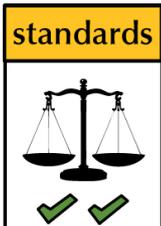


## Summary of Requirements in IEC TS 62257-9-8:2020

April 2020



The following pages provide a summary of the requirements and additional test methods in International Electrotechnical Commission (IEC) Technical Specification (TS) 62257-9-8: *Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W*. For over ten years, the VeraSol/Lighting Global Quality Assurance<sup>1</sup> program developed and maintained the world's most widely recognized QA framework for pico-solar products and SHS kits, with the Lighting Global Quality Standards at its core. Based on a revision of the Lighting Global Quality Standards, the standards in IEC TS 62257-9-8 address the same core aspects that have been the focus of the Lighting Global Quality Standards for years:

- **Truth in Advertising:** Advertising and marketing materials accurately reflect tested product performance.
- **Durability:** Product is appropriately protected from water exposure and physical ingress, has durable switches and connectors and, if portable, survives being dropped.
- **System Quality:** Product passes a visual wiring and assembly inspection.
- **Lumen Maintenance:** Product maintains consistent light output after 2,000 hours of operation.
- **Warranty:** A consumer-facing warranty is available; the required duration varies by product type.

The scope of IEC TS 62257-9-8 covers off-grid products with the following characteristics:

- All components required to provide basic energy services are sold/installed as a kit, included as a part of a family of products, or integrated into a single component.
- Peak power ratings (of the PV module or other power generating device) do not exceed 350 W
- PV module maximum power point voltage and the working voltage of any other components in the kit do not exceed 35 V DC (though AC inputs may exceed this voltage limit).
- Only DC systems, outputs, and loads are covered. AC-to-DC converters that meet appropriate safety standards may be included, but inverters, AC outputs/outlets, or AC appliances are not covered.
- All electrical connections, except for permanent connections made at the time of installation, can be made using plug-and-socket (plug-and-play) connectors without the use of tools.

Conformance with IEC TS 62257-9-8 is evaluated based on results from laboratory testing according to the Quality Test Method (QTM) or the Accelerated Verification Method (AVM) in the latest edition of IEC TS 62257-9-5.<sup>2</sup> The tests are conducted at laboratories which have demonstrated competence,

<sup>1</sup> **About VeraSol:** An evolution of Lighting Global Quality Assurance, VeraSol supports high-performing, durable off-grid products that expand access to modern energy services. VeraSol builds upon the strong foundation for quality assurance laid by the World Bank Group and expands its services to encompass off-grid appliances, productive use equipment, and component-based solar home systems. VeraSol is managed by CLASP in collaboration with the Schatz Energy Research Center at Humboldt State University. Foundational support is provided by the World Bank Group's Lighting Global program, UKaid, IKEA Foundation, and others. Please visit VeraSol.org for more information.

<sup>2</sup> Additionally, a few procedures for new PV module safety tests are included as annexes in IEC TS 62257-9-8, but these test methods are intended to be added to a future version of IEC TS 62257-9-5.

metrological traceability, and impartiality, for example by accreditation to ISO/IEC 17025, using randomly-procured samples. Products with similar or interchangeable components may not require full re-testing, as IEC TS 62257-9-5 includes provisions for:

- minimizing duplicative testing for [similar products](#) and products with pay-as-you-go ([PAYG](#)) add-ons,
- allowing for streamlined testing of [product families](#), and
- enabling products sold under [multiple brands](#) but technically identical to one another to reference one set of test results.

On-going qualification is subject to successful [market surveillance](#) testing according to the Market Check Method (MCM). Additionally, [renewal testing](#), equivalent to a primary check test in IEC TS 62257-9-5, is required after two years.

The following pages provide a *summary* of the requirements in IEC TS 62257-9-8 to enable companies to prepare to meet the new requirements for both newly tested products and products undergoing renewal testing. However, this summary is not exhaustive. Those using the standards are encouraged to carefully review the final version of IEC TS 62257-9-8 once published by the IEC.

New and changed requirements, i.e., differences from the most recent version of the Lighting Global Quality Standards, are written in **red** text. These changes are collected together and shown in a single list in the [Change Log for Quality Standards](#).

**Table 1. Summary of Requirements in IEC TS 62257-9-8 for Pico-Products and Solar Home System Kits**

Category <sup>a</sup>	Metric	Quality Standard
<b>Truth In Advertising<sup>b</sup></b>	Manufacturer, Product Name and Model No.	Accurately specified and uniquely identifiable
	Performance Reporting Requirements for Products ≤ 10 W (pico-products, referred to as “Size A” in IEC TS 62257-9-8)	-Light output and solar run time are accurately reported on the packaging for the brightest setting. <sup>c</sup> -The impact of mobile phone charging or other auxiliary appliance(s) on product performance (e.g. run time) is qualitatively described on packaging.
	Performance Reporting Requirements for Products > 10 W (SHS kits, referred to as “Size B” in IEC TS 62257-9-8)	-PV power must be accurately reported on the product packaging. - <b>At least one solar run time profile for all of the included light points on high and any other included appliances is provided on the packaging or in the user manual. (This profile may include advertised appliances.)</b> - The packaging or user agreement displays a clear statement regarding battery replacement.
	<b>Reporting Requirements for All Products</b>	-PV modules are labeled with key specifications. <sup>d</sup> - <b>Specifications are provided on packaging or user manual for key components including PV modules, batteries, lights, and appliances.<sup>e</sup></b> -Warranty terms are presented as described below. <sup>f</sup> -All information must be presented clearly, legibly and with equal prominence to other messages. All information shall be available to customers prior to sale.

Category <sup>a</sup>	Metric	Quality Standard
Truth In Advertising Continued <sup>b</sup>	All other specifications, including: Light Output, Run Time, Appliance Power Consumption, Lamp Type, PV Power, Battery Capacity, Charger Rating, Ingress Protection, Other Aspects	If reported, accurately specified. <sup>b</sup> If there are both pay-as-you-go (PAYG) and non-PAYG versions of a product, each must be truthfully advertised with respect to energy services provided.
	Fee-for-service or Pay-as-you-go (PAYG) Metering	The PAYG system should be capable of accurately metering service to customers so they reliably get the service that is paid for. <sup>g</sup>
	Functionality	All advertised features must be functional. Any description of the product that appears on the packaging, inside the package and in any other medium (internet, etc.) should be truthful and accurate. No statements should mislead buyers or end users about the features or utility of the product. Any user interfaces (charge indicators, SOC estimates, etc.) must be accurate.
Ports Requirements	Output Port Functionality and Truth-in-Advertising <sup>h</sup>	Port voltage and current specifications, if provided, must be accurate. Included appliances must function when connected to output ports. Power output of ports must be sufficient to power appliances that are advertised but not included. Specific guidelines for USB and 12 V ports are below. Ports that are intended for a function other than providing power, such as data ports, are not required to meet this standard, <b>but these ports must be marked as “not for charging” or similar.</b>
Lumen Maintenance	Lumen Maintenance at 2,000 Hours	Average relative light output of all samples $\geq 90\%$ of initial light output at 2,000 hours with only one sample allowed to fall below 85% OR All samples maintain $\geq 95\%$ of light output at 1,000 hours. <sup>i</sup> If an included lighting appliance provides $>15$ lumens, it is subject to the lumen maintenance standard.
Health and Safety	AC-DC Charger Safety	Any <i>included</i> AC-DC charger carries a recognized consumer electronics safety certification. <sup>j</sup>
	Hazardous Substances Ban	No battery may contain cadmium or mercury at levels greater than trace amounts ( $<0.0005\%$ Hg and $<0.002\%$ Cd by weight in accordance with the EU Battery Directive)

Category <sup>a</sup>	Metric	Quality Standard
Health and Safety Continued	Circuit and Overload Protection	The system must pass an overcurrent and an overload protection test. 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 must be easily resettable or replaceable by the user, or must automatically reset. If replaceable fuses are used for circuit protection, sizes must be labeled on the product and listed in the user manual, and, if fuses are replaceable by the user, at least one spare fuse must be included with the product. Included appliances are not required to meet this standard unless they have ports that are intended to provide power and are marked “not for charging” or similar.
	Wiring and Connector Safety	Wires, cables and connectors must be appropriately sized for the expected current and voltage, and all connectors and wire joints shall be robust. <sup>k</sup>
	PV Module Safety	All PV modules shall undergo additional safety testing <sup>l</sup> , including: <ul style="list-style-type: none"> <li>• Increased visual screening testing and wiring inspection</li> <li>• Durability of markings (not required for integrated PV modules)</li> <li>• Sharp edge test (not required for integrated PV modules)</li> <li>• Screw connection test (for <u>non-plug-and-play</u> products only)</li> <li>• An impact test (not required for integrated PV modules already subject to drop test)</li> <li>• A bending or folding test (if the module is intended to be bent or folded during use)</li> <li>• A hot-spot endurance or partial shading test (if the module is &gt; 10 W)</li> </ul>
	Requirements for Systems with Large PV Modules or Arrays	Products with a total maximum solar PV power greater than 240 W, open-circuit voltage greater than 35 V, or short-circuit current greater than 8 A shall meet additional safety requirements: <ul style="list-style-type: none"> <li>• PV modules shall meet the requirements for class II modules in IEC 61730, and</li> <li>• Charge controllers (or any component connected to the output of the PV module) shall meet IEC 62109 or UL 1741.</li> </ul>
Battery	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. 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.

Category <sup>a</sup>	Metric	Quality Standard		
Battery Continued	Battery Protection	All 4 samples are protected by an appropriate charge controller that prolongs battery life and protects the safety of the user. <sup>m</sup> Batteries of included appliances must also meet this standard. For PAYG systems, appropriate battery protection must 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 must be able to charge the battery even if the product is in a disabled state. <sup>n</sup>		
	Lithium Battery Safety	<p>Lithium batteries must have overcharge protection for individual cells or sets of parallel-connected cells.</p> <p>Lithium batteries shall additionally meet the requirements of a standard for safety during use. Test reports from accredited laboratories shall cover both the individual cell and the fully assembled battery pack.</p> <ul style="list-style-type: none"> <li>Batteries used in portable applications (i.e. easily hand-carried devices), shall meet either IEC 62133-2, UL 62133, or the combination of UL 1642 and UL 2054</li> <li>Batteries used in stationary applications shall either: <ul style="list-style-type: none"> <li>– meet the requirements for portable batteries above, or</li> <li>– meet the United Nations Recommendations on the transport of dangerous goods: manual of tests and criteria (UN 38.3) and either IEC 62619 or UL 1973.</li> </ul> </li> <li>Batteries used in a component with a mass &gt; 18 kg shall meet the requirements of IEC 62619 or UL 1973.</li> </ul> <p>Batteries of included appliances must also meet this standard.</p>		
	Battery Durability	The average capacity loss of all samples must not exceed 25% and only one sample may have a capacity loss greater than 35% following the battery durability storage test. <sup>o</sup> If an included lighting appliance provides >15 lumens, it is subject to the battery durability standard. All other included appliances are not required to meet this standard.		
Quality and Durability <sup>p,q,r</sup>	Physical Ingress Protection (for components containing electronics or electrical connections)	Fixed Outdoor	IP5x	
		All PV Modules	IP3x OR IP2x with circuit protection	
		All Other Components	IP2x	
	Water Protection <sup>s</sup> (for components containing electronics or electrical connections)	Fixed Outdoor Components	Permanent outdoor exposure: <i>IPx5</i>	
		All PV Modules	Outdoor rooftop installation: <i>Modified IPx4 OR circuit protection</i>	
		Portable Integrated Components	Frequent rain, which requires meeting one of: <ol style="list-style-type: none"> <li><i>IPx3</i></li> <li><i>IPx1 + technical protection</i></li> <li><i>IPx1 + warning label</i></li> <li><i>Technical protection + warning label</i></li> </ol>	
		Portable Separate Components	Occasional rain: <i>IPx1 OR technical protection OR warning label</i>	
Fixed Indoor Components	No requirement			

Category <sup>a</sup>	Metric	Quality Standard		
Quality and Durability Continued <sup>p,q,r</sup>	Drop Test	Portable Components	<p>Portable lighting components: The number of samples tested is dependent on the product and test type. For QTM tests of portable lights in products <math>\leq 10</math> W, at least 5 out of 6 samples must be functional after the drop test (1 m onto concrete on six faces). For all other tests, all samples are functional.</p> <p>Non-lighting portable appliances (such as battery-powered radios, fans, razors and lights with light output <math>\leq 15</math> lumens): For QTM tests, all but one sample must be functional following a modified drop test requiring only 2 drops per sample rather than the standard 6 drops. For all other test types, all samples must be functional following the modified drop test. The sides on which the product is dropped will be alternated between samples to ensure that all six sides are dropped at least once.</p> <p>In all cases, no samples may result in dangerous failures.<sup>t</sup></p>	
		Fixed Indoor and Outdoor Components	No requirement	
	Soldering and Electronics Quality	The system and any included appliances must be rated “Good” or “Fair” for workmanship quality as defined in Annex F of IEC TS 62257-9-5. At most, one sample may fail to function when initially evaluated.		
	Switch, Gooseneck, Moving Parts, and Connector Durability	Mechanisms expected to be used regularly	All samples and any included appliances are functional after 1000 cycles	
		Mechanisms expected to be used primarily during installation <sup>u</sup>	All samples and any included appliances are functional after 100 cycles	
	Strain Relief	All cables on all samples and any included appliances must pass a strain relief test.		
	Outdoor Cable Durability (for products > 10 W / SHS kits only)	Any outdoor cables must be outdoor-rated and UV resistant. <sup>v</sup> Compliance is primarily determined based on manufacturer declarations and documentation provided by the manufacturer, though market check testing may be used to verify any claims.		
	PV Overvoltage Protection	If the battery is disconnected or isolated, the system must not be damaged and the load terminals shall maintain a voltage that is safe for their intended uses. <sup>w</sup>		
	Miswiring Protection	The user interface should be designed to minimize the likelihood of making improper connections. If improper or reversed connections can easily be made, they shall cause no damage to the system or harm to the user.		

Category <sup>a</sup>	Metric	Quality Standard
Quality and Durability Continued <sup>p,q,r</sup>	<a href="#">Non-plug-and-play Connections</a>	Systems with non-plug-and-play connections must meet additional requirements as described in the “Electrical Connection Requirements” section below. <sup>x</sup>
Consumer Information	Minimum Warranty Terms for Products ≤ 10 W (pico-products)	Accurately specified and consumer-facing; minimum coverage of at least one year on manufacturing defects under normal use, including the battery. Details are noted below. <sup>f</sup>
	Minimum Warranty Terms for Products > 10 W (SHS kits)	Accurately specified and consumer-facing; minimum coverage of at least two years for the system and one year for most included appliances. Details are noted below. <sup>f</sup>
	Date of Manufacture	All products shall be labeled with the date of manufacture or a serial number assuring traceability of date of manufacture (i.e. the date need not be discernible to consumers, only to those who are able to interpret the code). The date of manufacture shall be reported with a precision of at least the month and year. If components are packaged separately, each component shall carry these component-specific markings. The label may be on the product or the packaging.
	User Manual (for products > 10 W / SHS kits only)	User manual must present instructions for installation, use, and troubleshooting of the system. Installation instructions must include appropriate placement and installation of the PV module. Basic electrical safety and system maintenance must also be covered. Installation and operation instructions should be presented using language and graphics that can be understood by the typical consumer. <sup>y</sup>
	Component Specifications and Replacement Methods (for products > 10 W / SHS kits only)	<p>Consumer information must provide at least one of the following options:</p> <ol style="list-style-type: none"> <li>1) State that components can be replaced and provide any specifications necessary for a PV module, battery, light, or fuse to function with the system (in addition to the required specifications outlined in the performance reporting requirements), OR</li> <li>2) Provide directions as to how the consumer can get components, including the battery, replaced at service centers, OR</li> <li>3) Include a clear consumer-facing statement that the batteries and other components are not replaceable.</li> </ol> <p>Detailed instructions or descriptions regarding replacing components may be included in the user manual, but a clear statement regarding the battery replacement must be included on the consumer-facing packaging or user agreement. Accepted phrases are:</p> <ol style="list-style-type: none"> <li>1. Battery is field replaceable</li> <li>2. Battery may only be serviced by manufacturer</li> <li>3. Battery is not replaceable</li> </ol> <p>Similar phrases may be acceptable.</p>

## Other Notes

### <sup>a</sup> General Notes

If a sample fails on any aspect at any point during testing, even if not during the specific test used to evaluate that aspect, the product will still fail on the basis of that aspect. For example, if a switch stops functioning on a sample while its luminous flux is being measured, the product would fail for functionality.

In certain cases, where products are designed for special applications (e.g., productive uses), certain requirements may be waived, altered, or strengthened at the discretion of the market development program or government that is using the requirements. Any deviations from the requirements listed in this document will be noted on the test report and any other verification materials (in the case of the VeraSol/Lighting Global program, the Standardized Specification Sheet and Verification Letter) for the product.

<sup>b</sup> *Notes on Assessment of Truth-in-Advertising*

Numeric aspects, such as light output and run time, must deviate no more than 15% from advertised ratings (though it is always acceptable if actual performance is better than advertised). If a range is provided, the best rating must be within the 15% tolerance. If a run time is advertised, it is assumed to be for solar run time and for the brightest setting, unless otherwise stated. Solar run time and daily energy service, if advertised, must be based on a solar resource of 5 kWh/m<sup>2</sup>. Additional solar run time and energy service values based on alternative values of solar resource may be advertised; the solar resource in kWh/m<sup>2</sup> used to calculate any such alternative values must be clearly indicated. All advertised features shall be functional. Any description of the product that appears on the packaging, inside the package, and in any other medium (internet, etc.) should be truthful and accurate. No statements should mislead buyers or end users about the features or utility of the product.

Light distribution must only be measured for one sample to determine the full-width-half-max (FWHM) angle.

Included appliances are subject to truth-in-advertising requirements for performance claims. Relevant tests include: light output, battery capacity, power consumption, and the full-battery and solar run time. At the discretion of the market development program, government, or other organization using the requirements, other internationally recognized standards may be referenced in lieu of certain appliance tests specified in IEC TS 62257-9-5. For example, Global LEAP testing may be referenced in lieu of the power consumption test, appliance operating voltage range test, and physical ingress protection test for TVs, fans, and refrigerators. Only lights with light output greater than 15 lumens are required to be assessed for light output and light distribution (these are defined as “accessory lights”).

Advertising regarding physical and water ingress protection is evaluated as follows. 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. If a component is advertised to be permanently mounted outdoors (including on a boat), the component shall meet the requirement for fixed outdoor products. 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. [Note, these requirements have been enforced previously with the Lighting Global Quality Standards, but were not formally documented.]

Manufacturers may provide documentation of meeting that IP rating based on test results from an accredited laboratory. The following common advertising terms are expected to meet the following IP levels:

- IPX7: Waterproof, or similar
- IP64: Weatherproof, or similar
- IPX4: Splashproof, or similar
- IPX3 (or IPX1 plus technical protection): Rainproof, protected from heavy rain, or similar
- IPX1 (or technical protection): Water resistant, splash resistant, rated for outdoor use, or similar
- IP5X: Dustproof, protected from dust, or similar

Note, advertisements cannot supersede the basic IP requirements by component form factor described in the “physical ingress protection” and “water protection” sections below. (For example, a fixed outdoor component is required to meet IP55 even if it is only claimed to be “water resistant” and even if it includes an appropriate warning to install in a sheltered area.)

<sup>c</sup> *Notes on Performance Reporting Requirement for Pico-products*

The light output and solar run time must be reported for the brightest setting, which is defined as all the included light points on, including torches or portable lamps, on their brightest settings and assumes a solar resource of 5 kWh/m<sup>2</sup>.

<sup>d</sup> *PV labeling requirement details*

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

- name, registered trade name or registered trade mark of manufacturer;
- type or model number designation;
- serial number (unless included in a kit and marked on another component);
- date and place of manufacture; alternatively, serial number allowing to trace the date and place of manufacture;
- maximum system voltage;
- open-circuit voltage (Voc);
- short-circuit current (Isc);
- maximum power (Pmpp).

All electrical ratings shall be compared to measurements made at standard test conditions (1 000 W/m<sup>2</sup>, 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.

<sup>e</sup> *Component labeling requirement details*

For all components, whether packaged with a kit or included as part of a product family, the following performance metrics must be advertised to enable consumers and distributors to compare products and make educated choices. All component specifications must be provided on the packaging or user manual. If the component is packaged with the kit, the information must be presented on the packaging or user manual of the kit. If the component is packaged separately from the kit, the information must be presented on the packaging or user manual of the component. Where indicated, specifications shall also be provided on the component. The requirements for lighting appliances do not apply to accessory lights ( $\leq 15$  lm).

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

<sup>f</sup> *Warranty Requirements Details*

To meet the Standard, the following guidelines shall be followed when presenting and offering a warranty:

- For products  $\leq 10$  W (pico-products), the minimum warranty period is at least one year from the time of purchase by the end-user. The warranty must cover the entire product, including the battery.
- For products  $> 10$  W products (SHS kits), the minimum warranty period from the time of purchase by the end-user is at least:
  - 2 years for the main system, including the PV module, control box, cables and lights and the system battery. (Note that batteries included within appliances are only required to meet the 1-year warranty). The battery warranty is assumed to include a capacity retention figure of at least 80% at two years, benchmarked to the rated battery capacity.
  - 1 year for all lighting appliances that include their own batteries (including pico-power lights), all non-lighting appliances, USB charging adaptors and similar accessories.

For all products:

- The warranty must cover, at a minimum, manufacturing defects that impede operation under normal use and protection from early component failure.

- The consumer-facing warranty must explain how the consumer can access the warranty (return to point of purchase/distributor/service center, call or SMS a number, etc.), how the warranty will be executed (repair, replacement, etc.), and should advise the customer to inquire about the warranty terms prior to purchase.
- The consumer-facing warranty must be available to the consumer in writing in a way that enables the end user to verify and understand the terms of the warranty prior to purchase. The written information should be in a regionally appropriate language. Consumer-facing warranties could be included on the product box, or on a user agreement or warranty card that is easily accessed prior to purchase.
- The warranty information must meet the same design requirements as specified for the performance reporting requirements.

Note that this is a *Minimum* Standard and it is up to the discretion of manufacturers and distribution partners to exceed the basic protection offered in these terms to differentiate their products in the market.

#### <sup>g</sup> *PAYG Assessment*

These aspects are primarily assessed through manufacturer declaration and measurement of parasitic consumption of the PAYG metering system. 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.

#### *b Requirements for Ports*

##### **Truth-in-Advertising Requirements**

Advertised port voltage ranges are subject to truth-in-advertising 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 behavior is clearly described in the user manual or in the same place where the voltage range is stated.

- For 5 V ports, the port voltage shall not be less than the advertised minimum voltage, minus a tolerance of 1%, when the port is operating at up to 95% of the advertised current (or power), or, if there is no advertised current (or power), up to 0.5 A.
- For all other ports, including 12 V ports, the port voltage shall not be less than the advertised minimum voltage, minus a tolerance of 1%, when the port is operating at up to 95% of the advertised current (or power), or, if there is no advertised current (or power), at all measured current (or power) values except the highest measured value for each simulated battery voltage level.
- For all ports, the port voltage shall not exceed the advertised maximum voltage, plus a tolerance of 1%, under any test conditions.

If both current and power ratings are advertised, whichever is least favorable to the product shall be used to evaluate the advertised voltage specification. A product may advertise a minimum voltage, a maximum voltage, both, or neither. In addition, a nominal port voltage is frequently advertised. If a single voltage value is specified for a port with no further description, it should be interpreted as a nominal port voltage. Nominal port voltages are not subject to a truth-in-advertising requirement, but should be accurate.

Any port power and current specifications, if provided, shall be accurate. If a current or power range is advertised in association with a port, the port shall be able to provide within 5% of the advertised rating at the typical battery discharge voltage, as defined in IEC/TS 62257-9-5. The current and power ratings are evaluated using the average measured value across all samples. Power output of ports shall be sufficient to power appliances that are advertised but not included.

Separate current ratings may be specified for functionality and for overcurrent protection. The current rating for functionality shall not be less than the current required to use the advertised appliances and to allow the operation of user-supplied appliances in a manner consistent with the consumer-facing advertising and documentation. For example, consider a 12 V-rated 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 may 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.”

## Functionality Requirements

Included appliances shall function when connected to ports and shall not be damaged or present a safety hazard over the entire voltage range of the port as assessed in the appliance operating voltage range test or the assessment of DC ports of IEC/TS 62257-9-5. Appliances shall function at all tested voltages, where “function” is defined as providing the expected service (e.g. lights turn on, television displays images and sound) for appliances without internal batteries, and is defined as charging for appliances with internal batteries. The appliance need not function when the product’s battery is at the low-battery voltage if the feature or behavior 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 may not work when the battery is low.”

### Non-standard connectors

Ports with a connector type that is not commonly used for 12 V or 5 V ports need not meet the functionality requirements below, 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 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 of any dimensions;
- A cigarette lighter receptacle.

### 12 V ports

All ports advertised or reasonably expected to provide 12 V shall maintain a voltage of at least 10.5 V when the port is operating at up to 95% of the advertised current (or power), at all simulated voltages. If no current (or power) range is advertised, the port shall maintain a voltage of at least 10.5 V over the entire tested range of currents (or powers) except the highest measured current (or power). However, port voltages may fall below 10.5 V when the product’s battery is at the low-battery voltage if the feature or behavior 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 may not work when the battery is low.” At no time shall the port voltage exceed 15 V.

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

- The port is a type defined by an industry standard or convention for use with 12 V systems, including but not limited to cigarette lighter receptacles.
- The product includes an adapter allowing such connectors to be used with the port (without changing the voltage), or such an adapter is separately advertised by the manufacturer.
- The port is advertised to work with one or more DC appliances (other than included lighting appliances).
- The nominal port voltage (whether advertised or not) is between 10.5 V and 15 V, or the range of measured port voltages overlaps with this range.

Ports that would be reasonably expected to provide 12 V, but meet all of the following criteria, need not comply with the lower voltage limit of 10.5 V:

- The port is not a cigarette lighter receptacle and no adapter to convert the port to a cigarette lighter receptacle is included or advertised.
- One of the following is true:
  - The consumer-facing documentation and advertising materials, including but not limited to the packaging, user manual, and manufacturer’s website, do not imply that the product can be used with any appliances other than the included lighting appliances or depict such use, or
  - There is a prominent consumer-facing statement on the product box or user agreement clearly stating that the product can be used only with manufacturer-supplied appliances, whether included or sold separately. No other consumer-facing information may contradict this statement.

Ports that meet the requirements above need not comply with the upper voltage limit if there is a consumer-facing warning on the packaging or user manual that clearly states that user-supplied appliances can be damaged if connected to the port.

## 5 V ports

All ports with a USB form factor and all 5 V ports advertised or reasonably expected to be used for mobile phone charging (including barrel plugs) must meet the requirements below. These standards 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 off-grid product market. Ports must comply with these default limits unless an acceptable reason and clear justification is presented for the port managing current and voltage in a different manner. Acceptance of alternate management schemes is at the discretion of **the market development program, government, or other entity using this document**.

- USB ports shall be able to provide at least 0.5 A at all simulated battery voltages when tested according to IEC/TS 62257-9-5.
- Voltage requirements when the port is operating at a current less than or equal to 0.5 A or **95% of the advertised maximum current (or a power less than or equal to 95% of the advertised power)**, whichever is greater:
  - 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.
  - Maximum steady-state voltage: 5.5 V
- Voltage requirements when the port is operating at a current greater than 0.5 A or **95% of the advertised maximum current (or a power greater than 95% of the advertised power)**, whichever is greater:
  - No minimum steady-state voltage requirement
  - Maximum steady-state voltage: 5.5 V

Separate current ratings may be specified for functionality and for overcurrent protection. The upper limit above refers to the advertised maximum current for functionality.

**The minimum steady-state voltage requirement at the low-battery voltage (4.25 V), may be waived if the port behavior 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. For 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.”**

In the special case that a product has at least two USB ports and at least one of these ports meets the voltage requirements for 5 V ports listed above, the other port may be designed to provide a voltage that exceeds 5.5 V. The maximum steady-state voltage of this port must not exceed 6.0 V under any test conditions and must comply with all other 5 V port requirements listed above. The user manual must include a description of the difference between the two ports, indicate which port is higher voltage, provide a way to identify each port, and state that not all devices will be compatible with the higher voltage port.

There are no requirements for dynamic port performance and the dynamic portion of the ports assessment need not be conducted.

### Ports powered directly from a PV module

Ports that are powered directly from a PV module (without a battery) can be tested by supplying power to the PV input using the apparatus from the solar charge test of IEC TS 62257-9-5 to simulate the PV module performance at TMOT (50°C and 1 000 W/m<sup>2</sup>). All functionality requirements that would normally apply at the typical battery discharge voltage shall apply under these conditions. These ports can also be tested using natural sunlight or a solar simulator meeting the requirements of IEC 60904-9 class BBB. If the product advertises that a mobile phone or other appliance can be charged directly from the PV module, the PV module output should be considered a “port” and should be evaluated according to the requirements described above.

### <sup>i</sup>Notes on Lumen Maintenance

The lumen maintenance standard can be assessed using a 2000-hour test or an expedited method that requires LM80 data for the LEDs. Each of these procedures is outlined in Annex J of IEC/TS 62257-9-5. If the 2000-hour test is used, and the pass/fail determination is made at 1000 hours, the test **may** continue to complete the 2000 hours with no further verdict. The expedited method includes a 500-hour lumen maintenance test and single point temperature measurements of the LED array. The temperature measurements are compared to IESNA

LM80-08 data from the LED manufacturer to determine the lumen maintenance at 2000 hours. For the LM80 method, the lumen maintenance of all samples at 500 hours must be greater than 95% and the average estimated lumen maintenance at 2000 hours must be  $\geq 90\%$  of initial light output, with no more than one sample below 85%. The LM80 test is intended as a way to expedite products entering the market and shall not be used for Renewal or Market Check Method tests.

For products that undergo 500-hour tests with a sample size of two ( $n=2$ ) to qualify for or maintain program support (Renewal, Market Check Method or Accelerated Verification Method tests), both samples must maintain  $\geq 95\%$  of initial light output at 500 hours. If a product fails the 500-hour test, re-testing for the full 2000 hours with either 4 or 6 samples, depending on the product type will be required.

#### <sup>j</sup> *AC Charger Safety*

Approved marks: UL, CE, TÜV, CCC, or similar, with accompanying valid documentation of testing by an accredited test laboratory. Detailed guidelines are described in the [AC Charger Safety Approval Policy](#).

#### <sup>k</sup> *Wiring and Connector Assessment*

This includes that all external cords provided with the product must be capable of carrying the electric currents present during normal operation without exceeding  $50\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$  (measured at  $25\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$  ambient temperature). This requirement is primarily assessed using a declaration from the manufacturer.

#### <sup>l</sup> *PV Safety Tests*

The procedures for these PV safety tests are included as annexes in IEC TS 62257-9-8, but are intended to be added to a future version of IEC TS 62257-9-5. Outside test results to IEC 61730 (all parts) or IEC 61215 (all parts) from an accredited laboratory may be provided to meet some of these requirements. 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. The visual screening, wiring inspection, and when applicable, the bending or folding test, will be conducted on all PV modules, regardless of whether the module already meets the requirements of IEC 61730 or IEC 61215.

#### <sup>m</sup> *Battery Charge Control Details*

Table 2 contains default battery deep discharge protection voltages and Table 3 contains default battery overcharge protection voltages specific to the four common types (i.e., chemistries) of batteries. The deep discharge protection voltage measured according to IEC TS 62257-9-5 shall not be less than the minimum value given in Table 2 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 2 or the value specified by the battery manufacturer, whichever is greater.

The overcharge protection voltage measured according to IEC TS 62257-9-5 shall not exceed the maximum value given in Table 3 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 3 or the value specified by the battery manufacturer, whichever is less. The test laboratory should discontinue the test if the cell temperature exceeds the value given in IEC TS 62257-9-5 or the value specified by the manufacturer, whichever is greater.

Note that the minimum voltage specification for nickel-based batteries only applies in cases where more than one cell is wired in series and if a product with a nickel-based battery 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 2. Default battery deep discharge protection voltage specifications**

Battery type	Deep discharge protection voltage (V/cell)		
	Recommended	Minimum	Maximum
Lead-acid	≥ 2.00	1.95	--
Lithium-ion	≥ 3.00	2.95	--
Lithium iron phosphate	≥ 2.50	2.45	--
Nickel-metal hydride	= 1.00	0.95	1.10

Note: The recommended values for lead-acid batteries correspond to a depth of discharge (DoD) of approximately 50%, which is recommended to improve the cycle life of the battery. In practice, the recommended deep discharge will vary according to the design of the battery and the desired cycle life. The recommended values for other battery types are designed to protect the battery from damage.

**Table 3. Default battery overcharge protection voltage specifications**

Battery type	Overcharge protection voltage (V/cell)		
	Recommended	Minimum	Maximum
Lead-acid	= 2.40	2.35	2.45
Lithium-ion	≤ 4.20	--	4.25
Lithium iron phosphate	≤ 3.65	--	3.70
Nickel-metal hydride	≤ 1.45	--	1.50

<sup>n</sup> *Charge Control Exception for Certain PAYG Products*

The requirement for PAYG products to be able to charge the battery in a disabled state may be waived for products using lithium-based batteries in cases where the product is designed to protect the battery from damage when not charged for extended durations (e.g. up to one year). The design shall also ensure the product can still charge once payment is made and the charging system is re-connected. The preventive measures shall address both the discharge during use and self-discharge of the battery and shall prevent the battery from being charged if it has been discharged to an unsafe voltage. [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.]

<sup>o</sup> *Battery Durability Storage Test Exceptions and Details*

The battery durability storage test requirement may be waived for flooded lead acid batteries which are shipped dry. (In cases where batteries are shipped dry, manufacturers must provide the test labs with an adequate amount of the appropriate electrolyte solution or accurately specify the density and composition of the solution to be used.) The requirement may also be waived for lithium iron phosphate batteries that have been tested according to and meet the requirements of the type tests specified in IEC 61427-1; third-party test results to IEC 61427-1 from an accredited laboratory may be provided as evidence.

When undergoing MCM, AVM, or renewal testing (i.e., testing with a sample size less than 4), no sample shall have a capacity loss exceeding 35% following the battery durability storage test.

<sup>p</sup> *PAYG Quality and Durability*

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

<sup>q</sup> *References to Other Standards*

Some quality and durability requirements may be waived for non-lighting appliances that can be proven to meet other relevant standards. For instance, the following tests may be waived if the manufacturer provides evidence (test report, certification and/or other relevant documentation) showing that the appliance meets an

internationally recognized standard for appliance safety, such as IEC 60065 or IEC 62368-1 (for TVs and radios) and IEC 60335 (for fans).

- Physical ingress protection,
- Strain relief,
- Switch, gooseneck, moving part, and connector durability,
- Drop test,

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

At the discretion of the market development program, government, or other organization using this document, other internationally recognized standards may be referenced in lieu of certain appliance tests specified in IEC TS 62257-9-5. For example, Global LEAP testing may be referenced in lieu of the power consumption test, appliance operating voltage range test, and physical ingress protection test for TVs, fans, and refrigerators.

If a lighting appliance without a battery has been tested according to IEC TS 62257-12-1, results may be referenced for light output, physical and water ingress, mechanical durability, light distribution, lumen maintenance, and appliance voltage range, though some conditions apply.

#### <sup>r</sup> *PV Cable Length*

PV cables must be at least 3 m long when connecting a "fixed indoor" or "portable separate" component to the PV module or any other fixed outdoor component. Otherwise, components will be considered "fixed outdoor" or "portable integrated."

#### <sup>s</sup> *Water Ingress Protection Details*

There are two alternative water protection compliance pathways to meeting the IP class requirements. In one alternative ("technical equivalent"), the whole system of protection (ingress protection + electronic circuit protection + manufacturing QC) is evaluated to determine if the protection level is equivalent to that of a product with the required level of ingress protection. In another alternative ("warning label") there are clear messages to the consumer about the degree of protection from water. The warning level messages must meet specific guidelines. The pathways and associated guidelines are described in greater detail in a document titled "[Integrated Water Protection Assessment](#)." Additional guidance on testing IP requirements for PV modules is in a document titled "[Test Methods for Ingress Protection for PV Modules](#)."

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

#### <sup>t</sup> *Dangerous Failures*

Dangerous failures are defined as those which may 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).

#### <sup>u</sup> *Mechanisms Expected to be Used Primarily During Installation*

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

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

#### <sup>v</sup> *Outdoor Cables*

Requirements for outdoor cables are detailed in the “[Solar Home System Testing Policy for Outdoor-rated Cables.](#)”

#### <sup>w</sup> *PV Overvoltage Details*

If the product has output ports, the product shall have sufficient protection from PV overvoltage as determined by the PV overvoltage protection test of IEC/TS 62257-9-5. 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. For ports with a nominal port voltage of 5 V, the allowable port voltage limit shall be 6.0 V, which deviates from the limit listed in IEC/TS 62257-9-5. Allowable port voltage limits for 6 V and 12 V ports are as listed in IEC TS 62257-9-5. If the allowable port voltage limit for a port is not listed in IEC TS 62257-9-5, the allowable port voltage limit shall be 1.3167 times the nominal voltage of the port (e.g. the limit for a 9 V port would be 11.85 V). The PV overvoltage protection requirement is not applicable to ports that are powered directly from a PV module (without a battery).

#### <sup>x</sup> *Electrical Connection Requirements*

All electrical connections, other than permanently installed connections made at the time of installation, must be made using plug-and-socket connectors without the use of tools.

Permanently installed connections that are made at the time of installation may be made with screw terminals, spring or lever-actuated terminals, quick disconnect (blade) terminals, or similar methods, provided that the following requirements are met:

- The connection is straightforward to make, provides a good quality electrical connection, and does not require technical expertise to make, such as wrapping wire in a specific direction, soldering, or crimping in the field. For example, the following connections are **not** eligible (note, this is not a comprehensive list):
  - Alligator (crocodile) clips
  - Connections made in the field that require soldering or crimping
  - Screw terminals or binding posts in which the wire is wrapped around the screw and held in place with the screw head or nut, rather than being clamped between two plates or washers. For instance, some binding posts have a hole to insert the wire; in others the wire needs to be wrapped around the post. The latter type requires slightly more care to make a good connection; those that require wrapping the wire are not permitted due to the increased likelihood of the connection being improperly made.
  - Twist-on wire connectors (wire nuts) or wires twisted together
- Adequate instructions are provided for making each type of connection, including:
  - A list of all required tools.
  - Sufficient instructions, including illustrations, to make each type of connection so that it will be safe and reliable.
- After installation, all terminals, other than connections on the charge controller, must be insulated so that no live electrical parts can be contacted or must 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 must be insulated.

Connectors on charge controllers need not be enclosed or insulated, but shall be designed in a way to minimize the potential for short-circuiting, such as with plastic dividers.

Additionally, the leads from the battery to the charge controller shall have short circuit protection which will be assessed by inspection. This protection shall be located as close to the battery as practical.

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

- The potential maximum current from all sources (the entire array) does not exceed the ampacity of the conductors.
- The battery or load is incapable of back-feeding power to the array.

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

NOTE: In most cases, these connections are not considered to be “sensitive electronics,” and therefore the physical and water ingress protection requirements according to IEC/TS 62257-9-5 are as follows:

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

[If connections other than plug-and-socket connectors are required, the following notice will be included in the VeraSol/Lighting Global Specification Sheet and Verification Letter/Type Approval and on the VeraSol/Lighting Global website: “Some connections required for installation of this product are not plug-and-play. VeraSol/Lighting Global verification assesses the performance of the system but cannot assess proper installation of the product.”]

<sup>y</sup> *User Manual Requirements*

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

- How to connect the PV module to the unit for charging.
- Instructing the user not to shade the PV module.
- Facing the PV module surface toward sun.
- How to make all required permanent connections.
- How to connect all advertised appliances.

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

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