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Lithium ion battery for electrical energy storage

电力储能用锂离子电池

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Table of Contents

Foreword	3
1 Scope	7
2 Normative references	7
3 Terms, definitions, symbols.....	7
4 Encoding	10
5 Technical requirements.....	12
6 Test methods	23
7 Inspection rules	76
8 Marking, packaging, transportation, storage.....	84
Appendix A (Normative) Battery operating parameters.....	86
Appendix B (Informative) Battery specification parameters	90

Lithium ion battery for electrical energy storage

1 Scope

This document specifies the appearance, size and mass, electrical performance, environmental adaptability, durability performance, safety performance and other requirements of lithium-ion batteries for electric energy storage (referred to as "lithium-ion batteries"); describes the corresponding test methods; stipulates coding, normal working environment, inspection rules, marking, packaging, transportation and storage, etc.

This document applies to the design, manufacturing, testing, inspection, operation, maintenance, and overhaul of lithium-ion batteries for electrical energy storage.

2 Normative references

The contents of the following documents constitute essential provisions of this document through normative references in the text. Among them, for dated reference documents, only the version corresponding to the date applies to this document; for undated reference documents, the latest version (including all amendments) applies to this document.

GB/T 191 Packaging - Pictorial marking for handling of goods

GB/T 2828.1 Sampling procedures for inspection by attributes - Part1:Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

GB/T 4857 (all parts) Packaging - Transport packages

GB/T 5398 Test methods for large transport packages

GB/T 16471 Dimensional and weight constraints for transport package

DL/T 2528 Basic terminology of electric energy storage

3 Terms, definitions, symbols

3.1 Terms and definitions

The terms and definitions as defined in DL/T 2528, as well as the following terms and definitions, apply to this document.

- f) The initial charge energy range is not greater than 4.0% of the average initial charge energy under 25 °C;
- g) The initial discharge energy range is not greater than 4.0% of the average initial discharge energy under 25 °C.

5.3.1.2 Battery module

The initial charge-discharge performance of the battery module under rated power conditions shall meet the following requirements:

- a) The initial charge energy is not less than the rated charge energy;
- b) The initial discharge energy is not less than the rated discharge energy;
- c) The initial charge-discharge energy efficiency is not less than 85.0% under 5 °C;
- d) The initial charge-discharge energy efficiency is not less than 94.0% under 25 °C;
- e) The initial charge-discharge energy efficiency is not less than 94.0% under 45 °C;
- f) The initial charge energy range is not greater than 4.5% of the average initial charge energy under 25 °C;
- g) The initial discharge energy range is not greater than 4.5% of the average initial discharge energy under 25 °C.

5.3.1.3 Battery cluster

The initial charge-discharge performance of the battery cluster under rated power conditions shall meet the following requirements:

- a) The initial charge energy is not less than the rated charge energy;
- b) The initial discharge energy is not less than the rated discharge energy;
- c) The initial charge-discharge energy efficiency is not less than 95.0%;
- d) The battery cell voltage range at the end of charge is not greater than 250 mV;
- e) The battery cell voltage range at the end of discharge is not greater than 300 mV;
- f) The temperature range of the battery cells at the end of charge shall not be greater than 6 °C;
- g) The temperature range of the battery cells at the end of discharge shall not be greater than 6 °C;
- h) The voltage range of the battery module at the end of charge is not greater than

5.0% of the nominal voltage of the battery module;

- i) The voltage range of the battery module at the end of discharge shall not be greater than 5.0% of the nominal voltage of the battery module.

5.3.2 Power characteristics

5.3.2.1 Battery cells

The power characteristics of the battery cell shall meet the following requirements:

- a) The charge energy under different charge-discharge powers is not less than the rated charge energy;
- b) The discharge energy under different charge-discharge powers is not less than the rated discharge energy;
- c) The energy efficiency under different charge-discharge powers is not less than 93.0%.

5.3.2.2 Battery module

Battery module power characteristics shall meet the following requirements:

- a) The charge energy under different charge-discharge powers is not less than the rated charge energy;
- b) The discharge energy under different charge-discharge powers is not less than the rated discharge energy;
- c) The energy efficiency under different charge-discharge powers is not less than 94.0%.

5.3.3 Rate charge-discharge performance

5.3.3.1 Battery cells

The battery cell's rate charge-discharge performance shall meet the following requirements:

- a) The energy retention rate of $2P_{rc}$ charge energy, as relative to P_{rc} charge energy, is not less than 95.0%;
- b) The energy retention rate of $2P_{rd}$ discharge energy, as relative to P_{rd} discharge energy, is not less than 95.0%;
- c) The energy efficiency of constant power charge-discharge of $2P_{rc}$ and $2P_{rd}$ is not less than 90.0%.

- b) The discharge energy is not less than the rated discharge energy;
- c) Energy efficiency is not less than 93.0%.

5.4.1.2 Battery module

The charge-discharge performance of the battery module, after returning to room temperature from a high temperature environment, shall meet the following requirements:

- a) The charge energy is not less than the rated charge energy;
- b) The discharge energy is not less than the rated discharge energy;
- c) Energy efficiency is not less than 94.0%.

5.4.2 Low temperature adaptability

5.4.2.1 Battery cells

The charge-discharge performance of the battery cell, after returning to room temperature from a low temperature environment, shall meet the following requirements:

- a) The charge energy is not less than the rated charge energy;
- b) The discharge energy is not less than the rated discharge energy;
- c) The energy efficiency is not less than 93.0%.

5.4.2.2 Battery module

The charge-discharge performance of the battery module, after returning to room temperature from a low temperature environment, shall meet the following requirements:

- a) The charge energy is not less than the rated charge energy;
- b) The discharge energy is not less than the rated discharge energy;
- c) The energy efficiency is not less than 94.0%.

5.4.3 Initial charge-discharge performance at high altitude

In high-altitude environments, the initial charge-discharge performance of battery cells under rated power conditions shall meet the following requirements:

- a) The initial charge energy is not less than the rated charge energy;

- b) The initial discharge energy is not less than the rated discharge energy;
- c) The energy efficiency is not less than 93.0%.

5.5 Durability

5.5.1 Storage performance

5.5.1.1 Battery cells

Battery cells shall meet the following requirements, after being stored at 50% energy state for 30 days:

- a) The charge energy recovery rate is not less than 96.5%;
- b) The discharge energy recovery rate is not less than 96.5%.

5.5.1.2 Battery module

The battery module shall meet the following requirements, after being stored at 50% energy state for 30 days:

- a) The charge energy recovery rate is not less than 97.0%;
- b) The discharge energy recovery rate is not less than 97.0%.

5.5.2 Cycle performance

5.5.2.1 Battery cells

The cycle performance of the battery cell under rated power conditions shall meet the following requirements:

- a) The average energy loss in a single cycle of charge is not greater than the average energy loss in a single cycle of charge, based on the rated charge energy;
- b) The average value of energy loss in a single cycle of discharge is not greater than the average value of energy loss in a single cycle of discharge, based on the rated discharge energy;
- c) The range of energy efficiency between all charge-discharge cycles is no more than 2%.

5.5.2.2 Battery module

The cycle performance of the battery module under rated power conditions shall meet the following requirements:

- a) The average energy loss in a single cycle of charge is not greater than the average

5.6.1.3 Overload performance

5.6.1.3.1 Battery cells

When the battery cells are charged and discharged under the conditions of $4P_{rc}$ and $4P_{rd}$, they shall not leak, smoke, catch fire, explode, or rupture at locations other than explosion-proof valves or pressure relief points.

5.6.1.3.2 Battery module

When the battery module is charged and discharged under the conditions of $4P_{rc}$ and $4P_{rd}$, there shall be no leakage, smoke, fire, or explosion.

5.6.1.4 Short circuit performance

5.6.1.4.1 Battery cells

After the battery cells are subject to initial charge, the battery cells shall be short-circuited to an external circuit of $1\text{ m}\Omega$ for 10 minutes. They shall not catch fire, explode, or rupture at locations other than explosion-proof valves or pressure relief points.

5.6.1.4.2 Battery module

After the battery module is subject to initial charge, it shall not catch fire or explode, if it is short-circuited to an external circuit of $1\text{ m}\Omega$ for 10 minutes or short-circuited to an external circuit of $30\text{ m}\Omega$ for 30 minutes.

5.6.1.5 Insulation performance

5.6.1.5.1 Battery module

The ratio -- of the insulation resistance to the nominal voltage between the positive electrode of the battery module and the external exposed conductive part, and between the negative electrode of the battery module and the external exposed conductive part, shall not be less than $1000\text{ }\Omega/\text{V}$.

5.6.1.5.2 Battery cluster

The ratio -- of the insulation resistance to the nominal voltage between the positive electrode of the battery cluster and the external exposed conductive part, and between the negative electrode of the battery cluster and the external exposed conductive part, shall not be less than $1000\text{ }\Omega/\text{V}$.

5.6.1.6 Withstanding voltage

5.6.1.6.1 Battery module

Apply corresponding voltage between the positive electrode of the battery module and

the external exposed conductive part, and between the negative electrode of the battery module and the external exposed conductive part. Breakdown or flashover shall not occur, meanwhile the DC withstand voltage leakage current shall be less than 10 mA.

5.6.1.6.2 Battery cluster

Apply corresponding voltage between the positive electrode of the battery cluster and the external exposed conductive part, and between the negative electrode of the battery cluster and the external exposed conductive part. Breakdown or flashover shall not occur, meanwhile the DC withstand voltage leakage current shall be less than 10mA.

5.6.2 Mechanical safety performance

5.6.2.1 Extrusion resistance

5.6.2.1.1 Battery cells

After the battery cells are subject to initialized charge, they shall be kept under a squeezing force of 50 kN for 10 minutes. There shall be no leakage, smoke, fire, explosion, or rupture at locations other than the explosion-proof valve or pressure relief point.

5.6.2.1.2 Battery module

After the battery module is subject to initialized charge, it shall be kept under a squeezing force of 50 kN for 10 minutes. There shall be no leakage, smoke, fire, or explosion.

5.6.2.2 Drop performance

5.6.2.2.1 Battery cells

After the battery cell is subject to initialized charge, it shall be dropped freely to the concrete floor from a height of 1.5 m. It shall not smoke, catch fire, explode, or rupture at locations other than the explosion-proof valve or pressure relief point.

5.6.2.2.2 Battery module

After the battery module is subject to initialized charge, it shall be freely dropped from a height of 2 m to the concrete floor. It shall not catch fire or explode.

5.6.2.3 Vibration performance

After initialized charge, the battery module vibrates randomly in the three directions of X, Y, Z axes. It shall not leak, smoke, catch fire, or explode. The insulation performance shall meet the requirements of 5.6.1.5.1. The voltage resistance shall meet the requirements of 5.6.1.6.1.

5.6.3.4.2 Battery cluster

In high-altitude environments, the withstanding voltage performance of battery clusters shall meet the requirements of 5.6.1.6.2.

5.6.4 Thermal safety performance

5.6.4.1 Adiabatic temperature rise characteristics

The adiabatic temperature rise characteristics of battery cells shall meet the following requirements:

- a) When the surface temperature is less than or equal to the first-level high-temperature alarm temperature of the battery cell, the temperature rise rate is less than 0.02 °C/min;
- b) No fire, no explosion, no rupture outside the explosion-proof valve or pressure relief point.

5.6.4.2 Thermal runaway performance

During the entire life cycle of the battery cell, the surface temperature of the battery cell shall be greater than 90 °C during thermal runaway. After thermal runaway, the battery cell shall not catch fire, explode, or rupture at locations other than the explosion-proof valve or pressure relief point.

5.6.4.3 Thermal runaway diffusion performance

When the temperature of any battery cell in the battery module rises, it shall not trigger thermal runaway in other battery cells, cause fire, or explode. The insulation performance shall meet the requirements of 5.6.1.5.1.

5.6.5 Alarm and protection functions

When the voltage, current, temperature, voltage range, temperature range, insulation resistance and other parameters reach alarm values during the operation of the battery cluster, an alarm signal shall be sent out and corresponding protection actions shall be performed.

6 Test methods

6.1 Test conditions

6.1.1 Test environment

Unless otherwise specified, the test shall be conducted in an environment at a temperature of 15 °C to 40 °C, a relative humidity of $\leq 80\%$, an atmospheric pressure

- f) The test sample is connected to the test device through an external connector. The external connector can withstand the maximum current during the test without fusing;
- g) Before the test, prepare a test plan and formulate safety protection measures based on the safety risks of the test sample. During the electrical performance test, environmental adaptability test, durability performance test process, if the test sample has expansion, rupture, leakage, smoke, fire, explosion, etc., it shall terminate all inspection items corresponding to the test sample.

6.2.2 Test line connection

6.2.2.1 Battery cells

Unless otherwise specified, battery cell's test circuit connections shall comply with the following requirements:

- a) Select test equipment based on test temperature, humidity, battery cell size, voltage, power and other parameters;
- b) The positive and negative poles of the battery cells are connected to the test equipment through input and output cables, to form a current loop;
- c) The positive and negative electrodes of the battery cells are connected to the test equipment through voltage data sampling lines, to form a voltage data collection loop;
- d) The battery cell temperature sampling point and the test equipment are connected through the temperature data sampling line, to form a temperature data collection loop. For inspection items that do not use fixtures, the temperature sampling point of the battery cell is the center position of the plane with a larger surface area of the battery cell. For inspection items using fixtures, the temperature sampling point of the battery cell is the center position of the side of the battery cell.

6.2.2.2 Battery module

Unless otherwise specified, battery module's test circuit connections shall comply with the following requirements:

- a) Select test equipment based on test temperature, humidity, battery module size, voltage, power and other parameters;
- b) The positive and negative poles of the battery module are connected to the test equipment through input and output cables, to form a current loop;
- c) The positive and negative poles of the battery module and battery cell are connected to the test equipment through voltage data sampling lines, to form a

voltage data collection loop;

- d) The battery module's temperature sampling point and the test equipment are connected through a temperature data sampling line, to form a temperature data collection loop. The battery module's temperature sampling point includes fixed sampling points of the positive electrode busbar and negative electrode busbar of the battery module and no less than 2 representative random sampling points;
- e) For battery modules using liquid cooling, the liquid cooling system can work during the power characteristic test, rate charge-discharge performance test, cycle performance test. During the cycle performance test, the liquid inlet temperature at the sample end is consistent with the test temperature. The high temperature adaptability test, low temperature adaptability test, storage performance test, liquid cooling pipeline pressure resistance performance test before draining the coolant, filling other test items with coolant and disconnecting the liquid cooling system before testing.

6.2.2.3 Battery cluster

Unless otherwise specified, battery cluster's test circuit connections shall comply with the following requirements:

- a) Select test equipment based on test temperature, humidity, battery cluster size, voltage, power and other parameters;
- b) The positive and negative poles of the battery cluster are connected to the test equipment through input and output cables, to form a current loop;
- c) The test equipment and the battery management system of the battery cluster are connected through communication lines, to form a control and protection loop;
- d) The positive and negative electrodes of battery clusters, battery modules and battery cells are connected to the test equipment through voltage data sampling lines, to form a voltage data collection loop;
- e) The battery cluster's temperature sampling point and the test equipment are connected through a temperature data sampling line, to form a temperature data collection loop.

6.2.3 Test parameter setting

Battery test parameter settings shall meet the following requirements:

- a) The test parameter setting values meet the requirements of Table A.1;
- b) The working parameter values of the battery cells, battery modules, battery clusters are unique and consistent with the working parameter values of the

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