unless the circuit to which the component is connected meets one of the following requirements:
 - 1) The circuit meets the requirements for protection in case of direct contact according to IEC 62109-1;

NOTE IEC 62109-1 defines both “protection against direct contact” and “protection in case of direct contact”; the two are not equivalent and the former is not sufficient to meet the requirement of 5.5.6 c) 1).
 - 2) The circuit meets the definition of a class 1 energy source according to IEC 62368-1;
 - 3) The circuit conductors are not classified as live parts according to IEC 60335-1;
 - 4) The circuit meets the requirements of another applicable safety standard for circuits accessible to an ordinary person.

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 5.5.6 a) through 5.5.6 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

5.6.2.1 General

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 of 5.6.2. Charge control is evaluated in accordance with IEC TS 62257-9-5. Included appliances with batteries shall also meet these requirements.

For all products, no damage or unsafe condition (such as fire, venting, or explosion) shall occur during the charge controller tests.

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

NOTE In IEC TS 62257-9-5:2024, charge control is evaluated in accordance with Annex S, Annex M or Clause FF.9. Passive overcharge protection is defined in IEC TS 62257-9-5:2024, S.4.4.

5.6.2.2 Voltage limits

The deep discharge protection voltage measured in accordance with IEC TS 62257-9-5 shall not be less than the minimum value given in Table 5 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 5 or the value specified by the battery manufacturer, whichever is greater.

The overcharge protection voltage measured in accordance with IEC TS 62257-9-5 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 for lead-acid batteries shall not be less than the minimum value given in Table 6 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 battery 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.)

Table 5 – Default battery deep discharge protection voltage specifications

Battery type	Deep discharge protection voltage		
	V/cell		
	Recommended	Min.	Max.
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 depending on 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 6 – Default battery overcharge protection voltage specifications

Battery type	Overcharge protection voltage		
	V/cell		
	Recommended	Min.	Max.
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

5.6.2.3 Requirements for pay-as-you-go systems

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 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.

5.6.2.4 Multiple power inputs

If the product has multiple power inputs, the overcharge protection shall function regardless of which input is used to charge the battery. To verify compliance, the overcharge protection test shall be repeated with the power supplied from one input of each type. However, if the laboratory can determine by inspection that an overcharge protection device protects multiple power inputs (e.g. the inputs are connected in parallel on the PCB), the overcharge test may be performed once for all such inputs.

5.6.3 Specific requirements for lithium-based batteries

5.6.3.1 Safety standards

All lithium batteries, including those in appliances and components that are included in product families but not tested, shall meet the requirements of a standard for safety during use. Except as noted in 5.6.3.2, 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 62133-2, or UL 2054. For this purpose, portable applications are defined as easily hand-carried components (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 5.6.3.1 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*, Section 38.3, 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*, Section 38.3, is often referenced as UN 38.3.

5.6.3.2 Single-cell batteries

5.6.3.2.1 Definition

For the purposes of this document, a single-cell battery is a cell fitted with devices necessary for use, for example case, terminals, marking and protective devices (per IEC 60050-482, 482-01-04), so that it can be handled as a stand-alone component.

5.6.3.2.2 Requirements

If a component contains one single-cell lithium-based battery not connected in series or parallel with any additional batteries, the cell shall meet the requirements of UL 1642 or one of the applicable standards listed in 5.6.3.1. There is no requirement for additional testing at the battery pack level.

If a component contains more than one but no more than four single-cell lithium-based batteries, one of the following shall be true:

- The individual single-cell batteries shall meet the requirements of 5.6.3.1, including both cell and battery tests;
- The entire component shall be tested as a battery in accordance with and shall meet the requirements of one of the standards listed in 5.6.3.1; or
- The component shall meet the requirements of IEC 62368-1.

5.6.3.3 Components containing multiple batteries

Multi-cell batteries meeting the requirements of 5.6.3.1 may be connected in series or parallel without additional testing. Overvoltage protection shall be provided for each cell or cell block connected in series as described in 5.6.3.5.

NOTE This provision is intended to apply to products that include multiple unmodified batteries of the type tested in accordance with 5.6.3.1. If the internal electrical circuit or mechanical structure of the battery pack is modified to combine multiple packs into a single larger battery, it is no longer a battery of the same type and would need to be tested according to the standards referenced in 5.6.3.1.

5.6.3.4 Summary

Table 7 summarizes the requirements of 5.6.3.1 through 5.6.3.2.

Table 7 – Summary of battery safety testing requirements of 5.6.3.1 through 5.6.3.2

Number of cells in battery	Number of batteries in component	Component tested to IEC 62368-1	Cell testing required	Battery testing required
1	1	No	Yes	No
1	>1	No	Yes	Yes
>1	Any	No	Yes	Yes
1	2-4	Yes	Batteries and cells evaluated in IEC 62368-1	

5.6.3.5 Overvoltage protection for individual cells

All lithium cells or 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 battery manufacturer-specified values, the overcharge protection voltage in Table 6 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 company 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 62257-9-5:2024.

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 subclause: Consider a product with a lithium-ion battery having four cells in series. If the company'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 subclause: Consider the same product as example 1, but the company 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 pass the battery durability storage test of IEC TS 62257-9-5:

- 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 %. No sample shall have a capacity loss exceeding 35 %. There shall be no failed samples as defined in the battery durability storage test of IEC TS 62257-9-5.

NOTE In IEC TS 62257-9-5:2024 battery durability is evaluated in Annex BB.

5.6.4.2 Exceptions

The requirements of 5.6.4.1 do not apply to the following batteries:

- Flooded lead-acid batteries that are shipped dry.
- Lithium iron phosphate batteries that have been tested in accordance with 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.

5.6.5 Authentication of battery documents

Since proper safety testing and adherence to the voltage limits specified by the battery manufacturer are critical for the safety and durability of products, entities using this document should take measures to verify the authenticity of the provided documents. This can be especially challenging since most batteries of the same type are similar in appearance and identifying information is often not marked on the battery.

Special attention should be given in the following cases:

- The operating voltage range specified by a battery manufacturer is outside the typical range for batteries of that type (e.g. a lithium-ion battery has a stated end-of-discharge voltage of 1,0 V or charging voltage of 4,5 V).
- Documents appear to have been altered or authentication features are missing.
- Documents do not include identifying information such as the battery manufacturer or test laboratory name.
- The company name, model number, or other details are inconsistent with other documents or with markings on the battery.
- The battery shown in the test report does not appear to be the same battery described in the documents (for example, aspects such as the rated capacity, nominal voltage, dimensions, number of cells, or cell configuration are different).

It is common for batteries to have minimal identifying information and for details such as colour and markings to differ between the certification or testing documents and the battery in the product. Therefore, small differences in these aspects are not typically an indication of fraudulent or erroneous documents, though it can still be appropriate to contact the entity that submitted the documentation to explain the discrepancies and confirm the correct documents were submitted.

If the authenticity of a document is in doubt, it should be validated by contacting the document's issuer (e.g. the test laboratory or battery manufacturer) directly.

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 4.2.8, some quality and durability requirements may be waived for components 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 in accordance with IEC TS 62257-9-5. All testing to meet the requirements of 5.7.2 shall be performed on samples that have been obtained in accordance with the sampling requirements of IEC TS 62257-9-5.

NOTE IEC 60529 and IEC 60598-1 do not have random sampling requirements. Therefore, this requirement generally cannot be satisfied by a company-provided IEC 60529 or IEC 60598-1 test report.

Connectors for outdoor use (e.g. terminating PV module cables) shall meet the requirements for permanent outdoor exposure (i.e. IP55); however, connectors may be exempted from the random sampling requirements. Therefore, the company may supply an IEC 60529 test report for a connector (or assembly of cable and connector) as evidence of the IP55 rating. If the report applies to the connector only, the cable shall be of the type specified by the connector manufacturer.

5.7.2.2 Physical ingress protection

All components that contain electronics or electrical connections shall meet the requirements in Table 8. For IP5X testing, components should be considered category 2 enclosures according to IEC 60529, unless a component has specific design aspects that would result in a pressure differential relative to ambient.

Table 8 – Physical ingress protection requirements

Component category as defined in 3.7	Required physical ingress protection level
Fixed outdoor	IP5X
All PV Modules	IP3X
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 62257-9-5:2024 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	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 61215-1 and IEC 61215-2, or • technical protection
^a Accessories that do not include built-in lights or radios and are used only in conjunction with an individual fixed-indoor component are exempt from water ingress requirements even if the accessory is portable. This exemption applies to remote controls, mice, keyboards, and similar devices. It shall not apply to accessories that are likely to be used in and carried between multiple locations, such as USB data storage devices and headphones.	

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:

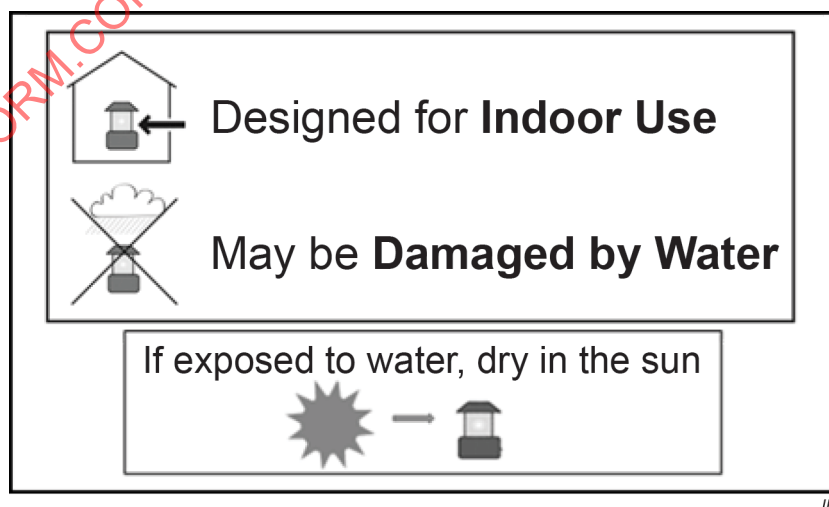
- a) The basic, unambiguous messages shall accurately describe:
 - 1) the degree of protection the product is afforded by its enclosure and other systems (e.g. "designed for indoor use" or "should not be exposed to rain"), and
 - 2) steps a consumer should take to drain or dry the product if it does 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 font size requirements of 5.2.3.2.3 are met;
 - ii) the graphic elements are clearly visible.

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 company is encouraged to design their own label or instruction but it is permitted to use the one provided herein.

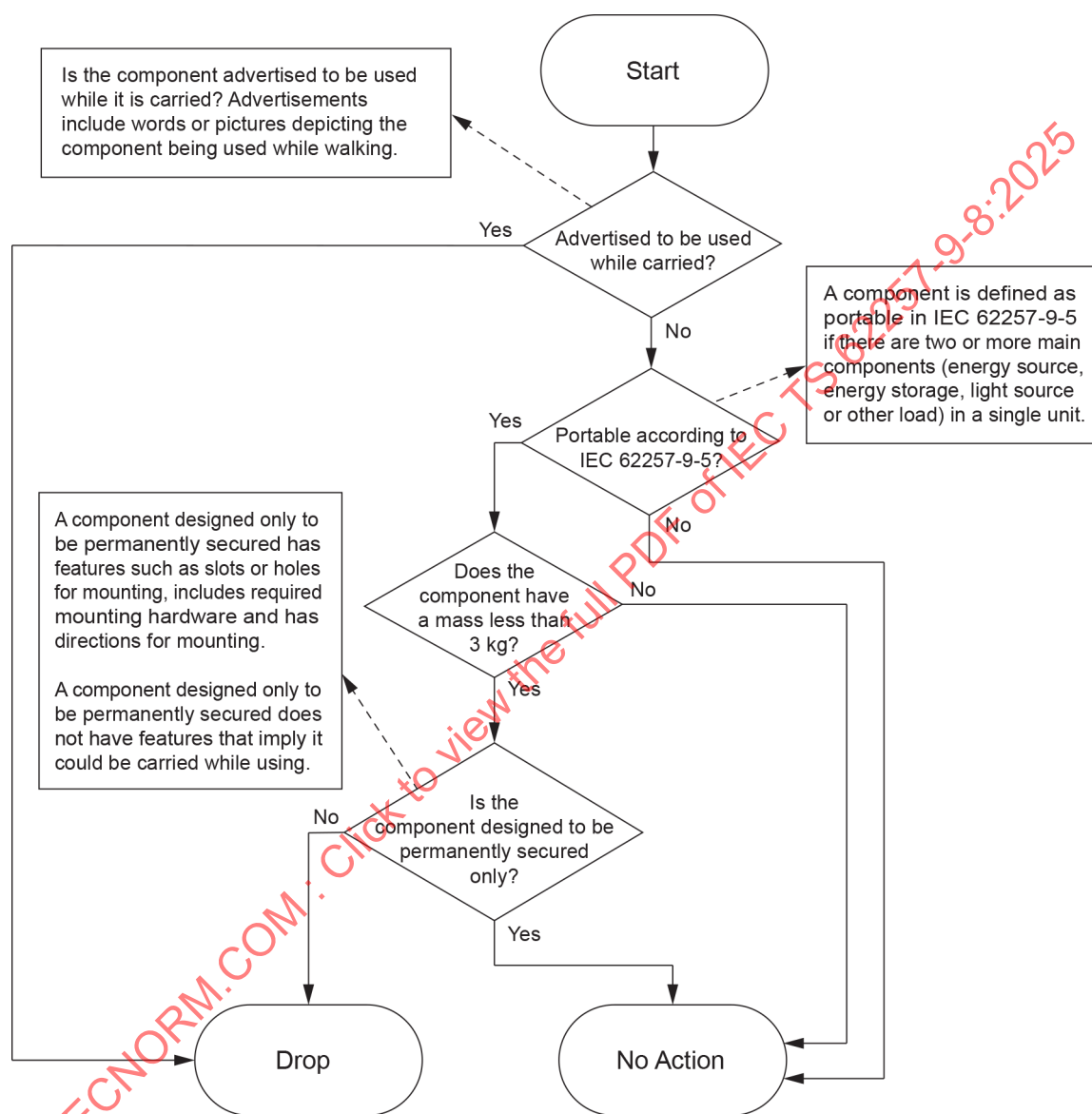


IEC

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.



IEC

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, the drop test may be omitted.

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

All tested components shall be functional after the drop test. 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, accessory lights as defined in 4.5.2 are considered non-lighting appliances.

NOTE 1 In IEC TS 62257-9-5:2024 the drop test is defined in Annex W.

NOTE 2 Although power control units are subject to 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

All components and all products 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. No hazards or safety issues shall be present on initial inspection and none shall develop as a result of normal use.

NOTE In IEC TS 62257-9-5:2024 the workmanship quality assessment is defined in F.4.3.6.4.

5.7.5 Switch, gooseneck, connector, and moving parts durability

These tests are conducted in accordance with 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.

The following examples may be used as guidelines to determine which category applies to each switch, connector, or moving part.

- Switches, connectors, and moving parts used primarily during installation:
 - A safety disconnect switch or circuit breaker that is turned on during installation and only turned off for maintenance;
 - Connections between a light point and an extension cable;
 - Outdoor connectors between a PV module intended for permanent mounting and its cable. For the purpose of determining the number of cycles, size A PV modules shall not be considered to be intended for permanent mounting;
 - Moving parts that are not critical to the function of the product;
 - Hinged joints adjusted only during installation;
 - Hinged PV modules intended for permanent mounting;
 - A moving part that will be fixed in place during installation so that it cannot be moved again.
- Switches, connectors, and moving parts intended for regular use:
 - USB plugs and sockets;
 - Plug-and-play connections between appliances (including lighting appliances) and main units, regardless of form factor;
 - PV sockets and plugs on main units;
 - Switches for light points or ports;
 - Keypad buttons;
 - Main power switches if unit is intended to be regularly turned off and on;
 - Hinges and goosenecks that include wires;
 - Moving parts that are intended to be adjusted regularly;
 - Radio dials and dials for dimming lights;
 - Hinged PV modules not intended for permanent mounting.

This requirement and the accompanying testing may be omitted for the following types of connections and moving parts:

- AC plugs and sockets that have been tested in accordance with applicable national or international standards;
- Connectors not used with the included components and not subject to the assessment of DC ports (e.g. audio, video, or RF inputs on televisions when no components are included that connect to these ports);
- Power output plugs on mobile-phone charging adapters when no compatible device is included in the kit;
- Certain non-plug-and-play connections (see 5.7.10);
- Lampholders and lamp caps (bases);
- Handles, stands, or straps that do not contain electrical conductors;
- Battery compartment covers;
- Inflatable components;
- Radio antennas.

Connections not subject to the mechanical durability test should be assessed in the visual screening of IEC TS 62257-9-5.

NOTE In IEC TS 62257-9-5:2024 the visual screening assessment of functionality and mechanical strength of all mechanical joints, connections, or moving parts is described in F.4.3.6.3 a).

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 (4.1.2), 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 company, though market check testing may be used to verify any claims.

As part of the testing process, companies are required to sign a declaration 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."

Companies 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) Laboratory test results indicating that the cable jacket material is resistant to damage from sunlight and water exposure:
 - 1) For sunlight resistance: UL 44:2021, 5.15; ISO 4892 (all parts); the sunlight resistance test of UL 1581; the weather (sunlight) resistance test of UL 2556; HD 605/A1; the ultraviolet light exposure requirements of UL 746C:2024, section 25; 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, 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 $\geq 2,5$ % by weight carbon black additive.
 - ii) Polyethylene with $\geq 2,5$ % by weight carbon black additive.
 - iii) PVC or polyethylene with an approved UV-resistant polymer additive, such as octabenzene, used in accordance with the additive manufacturer's directions.
 - iv) PVC or polyethylene with 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 octabenzene, formulated to protect the jacket material from damage due to sunlight exposure. These additives should be used in accordance with the additive 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 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.

5.7.8 PV overvoltage requirement

Products with either of the following characteristics shall pass the PV overvoltage protection test of IEC TS 62257-9-5:

- a) The battery can be isolated from the system by the user or installing technician without opening an enclosure that is not intended to be opened during installation, operation, or routine maintenance, or
- b) The battery is connected to the system in such a way that it can become disconnected during shipping, installation, or normal operation and maintenance.

NOTE In IEC TS 62257-9-5:2024 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.

The PV overvoltage protection requirement is not applicable to ports that are powered directly from a PV module (without a battery) or to ports on components that can only be powered from another port on a power control unit, not directly from the PV module (e.g. most ports on appliances).

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 62257-9-5:2024 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 (3.13) shall meet the requirements of this subclause. Terms used in this subclause for wire connection types are defined in 3.10.

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-type terminals, screwless-type terminals (e.g. spring or lever-actuated terminals), flat quick-connect terminations (blade terminals), or similar methods, provided that the following requirements are met:

- a) Connections made by the end user (or any person other than a trained installer or technician) shall provide a secure electrical connection and shall 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-type 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 connecting devices (wire nuts) or wires twisted together without a connector.
- b) Connections that are made by installers or technicians shall provide a secure electrical connection. All devices (e.g. terminals, connectors, materials, etc.) shall be used in accordance with their electrical ratings and the device manufacturer's instructions. Evidence shall be provided showing that technicians have received adequate training to use the required tools and make the connections correctly (e.g. training manuals, videos, or other training materials could be provided). Temporary connections such as alligator (crocodile) clips or unreliable connections such as twisting wires together without a connector shall not be used.
- c) 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.
- d) 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.
- e) Connectors on charge controllers 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.

- f) Overcurrent protection for the PV module or array shall meet the requirements of IEC 60364-7-712:2017, 712.43, unless all of the following criteria are met:
- The potential maximum current from all sources (the entire array) does not exceed the current-carrying capacity 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.

Operation at short-circuit current exceeding the STC value, as described in IEC 60364-7-712:2017, 712.433.1.101.1, should be taken into account by the company when sizing overcurrent protection. However, since the specific location of installation is not known, the laboratory generally cannot evaluate the appropriateness of the overcurrent protection for a specific site.

- g) All terminals for loads are considered ports and are subject to the ports and protection tests and requirements, 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).
- h) Adequate strain relief shall be provided for all non-plug-and-play connections. The method for providing strain relief shall be clearly described in the installation instructions and, if any equipment or tools 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.
- i) 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).
- j) 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, kits that are exclusively installed by the company's trained and authorized technicians may require the use of tools not included in the kit, but documentation shall be submitted confirming that the necessary tools are supplied to the installing technicians. All tools used shall be suitable for the intended purpose. (For example, any crimped terminations shall be made using a crimp tool specified for the terminal or connector included with the kit, not using ordinary pliers.)
- k) 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. Systems that are exclusively installed by the company's trained and authorized technicians may require the use of wire not 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. Other than this exception, the required wire shall be included with the kit.

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. Wires or cables in the kit that are plug-and-play and not intended to be cut during installation may be used for testing without modification.

- l) 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.

m) Connections shall undergo the following tests:

- 1) Screw-type terminals tightened by the user or installer shall be tested in accordance with IEC 61730-2 MST 33, UL 61730-2 MST 33, or the screw connections test of IEC TS 62257-9-5;
- 2) Reusable screwless-type terminals or connectors (e.g. those with levers or springs) operated by the user or installer shall be tested for 100 cycles in accordance with the switch and connector test of IEC TS 62257-9-5;
- 3) There is no testing requirement for single-use connectors such as crimp terminals, locking types of flat quick-connect terminations, insulation piercing connecting devices, or single-use push-in wire connectors;
- 4) There is no testing requirement for twist-on connecting devices, whether reusable or non-reusable;
- 5) When there are multiple clamping units (3.10.2) of the same type, it is permitted to test only one of each type of clamping unit.

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 are as follows:

- For connectors in junction boxes on the back of PV modules: IP3x and modified IPx4
- For connectors permanently installed outdoors: IP55
- For connectors used indoors: no water protection necessary (IP20)

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 (4.1.2):
 - 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 (4.1.2):
 - 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 warranty information shall explain how the consumer can access the warranty (e.g. return the product to point of purchase, distributor, or 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 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 presentation of the warranty information shall meet the design requirements in 5.2.3.2.

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