



BSI Standards Publication

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

National foreword

This Published Document is the UK implementation of IEC TS 62257-12-1:2020. It supersedes [PD IEC/TS 62257-12-1:2015](#), which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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TECHNICAL SPECIFICATION

**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**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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**

FOREWORD

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

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

IEC 62257-12-1, which is a Technical Specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

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

Title modified.

- Annex A and Annex B were combined into a single Annex A to eliminate duplicate tables and simplify the document. Annex A in this third edition now covers recommendations and requirements for both market support programmes and bulk procurement programs. Annex A provides specific examples for quality standards, warranty requirements, and performance criteria for off-grid lighting products.

This Technical Specification is to be used in conjunction with other parts of the IEC 62257 series.

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

Enquiry draft	Report on voting
82/1617/DTS	82/1642A/RVDTS

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

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

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

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

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

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The IEC 62257 series provides support and strategies for organizations and 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 1 000 V, and DC nominal voltage below 1 500 V.

These documents are recommendations:

- to support buyers who want to connect with good quality options in the market,
- to choose the right system for the right place,
- to design the system,
- to operate and maintain the system.

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

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems, and affordable 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 specify laboratory test methods for evaluating the quality assurance of lamps and lighting appliances for off-grid electricity systems, including product specifications and tests. In addition to supporting the selection of products by project developers and implementers, quality assurance can help market support organizations, manufacturers, and governments achieve the goals they have for lighting appliances in off-grid applications.

This part of IEC 62257 presents a quality assurance framework that includes product specifications (a framework for interpreting test results) and test methods.

The intended users of this document are:

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

The tests and inspections are designed to be widely applicable across different markets, countries, and regions.

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

1 Scope

This part of IEC 62257 establishes the framework for creating a product specification for lamps and lighting appliances to serve as the basis for evaluating quality for a particular context. Product specifications include minimum requirements for quality standards, warranty requirements, and/or performance criteria. Products are compared to specifications based on test results and other information about the product. The product specification framework is flexible and can accommodate the goals of diverse organizations and institutions.

This document applies to lamps and lighting appliances for off-grid electricity systems that have the following characteristics:

- The power supply is AC or DC:
 - AC nominal voltages up to 250 V;
 - DC nominal voltages up to 48 V.
- The light source is CFL, linear fluorescent, or LED.
- Operation of the lamp or lighting appliance does not require any components to be supplied by the testing laboratory other than lampholders, wire, connectors, and a power supply.
- The lamp or lighting appliance does not include a battery or energy source (for example, a photovoltaic module or electromechanical generator).

Luminaires are included in the definition of “lighting appliances” if packaged together with a lamp intended to be used with the luminaire. Luminaires without lamps are not included in the scope of this document.

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 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

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

IEC 60598-1, *Luminaires – Part 1: General requirements and tests*

IEC 60598-2-1, *Luminaires – Part 2-1: Particular requirements – Fixed general purpose luminaires*

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

IEC TS 62257-9-5: 2018, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-5: Integrated systems – Laboratory evaluation of stand-alone renewable energy products for rural electrification*

3 Terms and definitions

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

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

environmental conditions

characteristics, such as elevation, temperature, and humidity, that can influence performance

3.2

lux

SI unit of illuminance: illuminance produced on a surface of area 1 square metre by a luminous flux of 1 lumen uniformly distributed over that surface

[SOURCE: IEC 60050-845:1987, 845-01-52]

3.3

illuminance

illuminance of an elementary surface

E

luminous flux received by an elementary surface divided by the area of this surface

Note 1 to entry: In the SI system of units illuminance is expressed in lux (lx) or lumens per square metre (lm/m²).

[SOURCE: IEC 60050-723:1997, 723-08-30]

3.4

luminous efficacy

luminous efficacy of a source

quotient of the luminous flux emitted by the power consumed by the source

Note 1 to entry: Unit: lm/W.

[SOURCE: IEC 60050-845:1987, 845-01-55]

3.5

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]

3.6**power factor**

under periodic conditions, ratio of the absolute value of the active power P to the apparent power S

[SOURCE: IEC 60050-131:2002, 131-11-46, modified – The formula and note have been omitted.]

3.7**active power** P

real power

effective power

under periodic conditions, mean value, taken over one period T , of the instantaneous power p :

$$P = \frac{1}{T} \int_0^T p dt$$

Note 1 to entry: The coherent SI unit for active power is the watt (W).

[SOURCE: IEC 60050-131:2002, 131-11-42, modified – Note 1 to entry has been omitted.]

3.8**total harmonic distortion****THD**

ratio of the total r.m.s. value of the harmonics (in this context harmonic currents I_n of the order n) of orders 2 to 40 to the r.m.s. value of the fundamental:

$$\text{THD} = \sqrt{\sum_{n=2}^{40} \left(\frac{I_n}{I_1} \right)^2}$$

Note 1 to entry: This definition has been chosen in accordance with the relevant standard IEC 61000-2-2.

3.9**IP class****IP rating****IP code**

degree of protection provided by enclosures for electrical equipment against penetration by foreign bodies and dust/water

Note 1 to entry: IP classes are defined in IEC 60529.

[SOURCE: IEC TS 62257-9-5:2018, 3.16]

3.10**metadata**

information that relates a test result to a specific sample and provides context about the result (e.g. specific test method used)

[SOURCE: IEC TS 62257-9-5:2018, 3.21]

3.11**multimeter**

multirange multifunction measuring instrument intended to measure voltage, current and sometimes other electrical quantities such as resistance

[SOURCE: IEC 60050-312:2001, 312-02-24]

3.12**illuminance meter**

instrument for measuring illuminance

[SOURCE: IEC 60050-845:1987, 845-05-16]

3.13**integrating sphere**

hollow sphere whose internal surface is a diffuse reflector, as non-selective as possible

Note 1 to entry: An integrating sphere is used to determine the total luminous flux (lumen output) of a lighting device.

Note 2 to entry: An integrating sphere is used frequently with a radiometer or photometer.

[SOURCE: IEC 60050-845:1987, 845-05-24]

3.14**lamp**

device including a light source intended to be installed in or permanently fixed to a lampholder or luminaire

3.15**coefficient of variation**

ratio of the standard deviation to the mean

3.16**integrated compact fluorescent lamp**

compact fluorescent lamp that incorporates, permanently enclosed, all elements that are necessary for starting and for stable operation

3.17**non-integrated compact fluorescent lamp**

compact fluorescent lamp that incorporates electrical contacts intended for connection to a ballast through a lampholder

Note 1 to entry: Non-integrated compact fluorescent lamps are not included in the scope of this document, but can be components of a lighting appliance that is included in the scope.

3.18**compact fluorescent lamp****CFL**

tubular fluorescent lamp unit, having a bent tube, which does not include any replaceable or interchangeable parts

3.19**linear fluorescent lamp**

straight tubular fluorescent lamp unit that incorporates electrical contacts intended for connection to a ballast through a lampholder, and which does not include any replaceable or interchangeable parts

3.20**light emitting diode****LED**

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

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

3.21

integrated LED lamp

device including an LED light source, LED driver, and other optical, mechanical, and thermal components, and intended to connect directly to a power source

3.22

non-integrated LED lamp

device including an LED light source and other optical, mechanical, and thermal components, and intended to connect to an LED driver configured to control the lamp's light output

3.23

LED driver

electronic device configured to control the output of an LED light source, intended to connect directly to a power source, either packaged along with the LED light source in an integrated LED lamp or packaged separately from the LED light source

3.24

cap

base, en US

part of a lamp which provides connection to the electrical supply by means of a lampholder or lamp connector and, in most cases, also serves to retain the lamp in the lampholder

Note 1 to entry: The term "base" is also used in both the United Kingdom and the United States of America to denote an integral part of a lamp envelope which has been so shaped that it fulfils the function of a cap. It may engage either a holder or a connector, depending on other design features of the lamp- and holder system.

Note 2 to entry: The cap of a lamp and its corresponding holder are generally identified by one or more letters followed by a number which indicates approximately the principal dimension (generally the diameter) of the cap in millimetres. The standard code is to be found in IEC 60061.

[SOURCE: IEC 60050-845:1987, 845-08-15]

3.25

lampholder

device which holds the lamp in position, usually by having the cap inserted in it, in which case it also provides the means of connecting the lamp to the electric supply

Note 1 to entry: The term "socket" or, when the context is clear, the abbreviation "holder" are commonly used instead of "lampholder".

Note 2 to entry: See Note 2 to entry 3.24.

[SOURCE: IEC 60050-845:1987:1987, 845-08-24]

3.26

luminaire

apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply

Note 1 to entry: Luminaires that are not supplied with lamps are outside the scope of this document.

[SOURCE: IEC 60050-845:1987, 845-10-01, modified – Note 1 to entry has been added.]

3.27

lighting appliance

apparatus which distributes, filters or transforms the light transmitted from one or more light sources or lamps and which includes all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply

Note 1 to entry: A lighting appliance can be a luminaire with one or more lamps installed, including luminaires with integral lamps. A luminaire with no lamp installed or provided is not a complete lighting appliance (and is outside the scope of this document).

3.28

device under test

DUT

particular sample that is being measured or observed

4 Characteristics of lamps and lighting appliances

4.1 Product categories

Lamps and lighting appliances can be placed into one of three categories based on their expected range of use. It is important to categorize them because they have different inherent utility to the user and will encounter different environmental conditions based on their design.

Different quality standards and performance criteria may apply to different categories.

A product will fall into one of the following categories:

- Indoor-only products are designed for indoor use only, meaning they are generally intended to be mounted permanently or semi-permanently indoors.
- Indoor/outdoor products are designed to be used indoors or outdoors or both, depending on the user's needs.
- Outdoor-only systems are designed specifically for outdoor use, meaning they are generally intended to be mounted permanently or semi-permanently outdoors.

4.2 System measurements and observations

4.2.1 General

Subclause 4.2 describes aspects of a lamp or lighting appliance for off-grid electricity systems that may be measured and/or observed to ascertain its quality and performance. The aspects are grouped into categories, and each aspect begins with a description of its relevance. The description of each aspect concludes with a description of the result from the test procedure, the units, and an example result. In some cases, multiple pieces of information are grouped in a single aspect for clarity and concision.

4.2.2 Design, manufacture, and marketing

4.2.2.1 Arrangement of components

The arrangement of components, as in the example below, is a critical aspect to observe because it determines the product category.

- a) Test procedure(s): Annex F – visual screening.
- b) Result: qualitative description of the components comprising the lamp or lighting appliance.
- c) Units: qualitative description.
- d) Example: The product is an LED luminaire with all components integrated into a single enclosure.

4.2.2.2 Lighting system information

This aspect describes the types of light sources used in the product and their arrangement. This description is important for understanding the general product design.

- a) Test procedure(s): Annex F – visual screening, Annex C – manufacturer self-reported information.

- b) Result: qualitative description of the type, number, and arrangement of light sources.
- c) Units: qualitative description.
- d) Example: [Photographs attached to test reports], The luminaire consists of 3 LEDs mounted on a circuit board. The LEDs and board are encased in a clear plastic globe and attached to an Edison screw-type cap, making the entire product appear similar to a traditional incandescent light bulb.

4.2.2.3 Packaging and user's manual information

Information about the packaging, user's manual, and other consumer-facing information helps establish a baseline for comparing measured values in truth-in-advertising assessments. It may also be important to document if certain programmes require particular information to be included in the manual, such as instructions for end-of-life disposal.

- a) Test procedure(s): Annex F – visual screening.
- b) Result: there are two types of results:
 - 1) photographic documentation of the packaging and manual (or digital copies of the original proofs);
 - 2) notes on the type of manual and which languages are included.
- c) Units: qualitative type and photographs.
- d) Example: [Photographs attached to test reports], The user's manual is a single-sheet included in the package and includes pictograms with explanations in Hindi, English, French, and Swahili.

4.2.2.4 Warranty information

The terms and duration of warranty coverage provided to end-users are important factors for engendering confidence in stand-alone off-grid lighting and trying to prevent early failure. In practice, servicing warranties is highly variable depending on the structure of supply and service chains.

- a) Test procedure(s): Annex F – visual screening, Annex C – manufacturer self-reported information.
- b) Result: detailed warranty terms and a concise version that highlights the key points of coverage and duration.
- c) Units: qualitative description.
- d) Example: [Detailed warranty terms are documented in scanned attachments to test report], Coverage is against manufacturing defects or under normal use conditions. The product in general is covered for 12 months from the time of purchase.

4.2.2.5 Other visual screening results

This incorporates various other important results obtained from visual screening (Annex F), including, but not limited to, component dimensions, component masses, the number of light output settings, and provided specifications.

- a) Test procedure(s): Annex F – visual screening, Annex C – manufacturer self-reported information.
- b) Result: various results including qualitative descriptions and quantitative measurements.
- c) Units: qualitative descriptions and quantitative measurements.
- d) Example (for one result): The lighting appliance has a mass of 0,3 kg.

4.2.3 Durability and workmanship

4.2.3.1 Water protection – enclosure

This provides a description of the product enclosure's ability to keep out water in terms of IP class. For products intended to be used and/or charged outside, water protection is important for product function as well as user safety.

- a) Test procedure(s): Physical ingress and water protection test according to IEC 60529, or the alternative methods in Annex O (physical ingress and water protection) if the alternative method results are unequivocal.
- b) Result: pass or fail for IP class (second digit) and a description of degree of water protection provided by enclosure.
- c) Units: pass or fail and qualitative description.
- d) Example: The product is estimated to pass IPx3. The product's enclosure contains tight fitting components, all of which have gaskets to prevent water intrusion.

4.2.3.2 Water protection – circuit protection and drainage

This provides a description of any drainage means incorporated into a product and/or circuit board protection methods used in the product. The incorporation of drainage or circuit board protection is crucial for products intended to be outdoors that have enclosures providing little to no water intrusion protection.

- a) Test procedure(s): Annex F (visual screening) combined with Annex C (manufacturer self-reported information).
- b) Result: qualitative description of drainage or circuit protection methods used.
- c) Units: qualitative description.
- d) Example: The product has a conformal coating on its circuit board as well as drainage holes in the base of the enclosure to allow drainage of collected water.

4.2.3.3 Physical ingress protection

This provides a description of the degree of protection from the intrusion of foreign objects a product's enclosure provides in terms of IP class. Physical ingress protection is important for user safety as well as product functionality.

- a) Test procedure(s): Physical ingress and water protection test according to IEC 60529 or the alternative methods in Annex O (physical ingress and water protection) if the alternative method results are unequivocal.
- b) Result: pass or fail for IP class (first digit) and description of degree of physical ingress protection.
- c) Units: pass or fail and qualitative description.
- d) Example: The product passes IP4x; the product enclosure's components fit together snugly without gaps, so that only tiny particulate matter (e.g. dust) could intrude.

4.2.3.4 Shipping vibration durability

This provides an evaluation of a product's robustness and ability to withstand vibrations during shipping and distribution.

- a) Test procedure(s): Annex N – mechanical durability test.
- b) Result: pass or fail for functionality, damage, and the presence of user safety hazards.
- c) Units: a pass or fail result based on whether the DUT functions, incurs damage, or presents a safety hazard to the user.
- d) Example: When subjected to vibrations similar to those experienced during shipping, the product stopped working. Functional: fail. Damage: pass. Safety hazard: pass.

4.2.3.5 Gooseneck durability

This provides an evaluation of a product's gooseneck's robustness and ability to withstand being torqued through its expected range of motion. Gooseneck durability is important for product functionality and user safety and satisfaction.

- a) Test procedure(s): Annex N – mechanical durability test.
- b) Result: a pass or fail for functionality, damage, and the presence of user safety hazards.
- c) Units: a pass or fail result based on whether the DUT functions, incurs damage, or presents a safety hazard to the user.
- d) Example: After the gooseneck test, the LEDs worked properly but there was visible damage (a cracked housing) that did not pose a hazard. Functional: pass. Damage: fail. Safety: pass.

4.2.3.6 Connector durability

This provides an evaluation of a product's connectors' robustness and ability to withstand plug cycling. Connector durability is important for product functionality and user safety and satisfaction.

- a) Test procedure(s): Annex N – mechanical durability test.
- b) Result: a pass or fail for functionality, damage, and the presence of user safety hazards.
- c) Units: a pass or fail result based on whether the DUT functions, incurs damage, or presents a safety hazard to the user.
- d) Example: After 400 cycles in the connector test, the barrel plug socket detached from the LED driver enclosure, rendering the connector unusable. Functional: fail. Damage: fail. Safety: pass.

4.2.3.7 Switch durability

This provides an evaluation of a product's switches' robustness and ability to withstand switch cycling. Switch durability is important for product functionality and user safety and satisfaction.

- a) Test procedure(s): Annex N – mechanical durability test.
- b) Result: a pass or fail for functionality, damage, and the presence of user safety hazards.
- c) Units: a pass or fail result based on whether the DUT functions, incurs damage, or presents a safety hazard to the user.
- d) Example: After 600 cycles in the switch test, the DUT's light switch stopped turning on the DUT. Functional: fail. Damage: fail. Safety: pass.

4.2.3.8 Strain relief durability

This provides an evaluation of a product's strain reliefs' robustness and ability to withstand being pulled. Strain relief durability is important for product functionality and user safety and satisfaction.

- a) Test procedure(s): Annex N – mechanical durability test.
- b) Result: a pass or fail for functionality, damage, and the presence of user safety hazards.
- c) Units: a pass or fail result based on whether the DUT functions, incurs damage, or presents a safety hazard to the user.
- d) Example: The DUT's strain reliefs all withstood the strain relief test without incurring any damage. Functional: pass. Damage: pass. Safety: pass.

4.2.3.9 Wiring quality

This provides a qualitative evaluation of a product's wiring quality, including (but not limited to) neatness and connection quality.

- a) Test procedure(s): Annex F – visual screening.
- b) Result: a qualitative description of wiring quality.
- c) Units: qualitative description and number of failures with respect to key indicators.
- d) Example: The DUT's wires are neatly arranged (e.g. bundled into harnesses and secured with cable ties) and the solder joints are of good quality. There are no bad joints, pinched wires, or other poor wiring indicators.

4.2.4 Electrical characteristics

4.2.4.1 Operating input voltage range

This provides the voltage range over which the DUT can safely and properly operate.

- a) Test procedure(s): Annex K – input voltage range.
- b) Result: table showing relative light output over the operating voltage range; maximum allowable voltage; pass or fail for functionality, damage, and safety.
- c) Units: volts, DC or AC (V DC or V AC), and percentage (%); volts; pass/fail; qualitative description.
- d) Example: [Table with column headings: operating voltage (V), DUT voltage (V), and relative light output (%); a maximum allowable voltage of 15,8 V DC achieved.] The DUT remained functional after the test and no damage or safety hazard was present.

4.2.4.2 Power consumption

The power consumed by a lamp or lighting appliance is an important metric for use in off-grid applications in which the supply of energy is limited. The power consumption is also used in the calculation of luminous efficacy.

- a) Test procedure(s): Annex P – power consumption and power quality.
- a) Result: active power (AC) or DC power.
- b) Units: watts (W).
- c) Example: 1,50 W.

4.2.4.3 Power factor

The power factor of an AC device is the ratio of the active power (real power, measured in watts) to the apparent power (measured in volt-amperes). The power factor is an important metric for off-grid applications since the power output capacity of generators and inverters is often given in terms of apparent power. Using devices with high power factor results in more efficient use of a given generator or inverter's capacity.

- a) Test procedure(s): Annex P – power consumption and power quality.
- b) Result: active power (AC) or DC power.
- c) Units: unitless.
- d) Example: 0,95.

4.2.4.4 Current total harmonic distortion (THD)

The current total harmonic distortion is a measure of harmonic content in a device's current waveform – that is, how much the current waveform deviates from a true sine wave. High levels of harmonic current can cause heating in power generation and distribution equipment (such as generators and transformers) and can lead to distortions in the system's voltage waveform, negatively impacting the performance of other equipment connected to the electricity system.

- a) Test procedure(s): Annex P – power consumption and power quality.
- b) Result: active power (AC) or DC power.

- c) Units: percentage (%).
- d) Example: 15 %.

4.2.5 Photometric performance measures

4.2.5.1 Luminous flux output

Luminous flux output is the light output of a DUT when it is driven at a specific voltage. This is a key metric that compares the overall light output of DUTs.

- a) Test procedure(s): Annex I – light output.
- b) Result: luminous flux.
- c) Units: lumens (lm).
- d) Example: 95,6 lm.

4.2.5.2 Luminous efficacy

Luminous efficacy is the light output of a DUT (in lumens) divided by the power the DUT is consuming (in watts). This is a key metric that compares the ability of DUTs to turn electrical power into usable light.

- a) Test procedure(s): Annex I – light output.
- b) Result: luminous efficacy.
- c) Units: lumens per watt (lm/W).
- d) Example: 96,3 lm/W.

4.2.5.3 Full width half maximum (FWHM) angles

The full width half maximum angle is a metric used to understand the light distribution of a DUT and is the total angle over which the illumination is greater than or equal to half the illumination at the brightest point at a given distance from the light source in a given plane.

- a) Test procedure(s): Annex J – light distribution.
- b) Result: vertical and horizontal FWHM angles.
- c) Units: degrees (°).

4.2.5.4 Light distribution characteristics

A light distribution is the illuminance “map” of a DUT. This metric is useful for determining the utility with respect to task lighting. The test is done by driving the DUT at a specific voltage.

- a) Test procedure(s): Annex J – light distribution.
- b) Result: constant-voltage useable area at a specified distance and illuminance on a work surface of 0,3 m × 0,4 m.

NOTE The work surface dimensions were selected to correspond to two adjacent sheets of A4 paper.

- c) Units: square metres (m²) and lux (lx).

EXAMPLE The usable area at a distance of 0,75 m is 0,76 m² and the work surface illuminance is 40 lux.

4.2.5.5 Colour characteristics

The colour characteristics of light include the colour rendering index (CRI), a measure of how accurately the light renders colours, and the correlated colour temperature (CCT), a measure of the colour of the light expressed as a temperature in kelvin.

- a) Test procedure(s): Annex I – light output.
- b) Result: CRI and CCT values.
- c) Units: CRI is unitless and the CCT is in kelvin (K).

4.2.6 Photometric durability measures

4.2.6.1 Lumen maintenance (LED)

This is a measure of the amount of degradation in light output after 1 000 h and 2 000 h of operation at a constant voltage, which can provide valuable insight into the quality of the LEDs and/or the DUT's circuitry.

- a) Test procedure(s): Annex L – lumen maintenance.
- b) Result: percentage of lumen output maintained after 1 000 h and 2 000 h of constant operation.
- c) Units: percentage (%).
- d) Example: The DUT maintained 96 % and 93 % of its original lumen output after 1 000 h and 2 000 h of operation, respectively.

4.2.6.2 Cycle life (fluorescent)

This is a measure of the number of on/off cycles a fluorescent DUT can undergo before the DUT ceases to properly function.

- a) Test procedure(s): Annex M – cycling.
- b) Result: a pass or fail for functionality after 3 000, 6 000, and 12 000 on/off cycles.
- c) Units: a pass or fail for functionality.
- d) Example: The DUT continued to function after 12 000 on/off cycles.

4.2.7 Self-declaration aspects

4.2.7.1 Product and manufacturer information

Manufacturer-reported product and manufacturer information is important for tracking purposes as well as for ensuring the test laboratory has up-to-date product information.

- a) Test procedure(s): Annex C – manufacturer self-reported information.
- b) Result: various qualitative and quantitative information.
- c) Units: qualitative and quantitative.
- d) Example: The product's free-on-board price is 30 USD; it is sold in Kenya and India; etc.

4.2.7.2 Warranty coverage

Warranty coverage goes beyond the terms of a warranty and provides detail on coverage in a particular location. It is typically only provided in cases where it is necessary to verify coverage in a particular town or region.

- a) Test procedure(s): Annex C – manufacturer self-reported information
- b) Result: qualitative description.
- c) Units: qualitative description.
- d) Example: The support in [region name] is provided by a small network of technicians who have been trained to repair products by [manufacturer or distributor name]. For repairs that are beyond the scope of their capabilities, replacement products are provided. The consumers in [region name] can access warranty service by dialling a phone number that is on a sticker placed on the original packaging.

4.2.7.3 Third-party marks and certifications

Third-party marks and certifications (e.g. UL) can be an important aspect in the eyes of consumers and investors, alike.

- a) Test procedure(s): Annex C – manufacturer self-reported information.

- b) Result: qualitative marks and certifications.
- c) Units: qualitative type.
- d) Example: produced in an ISO 9001 certified factory.

5 Product specification

5.1 General

Quality standards, warranty requirements, and performance criteria are used to interpret the measurements and observations made about a product. Together they form a product specification.

- Quality standards set a minimum level of durability and protect buyers and users from false advertising claims.
- Warranty requirements set a minimum level of user protection from early failure.
- Performance criteria set a recommended level of service and features.

Each criterion in a specification refers to a particular aspect of the product, as listed in 4.2, and requires a minimum level of quality, service, or performance.

The standards, requirements, and performance criteria should be appropriate for the goals of the organization or individual who is using them as a framework for quality assurance and should consider the following factors:

- availability of products on the market with the necessary quality and performance;
- ability of buyers to pay for the products;
- diversity of end-user needs;
- tolerance for manufacturing variation.

Clause 5 describes the framework for standards, requirements, and performance criteria in general and offers insights on the best practices for creating a product specification. It includes a template product specification followed by guidance on completing each section. Annex A presents an example specification for off-grid lighting market support programme qualification.

5.2 Applications

Product specifications that include some combination of quality standards, warranty requirements, and performance criteria can support a broad range of quality assurance needs. Table 1 below lists examples of how they are applied depending on the type of quality assurance (QA) framework.

Table 1 – Applications of product specifications

Type of QA framework	Example(s) of applying Clause 5
General market support	Use quality standards and general warranty requirements to qualify for institutional market support; provide additional services if performance criteria are also met. Use quality standards to qualify for “verified product” programmes. Use quality standards and other requirements to qualify for investment or financing.
Manufacturing/distribution	For manufacturers: incorporate quality standards and performance criteria from market support programmes or distributors in the design and production quality control processes. For distributors: set minimum quality standards, warranty requirements, and/or performance criteria for products to identify suppliers.
Bulk procurement	Set minimum quality standards, warranty requirements, and/or performance criteria for products to qualify in a request for offers. If the project is in a specific location, the warranty requirements may also include specific levels of service in that particular area.
Trade regulation	Set minimum quality standards for tax exemption or customs.

5.3 Quality assurance principles

5.3.1 General

The framework for considering quality standards, warranty requirements, and performance criteria presented in this document is designed to support broad types of programmes and institutions in the off-grid lighting market. The following key principles guide the framework:

- Balance quality and affordability for price-sensitive buyers – it does not matter how well products perform if the target users cannot afford them.
- Encourage innovation and technological diversity. Wherever possible, be open-ended in the technical approaches that are allowed.
- Empower buyers to choose the right product for their needs and budget by focusing product specifications and communication on outcomes for end-users.
- Use low-cost, rigorous, targeted tests to match the general affordability requirements for the market and accommodate both incremental and innovative changes to product design. The tests should be feasible for use by a broad set of potential users.
- Focus quality standards on elements of a product that are difficult for typical buyers to assess themselves, like truth-in-advertising and durability.
- Focus warranty requirements on providing a baseline of support.
- Focus performance criteria on bottom-line user experience metrics like run time and brightness.

5.3.2 Rationale for dividing quality, warranty, and performance

Quality standards, warranty requirements, and performance criteria are considered separately to allow programmes and institutions the flexibility to establish targets with their goals in mind:

- Quality standards deal with basic consumer protection (from early product failure, unsafe operation, or false advertising) and typically are a “baseline” or minimum level.
- Warranty requirements deal with aspects of the products and projects that are not controlled at the factory or installation site – the service available for products is typically very dependent on the supply chain and geography.
- Performance criteria are typically in addition to quality standards and define service levels that should be met. The diversity of needs, power availability, and ability of end-users to pay for appliances and electric service shall be known to precisely set performance criteria.
- Enables tiered service offerings for market support programmes. For instance, it is possible to have a tiered support system in which certain services only require meeting

quality standards and warranty requirements while others also require meeting performance criteria.

5.4 Product specification framework description

5.4.1 General

Subclause 5.4 describes a framework of product specification documents for lamps and lighting appliances included in the scope of this document. First, a blank specification is provided that lists all the pieces that may be specified. It is followed by a subclause describing guidelines for setting tolerances in a product specification. Finally, the main sections in a specification are described in more detail with notes and guidance.

There are example product specifications in Annex A; one is for general market support programmes and the other is a “sample tender” for bulk purchasing.

A product specification has six parts, as follows:

- a) Scope defines the applicability and use of the quality standards and performance criteria.
- b) Test requirements defines requirements for test result validity.
- c) Product category requirements unambiguously defines the categories that may be referenced later.
- d) Quality standards lists quality-related aspects and minimum or required results for each aspect with a tolerance; may be subdivided by product category.
- e) Warranty requirements lists requirements for minimum levels of warranty support.
- f) Performance criteria lists performance-related aspects and minimum or required results for each aspect with a tolerance; may be subdivided by product category.

5.4.2 Product specification template

5.4.2.1 General

Subclause 5.4.2 is a blank, rough template for setting quality standards, warranty requirements, and performance criteria to support the goals of a programme or institution. Note that in many applications certain criteria or entire categories of criteria may not apply and should be removed.

NOTE *Text in italics* is intended for replacement and describes what should go in each space.

5.4.2.2 Scope

Describe the intended use of the product specification. Describe the contents in general and provide guidance on how to use the document.

5.4.2.3 Test requirements

Specify the level of testing that is required. For example, Quality Test Method (QTM) level testing (see Clause 6).

Describe if any external test results (such as test results from other IEC standards) could be used in place of results from this document. Describe any product sampling requirements for qualification testing.

Specify the number of light output settings required to be measured for products with multiple settings. Typically, at least one set of test results should fully characterize the performance on the highest light output setting.

5.4.2.4 Product category requirements

Describe which product technology categories (e.g. AC and/or DC, lamps and/or luminaires, LEDs and/or CFLs, etc.) are covered/allowed.

Describe any voltage limits or other required electrical system integration tolerances (e.g. nominal 12 V DC, AC voltage input range 100 V to 250 V, AC frequency 50 Hz, etc.).

Describe any other categorical requirements for products (e.g. shall have an E27 Edison screw cap, etc.).

5.4.2.5 Quality standards

The product shall meet each of the criteria listed in the truth-in-advertising (Table 2), safety and durability (Table 3), power quality for AC products (Table 4), and end-user support (Table 5) tables.

Table 2 – Truth-in-advertising tolerance

Truth-in-advertising criterion	Aspect(s) considered in assessment	Requirement
System performance tolerance – numeric ratings	4.2.5 Photometric performance measures Others, if applicable	<i>Define the tolerance for deviation from ratings.</i>
Other numeric ratings tolerance	Multiple	<i>Define the tolerance for deviation from ratings.</i>
Overall truth-in-advertising statement	Multiple	<i>Include an overall description of the requirements for truth-in-advertising that may not be covered by the requirements above.</i>

Table 3 – Safety and durability standards

Safety or durability criterion	Aspect(s) considered in assessment	Product category (form factor and/or technology)	Requirement
Level of water exposure protection (<i>overall, technical, or enclosure-only</i>)	4.2.3.1 Water protection – enclosure	Category 1	<i>Define level of protection in terms of water protection integrated assessment:</i> <i>No protection, occasional rain, frequent rain, or permanent outdoor exposure.</i>
	4.2.3.2 Water protection – circuit protection and drainage		
	4.2.7.1 Product and manufacturer information		
	4.2.2.3 Packaging and user's manual information	Category 2, Category 3, etc.	<i>Define level of protection in terms of water protection integrated assessment.</i>
Physical ingress protection	4.2.3.3 Physical ingress protection	Category 1	<i>Define level of protection in terms of IP class.</i>
		Category 2, Category 3, etc.	<i>Define level of protection in terms of IP class.</i>
Mechanical durability – shipping vibration	4.2.3.4 Shipping vibration durability	All products ^a	<i>Define maximum number of failures out of the number that are tested for damage, functionality, and safety.</i>
Mechanical durability – goosenecks	4.2.3.5 Gooseneck durability	Products with goosenecks	<i>Define maximum number of failures out of the number that are tested for damage, functionality, and safety.</i>

Safety or durability criterion	Aspect(s) considered in assessment	Product category (form factor and/or technology)	Requirement
Mechanical durability – connectors	4.2.3.6 Connector durability	Products with connectors	Define maximum number of failures out of the number that are tested for damage, functionality, and safety.
Mechanical durability – switches	4.2.3.7 Switch durability	All products	Define maximum number of failures out of the number that are tested for damage, functionality, and safety.
Mechanical durability – strain relief	4.2.3.8 Strain relief durability	Products with connectors	Define maximum number of failures out of the number that are tested for damage, functionality, and safety.
Workmanship	4.2.3.9 Wiring quality	All products	Define maximum number of samples with bad solder joints, poor wiring, etc. out of the number that are tested.
Operating input voltage range	4.2.4.1 Operating input voltage range	All products	Define maximum number of failures out of the number that are tested for functionality and safety. Define voltage range and maximum allowable voltage for testing, if different from recommendations in Table K.2.
Lumen maintenance	4.2.6.1 Lumen maintenance (LED)	All LED products	Define maximum number of samples that may fail specified lumen maintenance criteria out of the number that are tested.
Cycling durability	4.2.6.2 Cycle life (fluorescent)	All CFL or linear fluorescent products	Define maximum number of failures out of the number that are tested.
Safety ratings	4.2.2.5 Other visual screening results 4.2.7 Self-declaration aspects	All AC products	Define any safety ratings, markings or certifications required for AC products.
^a The shipping vibration test may add significant cost to the test programme, depending on the capabilities of the test laboratory. The costs and benefits of this testing should be weighed carefully when deciding whether to include a shipping vibration durability requirement in the product specification.			

Table 4 – Power quality standards for AC products

Power quality criterion	Aspect(s) considered in assessment	Product category (form factor and/or technology)	Requirement
Power factor	4.2.4.3 Power factor	All AC products	Define minimum acceptable power factor.
Current total harmonic distortion	4.2.4.4 Current total harmonic distortion (THD)	All AC products	Define maximum acceptable THD.

Table 5 – End-user support standards

Truth-in-advertising criterion	Aspect(s) considered in assessment	Requirement
Information on product design, use, and care	4.2.2.3 Packaging and user's manual information	<i>Define if there are requirements for consumer-facing information on packaging or in a user's manual, such as end-of-life disposal instructions.</i>
Other	4.2.2.5 Other visual screening results	<i>Define other product requirements that support end-users to maintain the quality of the product.</i>

5.4.2.6 Warranty requirements

The product shall meet each of the end-user support requirements listed in Table 6.

Table 6 – End-user support requirements

Support type	Aspect(s)	Requirement
Maintenance and warranty terms	4.2.2.4 Warranty information	<i>Define minimum warranty requirements (length, components covered, etc.)</i>
Service capabilities	4.2.7.2 Warranty coverage	<i>Define "on the ground" requirements for warranty service (typically only for projects in a specific location)</i>

5.4.2.7 Performance criteria

In addition to meeting the quality standards and warranty requirements, the product shall meet one of the lighting service criteria (Table 7).

Table 7 – Lighting service criteria for performance assessment

Light output criterion	Aspect(s)	Requirement
General illumination service	4.2.5.1 Luminous flux output	<i>Define minimum average lumen output (lm) and compliance tolerance (%).</i>
Luminous efficacy	4.2.5.2 Luminous efficacy	<i>Define minimum luminous efficacy (lm/W) and compliance tolerance.</i>
Other illumination requirements	Various	<i>Define minimum performance for other aspects, such as colour rendering, colour temperature, light distribution and illuminance characteristics</i>
Usability requirements	Various	<i>Define minimum requirements related to usability, such as flicker and warm-up requirements.</i>

5.4.3 Tolerances

Tolerances are an allowable deviation from the target value for a particular criterion in a product specification and are part of the product specification. In the case of truth in advertising, the target value is what is advertised. For performance criteria, the target value is the minimum performance level. Durability tests and other pass/fail criteria also have a target – passing the test.

Tolerances should be set carefully, considering how the measured or observed values from a test (with a limited number of samples) characterize the true quality or performance aspects of every product in the market. The sample size, expected manufacturing tolerance, and testing uncertainty should each be considered.

There are trade-offs between protecting buyers/end-users and suppliers from "false positive" and "false negative" results, respectively. Tighter tolerance tends to protect buyers/end-users better from poor quality or performance products but will also result in a higher number of