IEC 62932-2-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Flow battery energy systems for stationary applications –
Part 2-1: Performance general requirements and test methods

Systèmes de production d'énergie à batteries d'accumulateurs à circulation d'électrolyte pour les applications stationnaires –
Partie 2-1: Exigences générales de performances et méthodes d'essai

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FLOW BATTERY ENERGY SYSTEMS FOR STATIONARY APPLICATIONS –

Part 2-1: Performance general requirements and test methods

FOREWORD

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International Standard IEC 62932-2-1 has been prepared by IEC technical committee 21: Secondary cells and batteries, in collaboration with IEC technical committee 105: Fuel cell technologies.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
21/1028/FDIS	21/1036/RVD

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

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

A list of all parts in the IEC 62932 series, published under the general title *Flow battery energy systems for stationary applications*, can be found on the IEC website.

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

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- withdrawn,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

INTRODUCTION

A flow battery system (FBS) can be utilized as a main part of a flow battery energy system (FBES). Such an FBES can consist of:

– a flow battery system,
– a power conversion system,
– other equipment and surroundings.

The FBES is connected to the external power input or output via a point of connection (POC).

This document includes the domain of the FBES, as shown in Figure 1. Auxiliary energy to the battery management system (BMS), battery support system (BSS), and power conversion system (PCS) may be supplied by one of the following:

– direct connection to the external power source;
– the internal power source of the FBES or FBS itself.

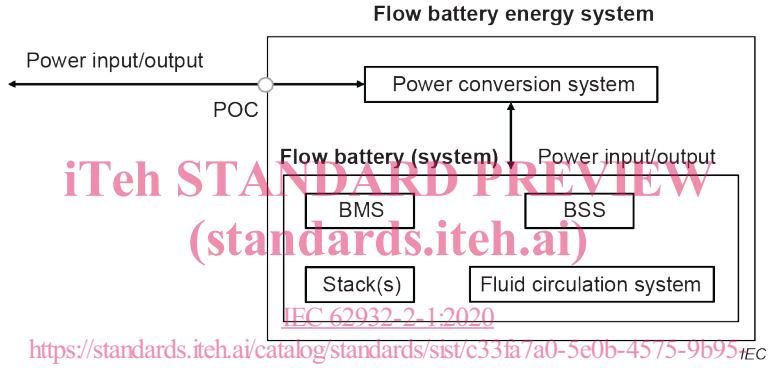


Figure 1 – Flow battery energy system

FLOW BATTERY ENERGY SYSTEMS FOR STATIONARY APPLICATIONS –

Part 2-1: Performance general requirements and test methods

1 Scope

This part of IEC 62932 specifies methods of test and requirements for the flow battery system (FBS) and the flow battery energy system (FBES) for the verification of their performances.

This document is applicable to FBES or FBS which are designed and used for service in stationary locations (i.e. not generally to be moved from place to place).

This document does not cover testing of the system for electromagnetic compatibility (EMC).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62932-1, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*

IEC 62932-2-2, *Flow battery energy systems for stationary applications – Part 2-2: Safety requirements*

IEC 61427-2, *Secondary cells and batteries for renewable energy storage – General requirements and methods of test – Part 2: On-grid applications*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 62932-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/.
- ISO Online browsing platform: available at http://www.iso.org/obp.

3.2 Abbreviated terms

BMS battery management system
BSS battery support system
FBES flow battery energy system
FBS flow battery system
PCS power conversion system
POC point of connection
POM point of measurement
TOU test object unit

4 General requirements

The FBES or FBS shall be designed to withstand mechanical stresses, vibrations and shocks during transportation, handling and use.

The manufacturer shall provide documentation for transportation, installation, commissioning, operation, maintenance, and disposal of the FBES or FBS.

The FBES or FBS shall be characterized by appropriate performance parameters, including rated power, rated energy, rated energy efficiency, maximum output and input powers. More information, such as energy or energy efficiency at different power levels (see Annex A), will help the user know and use the FBES or FBS better.

Safety related requirements and methods of test shall be in accordance with IEC 62932-2-2.

5 General test conditions

5.1 Accuracy of measuring instruments

5.1.1 Voltage measurement

The instruments used shall be of an accuracy class equal to 1 % or better. The internal resistance of the voltmeter used shall be at least 1 kΩ/V.

5.1.2 Current measurement

The instruments used shall be of an accuracy class equal to 1 % or better.

Particular attention shall be given to the accuracy of DC and AC current measurement devices as any degraded accuracy or instability will negatively impact the precision of energy and efficiency determinations.

5.1.3 Electric energy measurement

The instruments used shall be of an accuracy class equal to 1 % or better.

Particular attention shall be given to the accuracy of DC and AC power and energy measurement devices as any degraded accuracy or instability will negatively impact the precision of energy and efficiency determinations.

5.1.4 Temperature measurement

The instruments used shall have a resolution of 0,5 K and the accuracy of the instruments shall be ±1 K or better.

5.1.5 Time measurement

The instruments used shall have a resolution of 1 s and the accuracy of the instruments shall be 1 % of the measured time interval or better.

5.2 Ambient temperature

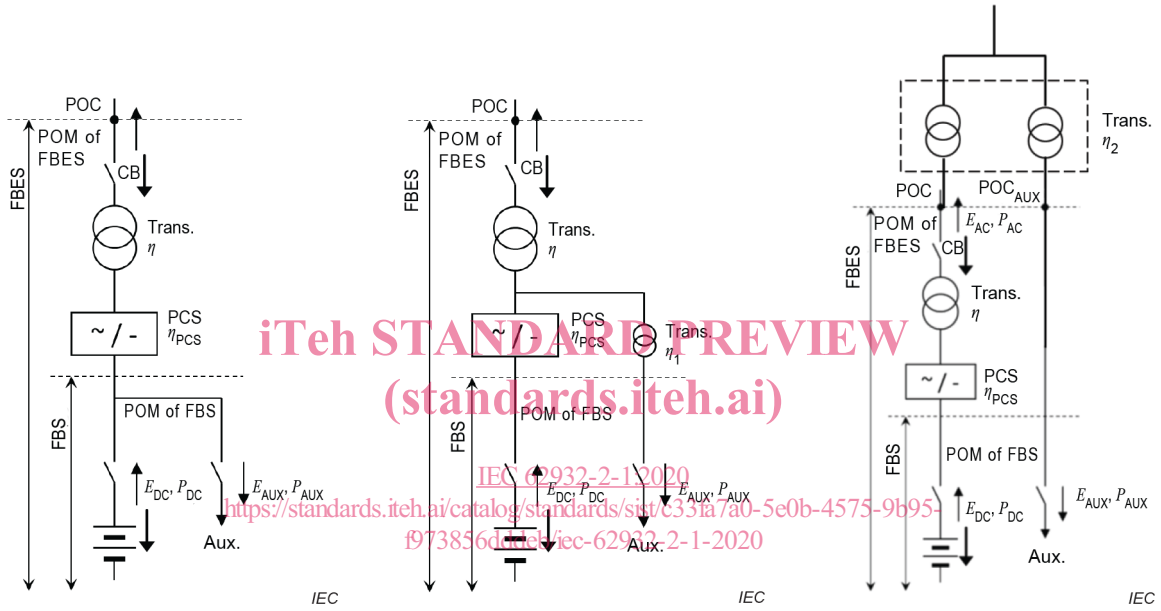
All tests of an FBES or FBS shall be carried out at an ambient temperature of 25 °C ± 5 K unless otherwise specified in a test clause or agreed by the manufacturer and user. The ambient temperature shall be measured and reported. The measuring instrument or probe shall be shielded from draught and radiant heating.

During a test, the FBES or FBS will operate spontaneously at a temperature different to the ambient one due to energy conversion inefficiencies, internal frictional or ohmic losses and similar.

For any test, the average ambient temperature and the temperature of the fluids entering the flow battery cell or stack shall be recorded and reported. The location of the fluid temperature probe shall be described.

5.3 Point of connection (POC) and point of measurement (POM)

The POC and POM shall be selected according to relevant examples and conditions a), b) or c) of Figure 2. The power and the energy value are to be measured at the corresponding POM of the FBS, FBES and the auxiliary equipment.



a) Case a), auxiliary energy/power as DC is supplied by the FBS

b) Case b), auxiliary energy/power as AC is supplied below the POC by the FBES or FBS

c) Case c), auxiliary energy/power as AC supplied via an auxiliary POC from the grid

Key

P_{DC}	DC power entering or exiting the FBS (W)
E_{DC}	DC energy entering or exiting the FBS (Wh)
P_{AC}	AC power entering or exiting the FBES (W)
E_{AC}	AC energy entering or exitingthe FBES (Wh)
P_{aux}	auxilary power (W)
E_{aux}	auxilary energy (Wh)
η and η_1	conversion efficiency of the transmitter in different positions. If there is no transmitter, the conversion efficiency value is 1
η_2	product of the conversion efficiencies of all the transmitters in the dashed wire frame in Figure 2 c). If there is no transmitter, the conversion efficiency value is 1
η_{PCS}	conversion efficiency of the PCS

Figure 2 – POM/POC interconnection cases a), b), c)

5.4 Test object

In the definition of the test object, the boundary shall physically cover or include the following:

– for the FBS: BMS, BSS, pumps;
– for the FBES: BMS, BSS, pumps, PCS;
– for the TOU: BMS, BSS, pumps, with or without PCS.

In an FBES or FBS or TOU, the auxiliary energy either at DC or AC level has to be taken into account.

To ensure transparency in data, the relevant and appropriate POM and POC as defined in Figure 2, conditions a), b) or c) shall be recorded and reported.

A schematic layout of the components forming the test units and their interconnection points shall accompany the test object description.

5.5 Test object unit (TOU) selection

– The FBES or FBS shall be tested in a defined layout.
– When due to test facility, costs or similar limitations this is not possible or desirable then a representative test object unit (TOU) shall be defined and tested instead.
– This test object unit (TOU) shall encompass all components as defined in the test boundary for an FBES or an FBS.
– These components shall be sized to match the TOU if needed or possible.
– The final assembly of the TOU shall faithfully represent the full-sized FBES or FBS so that the test data obtained therewith can be extrapolated to them.
– The tested FBS, FBES or TOU shall be fully described in the relevant test report.
– Auxiliary energy data shall be scaled to the size of the TOU tested.
– All tests shall be carried out with the same and identical FBS, FBES or TOU throughout the duration of the test.

6 Test methods

6.1 Determination of energy at a constant power

6.1.1 General

This test is for determining the discharge energy of the FBES or FBS at the constant power mode, by measuring the total discharge energy outputs from the FBES or FBS and the auxiliary energy consumed by auxiliary equipment (e.g. BMS, BSS and pumps).

The FBES, FBS or TOU (collectively the "test unit"), as defined in 5.4 and 5.5, shall be in a stable temperature condition prior to measurements. The temperature and concentration of electroactive species in the fluid entering the cell or stack shall be recorded and reported.

6.1.2 Test procedures

The test shall be in accordance with the following procedures:

a) The test unit shall be connected to a load circuit which can charge or discharge the test unit as needed. Adequate equipment shall be in place to determine the auxiliary energy of the auxiliary equipment during the determination.
b) The test unit shall be fully charged with the method declared by the manufacturer.

c) The test unit shall be discharged with a constant power until the end-of-discharge is reached. This power shall be kept constant to within ±2 %. The criteria of end-of-discharge shall be declared and implemented in the test circuit.

NOTE 1 The criteria of end-of-discharge are typically the attainment of specified discharge duration or cut-off voltage or the percentage of retained energy to the rated energy.

d) The total discharged energy from the test unit and the auxilary energy consumption during discharge in c) shall be measured and recorded.

NOTE 2 The total discharged energy can be defined as the integral of the constant discharge power over the discharge duration in hours or be determined directly by the energy measuring instrument.

e) Any change of the state of charge or state of health of the test unit, change in the power consumption of the auxiliaries, or the use of different discharge power, ambient/electrolyte temperature or end-of-discharge parameters will result in different energy values. For this reason, any energy statement has to be accompanied by the declaration of the conditions operative during its determination.

f) To verify a manufacturer declared value, i.e. the rated energy value, three consecutive and identical energy determinations shall be carried out at rated power.

g) To show compliance with the rated energy value declared by the manufacturer, the experimentally determined average energy of three consecutive cycles shall be equal to or greater than the rated value.

6.2 Determination of maximum deliverable output power

6.2.1 General

The maximum deliverable output power is affected by the discharge time, the state of charge, the ambient temperature and the auxiliary power needs for the FBES/FBS or TOU operation. Any maximum deliverable output power value determined is hence representative or applicable only to the specific operation condition of the FBES/FBS or TOU as mentioned above.

6.2.2 Test procedures

The test for the determining the maximum deliverable output power shall be in accordance with the following procedures:

a) The duration of discharge t_d shall be defined before the test. The defined duration of 1/50 rated energy to rated power is recommended. The manufacturer shall, alternatively, declare the duration time used.

b) The test unit shall be charged to a desired state of charge according to the method declared by the manufacturer.

c) The test unit shall be discharged at a constant selected power level until the end-of-discharge is reached. The duration time of discharge shall be recorded. The power level shall be kept constant to within ±2 %. It shall be noted that the selected discharge power level shall not cause irreversible damage to the unit.

d) If the duration of discharge t is higher than the defined duration value t_d, repeat b) and c) with an increased power level until the determined duration value t_d of discharge is achieved. All the other conditions (such as ambient temperature, end-of-discharge) shall be kept constant. It is recommended to conduct the test from higher power to lower power.

e) If the duration of discharge t is lower than the defined duration t_d, repeat b) and c) with a decreased power level until the defined duration t_d of discharge is achieved. All the other conditions (such as ambient temperature, end-of-discharge) shall be kept constant.

f) The maximum deliverable output power value and the corresponding auxilary power supplied shall be recorded. The maximum deliverable output power value shall be accompanied with the duration of discharge t_d, the state of charge and ambient temperature.