SLOVENSKI STANDARD
oSIST prEN IEC 61427-2:2023

01-junij-2023

Sekundarni členi in baterije za shranjevanje obnovljive energije - Splošne zahteve in preskusne metode - 2. del: Omrežne izvedbe

Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 2: On-grid applications

Wiederaufladbare Zellen und Batterien für die Speicherung erneuerbarer Energien - Allgemeine Anforderungen und Prüfverfahren - Teil 2: Netzgekoppelte Anwendungen

Accumulateurs pour le stockage de l'énergie renouvelable - Exigences générales et méthodes d'essais - Partie 2: Applications en réseau

Ta slovenski standard je istoveten z: **prEN IEC 61427-2:2023**

ICS:

27.160	Sončna energija	Solar energy engineering
29.220.20	Kislinski sekundarni členi in baterije	Acid secondary cells and batteries

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21/1166/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 61427-2 ED1/AMD1***	
DATE OF CIRCULATION: **2023-04-21**	CLOSING DATE FOR VOTING: **2023-07-14**
SUPERSEDES DOCUMENTS: **21/1159/CD, 21/1165/CC**	

IEC TC 21 : SECONDARY CELLS AND BATTERIES

SECRETARIAT: France	SECRETARY: Mr Yves BOUDOU
OF INTEREST TO THE FOLLOWING COMMITTEES: SC 21A,TC 82,TC 88,TC 120	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING
Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of

- any relevant patent rights of which they are aware and to provide supporting documentation,
- any relevant “in some countries” clauses to be included should this proposal proceed. Recipients are reminded that the enquiry stage is the final stage for submitting "in some countries" clauses. See AC/22/2007.

TITLE:

Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 2: On-grid applications

PROPOSED STABILITY DATE: 2027

NOTE FROM TC/SC OFFICERS:

*Please be informed that the project was erroneously registered as an ED2 instead of an Amendment 1 to ED1. Please note that the project number has been updated accordingly.

Text to be added at the end of clause 6.1 in the main body of the standard.

6 Battery endurance

6.1 General

to be added at end of clause 6.1

Since the publication of IEC 61427-2 in 2015, details of a complex pattern of energy exchange in frequency-regulation duty, at 4 s intervals and over a 24 h period, has been published in the PNNL-22010 Rev 2/ SAND 2016-3078 R Report.

In Annex B (informative) details of this energy exchange profile are made available for evaluating, if useful, the service-induced decay of battery performance also with a more randomized usage pattern compared to that offered by the symmetric 6.2 profile.

Text to be added after Annex A

Annex B
(Informative)

B.1 Introduction

The batteries in on-grid electrical energy storage (EES) applications provide and accept the energy needed to maintain the mains frequency within specified limits. This exchange of energy results in multiple charge and discharge events per hour in the electrochemically active masses of the battery. The order, intensity and duration of these events influences the stability and activity of the involved active mass structures and hence the endurance of the batteries.

This additional test procedure for evaluating battery performance under frequency-regulation service, is based on data acquired by actual monitoring of a regional transmission organization grid frequency balancing signal by Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (SAND) in the USA.

The balancing signal data are reported in section 5.3.2 Frequency regulation duty cycle of the document PNNL-22010 Rev 2 / SAND 2016-3078 R - Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems and dated April 2016.

The complex pattern of energy exchange and the associated procedures described in B.2, can be used as a tool to complement and reinforce, as appropriate or useful, the information on the service-induced decay of battery performance gathered with the test profile in 6.2. The profile in 6.2 remains however the normative profile if product comparisons or qualifications are carried out.

The test and associated test profile specified in B.3 is optional; it is not necessary to carry it out to claim conformance with the document.

However, if this test is carried out, it shall be executed as specified in B.3.

B.2 The Annex B profile for evaluating battery endurance in frequency-regulation duty

The Annex B profile consists in a sequence of 2 h average and 2 h aggressive signal levels reflecting the deviation from the grid frequency dead band and the resulting demand to deliver energy from or store in the battery of the frequency-regulation application. Each signal specifies a constant power level for a duration of 4s resulting in 1800 signal levels per 2 h period. The adjective of average and aggressive reflects the intensity of the energy flow to and from the battery.

Over 24 h, the Annex B duty cycle consists of a sequence with three 2-hour duration average signal deviation levels, one 2-hour duration aggressive signal deviation level, three 2-hour duration average signal deviation levels, one 2-hour duration aggressive signal deviation level and four 2-hour duration average signal deviation

levels. The values of average and aggressive deviation signal level, forming the 24h duty cycle as shown in Figure B.1, are listed in a spreadsheet.

The file containing the spreadsheet is available for download on the IEC platform via
https://collaborate.iec.ch/#/pages/workspaces/200650/documents/63751/details/691813?onlyWithPreview=false&fileId=691813

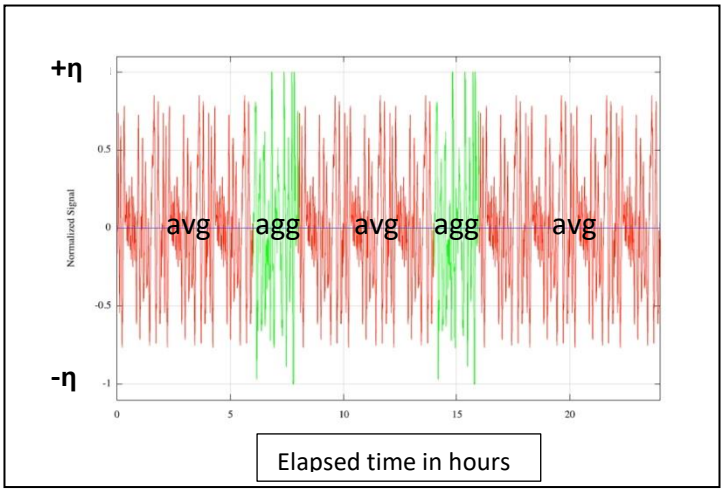

Figure B.1 – 24 h sequence of the Annex B profile for a supplemental evaluation of the service-induced performance decay of a battery in frequency-regulation service

The exchanged power η is normalized with respect to the rated power of the EES application where the positive value represents a discharge from the battery and negative value a charge into the battery.

The longest duration at full discharge power or η = 1.0 is 52 s. The daily averaged power level is 30 % of the rated power capability of the EES system. The amount of energy charged daily into the battery (Wh-in) is equal to the daily amount of energy discharged (Wh-out).

This will result, due to a roundtrip Wh efficiency of <1.0, in a slow walk-down of the battery capacity over time requiring periodic auxiliary charge energy input to re-establish the proper target level of operational state of charge (SoC_{OT}) required to fulfil all peak power demands. The SoC_{OT} level is specific for each type of battery and application and is specified by the battery manufacturer.

It is recommended that the machine instructions or commands for the power levels during a full 24h-duration duty cycle, are broken down into the appropriate consecutive sequences of 2 h with 1800 signal levels each. This facilitates the upload and the execution of the power level setting instructions by the control unit of the battery cycling equipment.

The overall composite 24 h instruction set is the following

Start the 24h sequence
- Go to data set of a 2h sequence at average power level and execute set 3 times
- Go to data set of a 2h sequence at aggressive power level and execute set 1 time
- Go to data set of a 2h sequence at average power level and execute set 3 times
- Go to data set of a 2h sequence at aggressive power level and execute set 1 time
- Go to data set of a 2h sequence at average power level and execute set 4 times

Stop the 24h sequence

B.3 Test procedure

Annex B is informative in nature i.e., it is given for information purposes only.

The test given in B.3 is optional; it is not necessary to carry it out to claim conformance with the document.

However, if this test is carried out, it shall be executed as specified in B.3.

The procedure makes reference to the requirements in 5 and 6 of this document in order to provide boundary conditions comparable to those required for tests with the profile in 6.2.

B.3.1 The Full-sized battery (FSB) shall be selected according to 5.3. and meet the bidirectional absolute power level requirements of η = 1.0 or 1 000 kW of the composite 24 h Annex B profile at the selected initial SoC_{OT} and within the voltage limits specified by the manufacturer. The battery shall be operated at an ambient temperature of + 25 °C ± 3 K or as appropriate for the battery design.

B.3.2 The manufacturer shall report how many cells, modules or stacks make up such an FSB. This value is termed *n*.

B.3.3 The manufacturer shall define the fraction of power (1000/*n*) kW such a cell, module or stack will deliver or accept when it is part of the FSB and this battery meets the condition in B.3.1.

B.3.4 The manufacturer shall assemble with *x* of such cells, modules or stacks the appropriate Test object battery (TOB) having at least

1) four (4) cells in series (only if these cells are commercialized individually),
or
2) one or more modules that result in at least four (4) cells in series,
or
3) one stack with at least four (4) flow cells in series,

and incorporate the relevant BMS and BSS peripherals.

B.3.5 When a battery based EES application with different power capability and/or energy content requires to be tested according with this part of IEC 61427-2, then such choice is acceptable provided that all other testing provisions are fulfilled and this deviation is stated in the test documentation.

B.3.6 The actual energy content *E* (in kWh) of this TOB, after the manufacturer-specified full charge and thermal equilibration in air at +25 °C ± 3 K ambient temperature or as appropriate for the battery design, shall be determined with a constant power discharge at the (x × 500/n) kW power level to the final voltage U_{final} or to the BMS mandated discharge limit as specified by the manufacturer. The energy content value is for comparison purposes as needed in other clauses.

B.3.7 The TOB shall then be fully recharged according to the manufacturer's specifications.

B.3.8 The TOB shall then be discharged to such a SoC_{OT} that it can repetitively deliver and accept the fractional power and energy levels of the 24 h Annex B profile without exceeding the manufacturer's specified operating voltage limits.

B.3.9 The manufacturer shall report this SoC_{OT} level, expressed as a percentage of the actual energy content as determined in B.3.6 and ways to achieve it.

B.3.10 The TOB shall then be submitted, at an ambient temperature of +25 °C ± 3 K or as appropriate for the battery design, to a 24 h Annex B profile consisting of a sequence of average and aggressive power level periods as described in B.2. The battery voltage and the cumulative discharged and charged capacity (in Ah) and energy (in kWh) of the TOB shall be monitored and recorded once at the end of each 4 s constant power segment.

B.3.11 After completing a 24 h Annex B test sequence, the TOB shall be immediately discharged for 52s at its actual temperature with a power equivalent to (1000/*n*) kW and the reached final voltage level monitored and recorded.

B.3.12 If the TOB voltage in B.3.10 and B.3.11 exceeds the upper and lower limits of operating voltages then the energy-delivery and energy-acceptance capability under frequency-regulation service of the TOB and by derivation that of the FSB, shall be considered degraded and the procedure B.3.13 carried out.

B.3.13 The proper functioning of the battery shall be reestablished with a charge or discharge whose power levels shall not exceed (1000/*n*) kW. The voltage levels encountered in this charge or discharge shall

not exceed the upper and lower limits of operating voltages defined for the Annex B profile. The conditions of this performance recovery action shall be specified by the manufacturer and take in consideration commercial viability, contractual and timing constraints in frequency-regulation service.

B.3.14 Suggested metrics for the evaluation of the performance of a battery in simulated frequency-regulation service with the 24 h Annex B profile sequence are

1) Energy content level of the TOB as determined in B.3.6
2) Voltage levels of the battery during a 24 h Annex B profile sequence
3) Cumulated amount of energy discharged in a 24 h Annex B profile sequence from the battery
4) Cumulated amount of energy charged in a 24 h Annex B profile sequence into the battery
5) SoC_{OT} level at the conclusion of each 24 h Annex B profile sequence
6) Number of 24 h Annex B profile sequences carried out before conditions of B.3.12 are encountered
7) Plot of the achieved number of Annex B profile sequences vs. elapsed days in the endurance test
8) Amount of energy (kWh) consumed to reestablish proper functioning of the battery as per B.3.13
9) Duration in minutes of the B.3.13 activity before the battery returns to regular Annex B profile-based frequency-regulation service
10) Power levels in the form of a W vs. time profile of the B.3.13 activity
11) Ampere hour capacity as per B.3.6 and/or internal resistance of the battery at selected intervals to quantify capacity or internal conductivity degradation
12) Any battery design-specific parameter revealing its actual status of health, or inverse, its degree of performance degradation

B.3.15 The endurance test steps B.3.10 to B.3.13 shall be carried until the planned service life and commercial viability of the battery in frequency-regulation service has been demonstrated based on the data gathered and analyzed as per B.3.14

B.4 Examples of data acquired with the 6.2 and the 24 h Annex B sequence

Figure B.2 and B.3 show examples of a graphical display of selected battery data acquired with the 6.2 c and the 24 h Annex B profile sequences. A same battery type was submitted to test conditions simulating frequency-regulation duty and in both cases the acquired data revealed charge acceptance issues.

When tested with the 6.2 c profile, this deficiency is characterized by escalating on-charge voltages which inhibit full SoC_{OT} adaptations within the voltage window of the frequency-regulation installation.

When tested with the Annex B sequence profile, a decaying charge acceptance and SoC_{OT} is observed that results in reduced operating time in frequency-regulation duty before a performance recovery action becomes again necessary.

If not corrected, these deficiencies impair the commercial viability of the frequency-regulation plant equipped with this type of battery.

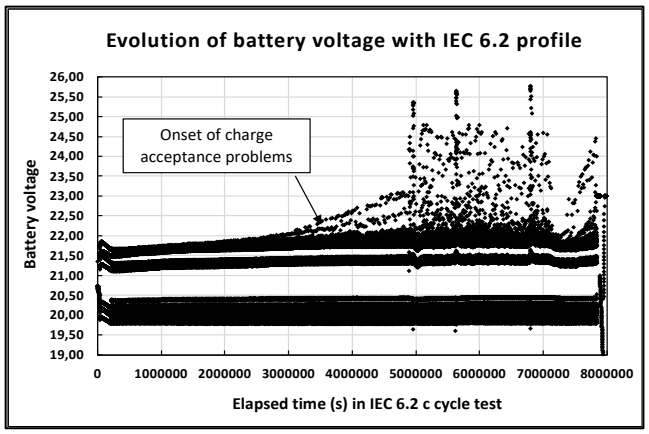

Figure B.2 Development of excessive on-charge voltage levels after about 40 days of simulated frequency-regulation with

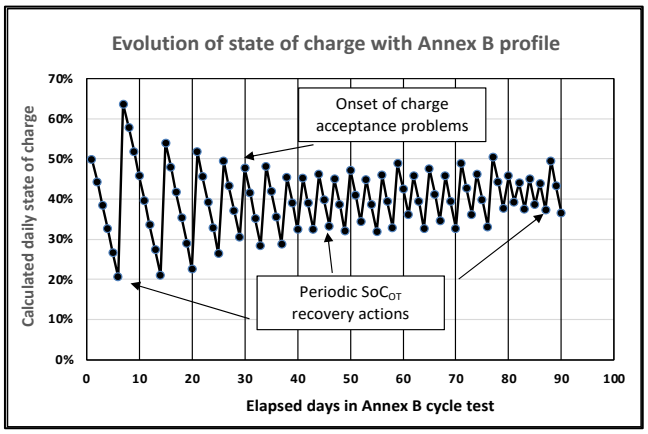

Figure B.3 Decay of charge acceptance resulting, after about 20 days, in the need of an increased incidence of SoC_{OT} recovery