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INTERNATIONAL STANDARD

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AMENDMENT 1
AMENDEMENT 1

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

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

IEC 61427-2:2015-08/AMD1:2024-03(en-fr)

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

Part 2: On-grid applications

AMENDMENT 1

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Amendment 1 to IEC 61427-2:2015 has been prepared by IEC technical committee 21: Secondary cells and batteries.

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

Draft	Report on voting
21/1179/FDIS	21/1194/RVD

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

The language used for the development of this Amendment is English.

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

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

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

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6 Battery endurance

6.1 General

Add the following at the end of 6.1:

Since the publication of this document in 2015, details of a complex pattern of energy exchange in frequency-regulation duty, at 4 s intervals and over a 24 h period, have been published by Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (SAND) 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.

6.2 Test for endurance in frequency-regulation service

Add the following sentence as a new paragraph after the existing list item r).

See Annex B for supplemental test profile for frequency regulation duty service.

Add the following new annex after Annex A:

Annex B
(informative)

Supplemental test profile for frequency regulation duty service

B.1 General

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. This data is available as a spreadsheet on the IEC website courtesy of the Pacific Northwest National Laboratory, operated by Battelle for the U.S. Department of Energy. The spreadsheet, SAND2013-7315P profile details.xlsx can be accessed via TC 21 supporting documents on the IEC website – www.iec.ch/tc21/supportingdocuments. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the data named.

The complex pattern of energy exchange and the associated procedures described in Clause 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 required profile if product comparisons or qualifications are carried out.

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

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

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

The Annex B profile consists of 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 4 s resulting in 1 800 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-h duration average signal deviation levels, one 2-h duration aggressive signal deviation level, three 2-h duration average signal deviation levels, one 2-h duration aggressive signal deviation level and four 2-h duration average signal deviation levels. The values of average and aggressive deviation signal level, forming the 24 h duty cycle as shown in Figure B.1, are listed in the abovementioned spreadsheet on the IEC website.

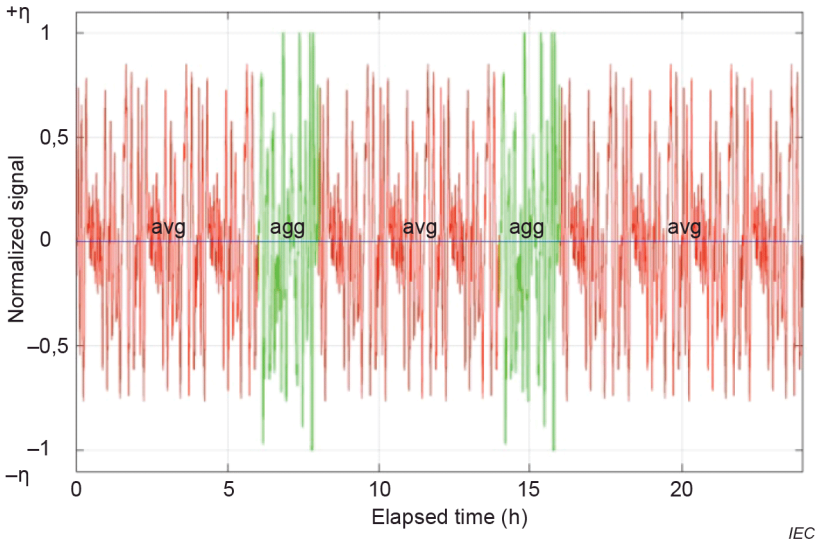

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Figure B.1 – 24 h sequence of the Annex B profile for a supplemental evaluation of the service-induced performance decay of a battery in frequency-regulation service

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 24 h-duration duty cycle be broken down into the appropriate consecutive sequences of 2 h with 1 800 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 24 h sequence

– Go to data set of a 2 h sequence at average power level and execute set 3 times,
– Go to data set of a 2 h sequence at aggressive power level and execute set 1 time,
– Go to data set of a 2 h sequence at average power level and execute set 3 times,
– Go to data set of a 2 h sequence at aggressive power level and execute set 1 time,
– Go to data set of a 2 h sequence at average power level and execute set 4 times,

Stop the 24 h sequence.

B.3 Test procedure

B.3.1 Annex B is informative in nature, i.e., it is given for information purposes only.

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

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

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

B.3.2 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.3.3 The manufacturer shall report how many cells, modules or stacks make up such an FSB. This value is termed n.

B.3.4 The manufacturer shall define the fraction of power (1 000 / 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.3.2.

B.3.5 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.3.6 When a battery based EES application with different power capability and/or energy content is required to be tested in accordance with this Annex B, then such a choice is acceptable provided that all other testing provisions are fulfilled and this deviation is stated in the test documentation.

B.3.7 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.3.8 The TOB shall then be fully recharged according to the manufacturer's specifications.

B.3.9 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.3.10 The manufacturer shall report this SoC_{OT} level, expressed as a percentage of the actual energy content as determined in B.3.7 and ways to achieve it.

B.3.11 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 Clause 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.3.12 After completing a 24 h Annex B test sequence, the TOB shall be immediately discharged for 52 s at its actual temperature with a power equivalent to (1 000 / n) kW and the reached final voltage level monitored and recorded.

B.3.13 If the TOB voltage in B.3.11 and B.3.12 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.3.14 carried out.

B.3.14 The proper functioning of the battery shall be re-established with a charge or discharge whose power levels shall not exceed (1 000 / 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 into consideration commercial viability, contractual and timing constraints in frequency-regulation service.

B.3.15 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.3.7.
2) Voltage levels of the battery during a 24 h Annex B profile sequence.
3) Cumulated amount of capacity discharged in a 24 h Annex B profile sequence from the battery.
4) Cumulated amount of capacity 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.3.13 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 re-establish proper functioning of the battery as per B.3.14.
9) Duration in minutes of the B.3.14 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.3.14 activity.
11) Ampere hour capacity as per B.3.7 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 inversely, its degree of performance degradation.

B.3.16 The endurance test steps B.3.11 to B.3.14 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 analysed as per B.3.15.

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

Figure B.2 and Figure B.3 show examples of a graphical display of selected battery data acquired with the 6.2 c profile 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.

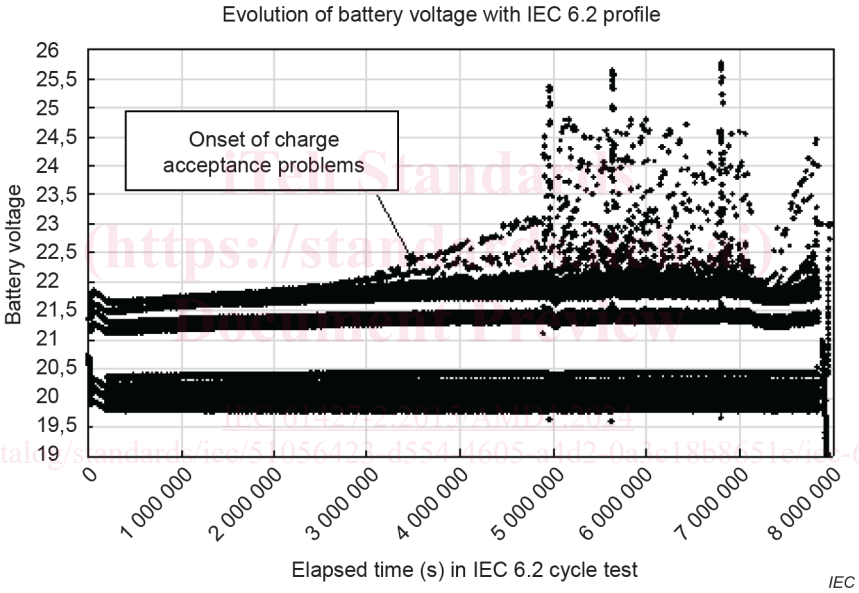

Figure B.2 – Development of excessive on-charge voltage levels after about 40 days of simulated frequency-regulation with the 6.2 c profile