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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Secondary cells and batteries for renewable energy storage – General requirements and methods of test – Part 1: Photovoltaic off-grid application

Accumulateurs pour le stockage de l'énergie renouvelable – Exigences générales et méthodes d'essais – Partie 1: Applications photovoltaïques hors réseaux

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SECONDARY CELLS AND BATTERIES FOR RENEWABLE ENERGY STORAGE – GENERAL REQUIREMENTS AND METHODS OF TEST –

Part 1: Photovoltaic off-grid application

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International Standard IEC 61427-1 has been prepared by IEC technical committee 21: Secondary cells and batteries.

This first edition cancels and replaces the second edition of IEC 61427 published in 2005.This edition constitutes a technical revision.

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

a) a restructuration of the previous edition of the document;
b) a clarification of the different clauses with regard to conditions of use, general requirements, functional characteristics, general tests conditions, test method and recommended use of tests, the aim being to ensure a better understanding by the end user;
c) a clear distinction between on-grid and off-grid applications for future markets needs.

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

FDIS	Report on voting
21/793/FDIS	21/802/RVD

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

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

A list of all parts in the IEC 61427 series, published under the general title *Secondary cells and batteries for renewable energy storage – General requirements and methods of test*, can be found on the IEC website.

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

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- withdrawn,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

SECONDARY CELLS AND BATTERIES FOR RENEWABLE ENERGY STORAGE – GENERAL REQUIREMENTS AND METHODS OF TEST –

Part 1: Photovoltaic off-grid application

1 Scope

This part of the IEC 61427 series gives general information relating to the requirements for the secondary batteries used in photovoltaic energy systems (PVES) and to the typical methods of test used for the verification of battery performances. This part deals with cells and batteries used in photovoltaic off-grid applications.

NOTE The part 2 of this series will cover cells and batteries used in “renewable energy storage in on-grid applications”.

This International Standard does not include specific information relating to battery sizing, method of charge or PVES design.

This standard is applicable to all types of secondary batteries.

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at <www.electropedia.org>)

IEC 60622, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Sealed nickel-cadmium prismatic rechargeable single cells*

IEC 60623, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells*

IEC 60896-11, *Stationary lead-acid batteries – Part 11: Vented types – General requirements and methods of test*

IEC 60896-21, *Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test*

IEC 61056-1, *General purpose lead-acid batteries (valve-regulated types) – Part 1: General requirements, functional characteristics – Methods of test*

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

IEC 61951-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells – Part 1: Nickel-cadmium*

IEC 61951-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells – Part 2: Nickel-metal hydride*

IEC 61960, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for portable applications*

IEC 62259, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Nickel-cadmium prismatic secondary single cells with partial gas recombination*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-482 concerning secondary cells and batteries, and those given in IEC 61836 concerning photovoltaic generator systems apply.

4 Conditions of use

4.1 General

This clause specifies the particular operating conditions experienced by secondary batteries during their use in photovoltaic applications.

4.2 Photovoltaic energy system

The photovoltaic energy system with secondary batteries referred to in this standard can supply a constant, variable, or intermittent energy to the connected equipment (pumps, refrigerators, lighting systems, communication systems, etc.).

4.3 Secondary cells and batteries

Secondary cells and batteries mainly used in photovoltaic energy systems are of the following types:

a) vented (flooded);

b) valve-regulated, including those with partial gas recombination;

c) gastight sealed.

The cells and batteries are normally delivered in the following state of charge:

d) discharged and drained (vented nickel-cadmium batteries only);

e) charged and filled;

f) dry charged and unfilled (vented lead-acid batteries only);

g) discharged and filled (nickel-cadmium batteries only).

For optimum service life, the battery manufacturer’s instructions for initial charge of the battery shall be followed.

Other secondary cells and batteries such as based on sodium or vanadium electrochemical systems can be potentially used for such an application. Due to the fact that they are in a phase of adaptation for a possible use in PV systems, it is recommended that their respective supplier be contacted for the necessary planning, test and operation details.

4.4 General operating conditions

4.4.1 General

Batteries in a typical PV system operating under average site weather conditions may be subjected to the following conditions.

4.4.2 Autonomy time

The battery is designed to supply energy under specified conditions for a period of time, typically from 3 days to 15 days without solar irradiation.

When selecting the required battery capacity, the following items should be considered, e.g.:

- required daily/seasonal cycle (there may be restrictions on the maximum depth of discharge);
- time required to access the site;
- ageing;
- operating temperature;
- future expansion of the load.

4.4.3 Typical charge and discharge currents

The typical charge and discharge currents are the following:

– maximum charge current: I_{20} (A)
– average charge current: I_{50} (A)
– average discharge current as determined by the load: I_{120} (A)

Depending on the system design, the charge and the discharge current may vary in a wider range.

In some systems the load current must be supplied at the same time as the battery charging current.

NOTE 1 The following abbreviations are used:

- C_{rt} is the rated capacity declared by the manufacturer in ampere-hours (Ah)
- t is the time base in hours (h) for which the rated capacity is declared
- $I_{rt} = C_{rt}/t$

For Nickel Cadmium, Nickel Metal Hydride and Lithium battery systems

- $I_{rt} = C_{rt}/1$h in this document corresponds to $I_t = C_5/1$h

4.4.4 Daily cycle

The battery is normally exposed to a daily cycle as follows:

a) charging during daylight hours;
b) discharging during night-time hours.

A typical daily usage results in a discharge between 2 % to 20 % of the battery capacity.

4.4.5 Seasonal cycle

The battery may be exposed to a seasonal cycle of its state of charge. This arises from varying average-charging conditions as follows:

- periods with low solar irradiation, for instance during winter causing low energy production. The state of charge of the battery (available capacity) can go down to 20 % of the rated capacity or less;
- periods with high solar irradiation, e.g. in summer, which will bring the battery up to the fully charged condition, with the possibility that the battery could be overcharged.

4.4.6 Period of high state of charge

During summer for example, the battery will be operated at a high state of charge (SOC), typically between 80 % and 100 % of rated capacity.

A voltage regulator system normally limits the maximum battery voltage during the recharge period.

NOTE In a "self-regulated" PV system, the battery voltage is not limited by a charge controller but by the characteristics of the PV generator.

The system designer normally chooses the maximum charge voltage of the battery as a compromise allowing to recover to a maximum state of charge (SOC) as early as possible in the summer season but without substantially overcharging the battery.

The overcharge increases the gas production resulting in water consumption in vented cells. In valve-regulated lead-acid cells, the overcharge will cause less water consumption and gas emission but more heat generation.

Typically the maximum charge voltage is 2,4 V per cell for lead-acid batteries and 1,55 V per cell for vented nickel-cadmium batteries at the reference temperature specified by the manufacturer. Some regulators allow the battery voltage to exceed these values for a short period as an equalizing or boost charge. For the other batteries the battery manufacturers shall give the most adapted charge voltage values. Charge voltage compensation shall be used according to the battery manufacturer instructions if the battery operating temperature deviates significantly from the reference temperature.

The expected lifetime of a battery in a PV system, even kept regularly at a high state of charge, may be considerably less than the published life of the battery used under continuous float charge conditions.

4.4.7 Period of sustained low state of charge

During periods of low solar irradiation, the energy produced by the photovoltaic array may not be sufficient to fully recharge the battery. The state of charge will then decrease and cycling will take place at a low state of charge. The low solar irradiation yield of the photovoltaic array may be a result of the geographical location combined with the winter periods, heavy clouds, rains or accumulation of dust on the photovoltaic array.

4.4.8 Electrolyte stratification

Electrolyte stratification may occur in lead-acid batteries. In vented lead-acid batteries, electrolyte stratification can be avoided by electrolyte agitation/recirculation or by periodic overcharge whilst in service. In valve regulated lead-acid (VRLA) batteries, electrolyte stratification can be avoided by design or by operating them according to the manufacturer’s instructions.

4.4.9 Storage

Manufacturers’ recommendations for storage shall be observed. In the absence of such information, the storage period may be estimated according to the climatic conditions as shown in Table 1 as below.

Table 1 – Limit values for storage conditions of batteries for photovoltaic applications

Battery type	Temperature range °C	Humidity %	Storage period for batteries	
			With electrolyte	Without electrolyte
Lead-acid	-20 to +40	< 90	Up to 12 months (depending of the design)	1-2 years (dry charged)
Nickel-cadmium	-20 to +50 (standard electrolyte) -40 to +50 (high density electrolyte)	< 90	Up to 6 months	1-3 years (fully discharged, drained and sealed)
Nickel metal hydride	-40 to +50	< 90	Up to 6 months	N/A
Lithium Ion	-20 to +50	< 90	Up to 12 months	N/A

The exact limits of storage conditions are to be verified with the manufacturer.

Lead-acid or nickel-cadmium batteries with electrolyte shall be stored starting from a state at full charge.

A loss of capacity may result from exposure of a battery to high temperature and humidity during storage.

The temperature of a battery stored in a shipping container in direct sunlight, can rise to +60 °C or more in daytime. Choice of a shaded location or cooling should avoid this risk.

4.4.10 Operating temperature

The temperature range during operation experienced by the battery at the site is an important factor for the battery selection and the expected lifetime (see IEC 60721-1 for definitions of climatic conditions).

Manufacturers' recommendations for operating temperatures and humidity shall be observed.

In the absence of such information, operating temperatures and humidity may be those shown in Table 2.

Table 2 – Limit values for operating conditions of batteries for photovoltaic applications

Battery type	Temperature range °C	Humidity %
Lead-acid	-15 to +40	< 90
Nickel-cadmium (standard electrolyte)	-20 to +45	< 90
Nickel-cadmium (high density electrolyte)	-40 to +45	< 90
Nickel-metal hydride	-20 to +45	< 90
Lithium-ion and other electro chemistries	To be verified with the battery manufacturer	To be verified with the battery manufacturer

The manufacturer should be consulted for operation at temperatures outside this range. Typically the life expectancy of batteries will decrease with increasing operating temperature.

Low temperature will reduce the discharge performance and the capacity of the batteries. For details, the manufacturer should be consulted.

4.4.11 Charge control

Excessive overcharge does not increase the energy stored in the battery. Instead, overcharge affects the water consumption in vented batteries and consequently the service interval. In addition, valve-regulated lead-acid batteries may dry out resulting in a loss of capacity and / or overheating.

Overcharge can be controlled by the use of proper charge controllers. Most non-aqueous systems, such as lithium-ion batteries and similar, will not accept any overcharge without damage or safety problems. Such batteries are normally supplied with a BMS (battery management system) that prevents, independently from its charge controller, that such overcharge happens.

The parameters of the regulator shall take into account the effects of the PV generator design, the load, the temperature and the limiting values for the battery as recommended by the manufacturer.

Vented lead-acid or nickel-cadmium batteries including those with partial gas recombination shall have sufficient electrolyte to cover at least the period between planned service visits. Overcharge in valve-regulated lead-acid batteries shall be carefully controlled to be able to reach the expected service life.

The water consumption is measured during the cycle test (see 8.4.6) and can be used together with the system's design information to estimate the electrolyte service intervals.

4.4.12 Physical protection

Physical protection shall be provided against consequences of adverse site conditions, for example, against the effects of:

- uneven distribution and extremes of temperature;
- exposure to direct sun light (UV radiation);
- air-borne dust or sand;
- explosive atmospheres;
- flooding, water vapour condensation and sea water spray;
- earthquakes;
- shock and vibration (particularly during transportation).

5 General requirements

5.1 Mechanical endurance

Batteries for photovoltaic application shall be designed to withstand mechanical stresses during transportation and handling taking in account that PVES installations may be accessed via unpaved roads and installed by less qualified personnel. Additional packing or protection shall be provided for off-road conditions.

Particular care shall be taken while handling unpacked batteries. Manufacturer's instructions shall be observed.

In case of specific requirements regarding mechanical stresses, such as earthquakes, shock and vibration, these shall be individually specified or referred to in a relevant standard.