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General specification of lithium-ion cells for aerospace

空间用锂离子蓄电池通用规范

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General specification of lithium-ion cells for aerospace

1 Scope

This document specifies the technical requirements, test methods, inspection rules, packaging, transportation and storage of lithium-ion cells for aerospace (hereinafter referred to as "cell").

This document applies to lithium-ion cells for space vehicles such as satellites, space stations, and space probes.

2 Normative references

The following referenced documents are indispensable for the application 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.

GB/T 191, *Packaging and storage marks*

GB/T 2900.41, *Electrotechnical terminology -- Primary and secondary cells and batteries*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 2900.41 as well as the followings apply.

3.1 Coulomb efficiency

The ratio of the capacity output when the cell is discharged to the capacity input during previous charging.

3.2 energy efficiency

The ratio of the energy output when a cell is being discharged to the energy input when it was previously charged.

[Source: GB/T 2900.41-2008, 482-05-53]

3.3 cycling

A group of operations that are regularly repeated on the cell in the same sequence.

The high temperature capacity of the cell shall not be less than 95% of the rated capacity.

5.5.7 Low temperature capacity

The low temperature capacity of the cell shall not be less than 80% of the rated capacity.

5.5.8 Pulse test

The voltage during the cell pulse test shall not be lower than 3.3 V or the value specified in the product technical conditions provided by the manufacturer.

5.6 Environmental adaptability

5.6.1 Steady-state acceleration

When the cell is tested according to 6.6.1, the discharge current and discharge voltage shall have no sudden changes and no mechanical damage.

5.6.2 Random vibration

When the cell is tested according to 6.6.2, the discharge current and discharge voltage shall have no sudden changes and no mechanical damage.

5.6.3 Sinusoidal vibration

When the cell is tested according to 6.6.3, the discharge current and discharge voltage shall have no sudden changes and no mechanical damage.

5.6.4 Impact

When the cell is tested according to 6.6.4, the discharge current and discharge voltage shall have no sudden changes and no mechanical damage.

5.6.5 Thermal vacuum

When the cell is tested according to 6.6.5, it shall not deform, crack or leak.

5.7 Safety performance

5.7.1 Short circuit

When the cell is tested according to 6.7.1, it shall not catch fire or explode.

5.7.2 Overcharging

When the cell is tested according to 6.7.2, it shall not catch fire or explode.

5.7.3 Over-discharging

When the cell is tested according to 6.7.3, it shall not catch fire or explode.

5.7.4 Overtemperature

When the cell is tested according to 6.7.4, it shall not catch fire or explode.

5.8 Cycling life

5.8.1 Low Earth Orbit (LEO) cycling life performance

For cells used in Low Earth Orbit, the number of cycles shall reach 48,000 times at 20% DOD. The number of life assessments submitted for identification shall comply with the requirements of the product technical conditions provided by the manufacturer.

5.8.2 Geosynchronous orbit (GEO) cycling life performance

The number of cycles of cells used in geosynchronous orbit shall reach 2,000 times. The number of life assessments submitted for identification shall comply with the requirements of the product technical conditions provided by the manufacturer.

5.9 Irradiation

When the cell is tested according to 6.9, it shall be well sealed and not bulge.

6 Test methods

6.1 Test conditions

6.1.1 Environmental conditions

Unless otherwise specified, each test shall be conducted under the following environmental conditions:

a) Temperature: 15℃~35℃;

b) Relative humidity: 20%~80%;

c) Air pressure: 86 kPa ~ 106 kPa.

6.1.2 Measuring instruments and instrument requirements

The requirements for measuring instruments and meters are:

a) The accuracy of dimensional measurement tools shall not be less than 0.02 mm.

b) The sensing capacity of the electronic balance shall not be less than 0.00 1kg.

6.7.2 Overcharging

Carry out the overcharge test according to the following steps:

a) Stabilize the cell temperature at 20℃±3℃;

b) Charge to 4.5 V at 0.1 C_1A or the value specified in the product technical conditions provided by the manufacturer;

c) Let it stand for 60 min ~ 75 min;

d) Discharge to 2.75 V at 0.67 C_1A or the value specified in the product technical conditions provided by the manufacturer;

e) Repeat steps a) ~ d) for a total of 10 times.

6.7.3 Over-discharging

Carry out over-discharging test according to the following steps:

a) Stabilize the cell temperature at 20℃±3℃;

b) Charge to 4.1 V at 0.1 C_1A or the value specified in the product technical conditions provided by the manufacturer;

c) Charge at constant voltage until the current drops to 0.05 C_1A;

d) Let it stand for 60 min ~ 75 min;

e) Discharge to 2.75 V with a current of 0.67 C_1A;

f) Continue to discharge at a current of 0.67 C_1A to -0.8 V or 1.2 h, whichever comes first, or in accordance with the product technical conditions provided by the manufacturer;

g) Repeat steps a) ~ f) for a total of 10 times.

6.7.4 Overtemperature

In an environment of 20℃±3℃, discharge the cell at a constant current of 0.2 C_1A to 2.75 V or the value specified by the product technical conditions provided by the manufacturer. Place the cell in a constant temperature box at 60℃±2℃. Carry out over-temperature test as follows:

a) Let stand for 24 h;

b) Charge to 4.1 V at 0.2 C_1A or the value specified by the product technical conditions provided by the manufacturer;

c) Charge at constant voltage until the current drops to 0.05 C_1A;

d) Let it stand for 10 min;

e) Discharge at 0.2 C_1A constant current to 2.75 V or the value specified in the product technical conditions provided by the manufacturer.

6.8 Cycling life

6.8.1 Low Earth Orbit (LEO) cycling life performance

The cell low earth orbit (LEO) cycling life test shall be performed in accordance with the product technical conditions provided by the manufacturer. If there is no provision, the following provisions may apply.

a) In an environment of 20°C± 3°C, charge the cell with a constant current of 0.2 C_1A to 3.95 V or the value specified in the product technical conditions provided by the manufacturer. When the charging current drops to 0.01 C_1A, the charging ends. After leaving it alone for 1 h, conduct cycling through the following steps:

1) Discharge the cell at a current of 0.4 C_1A for 30 min;

2) Charge at 0.3 C_1A constant current to 3.95 V or convert to constant voltage charging according to the product technical conditions provided by the manufacturer. Charging ends when the charging current drops to 0.01 C_1A or the charging time reaches 60 min;

3) Repeat 1) and 2) charge and discharge cycles. Record the discharge termination voltage for each charge-discharge cycle.

b) During the cycle, when the discharge end voltage of three consecutive cycles is lower than 3.30 V or the value specified in the product technical conditions provided by the manufacturer, the constant current charge cutoff voltage is increased in steps of 0.05 V. After the charge cut-off voltage is raised to 4.1 V or the value specified in the product technical conditions provided by the manufacturer, if the discharge end voltage for 5 consecutive cycles is lower than 2.75 V or the specified value in the product technical conditions provided by the manufacturer, the test ends. The accumulated number of cycles at this time shall be the cycling life.

6.8.2 Geosynchronous orbit (GEO) cycling life performance

The cell geostationary orbit (GEO) cycling life test shall be performed in accordance with the product technical conditions provided by the manufacturer. If there is no provision, the following provisions may apply.

a) In an environment of 20°C±3°C, the cell shall be cycled according to the following

steps:

1) The cell is charged to 4.0 V at a constant current of 0.2 C_1A or to constant voltage charging according to the product technical conditions provided by the manufacturer;

2) Charging ends when the charging current drops to 0.01 C_1A. After standing for 0.5 h ~ 1 h, discharge with a current of 0.67 C_1A according to the weekly discharge time shown in Table 5 (for example, the first weekly discharge is 21.00 min);

3) Then charge in the same way. After charging is completed and left to stand for 0.5 h ~ 1 h, discharge is performed with a current of 0.67 C_1A according to the weekly discharge time shown in Table 5 (for example, the second weekly discharge is 29.37 min). By analogy, one week is one cycle. In 1 shadow period, conduct 45 charge and discharge cycles;

4) Charge the cell with a constant current of 0.2 C_1A to 4.0 V or the value specified in the product technical conditions provided by the manufacturer. Switch to constant voltage charging. Charging ends when the charging current drops to 0.01 C_1A. Fully charge and left for 10 d. Enter the second shadow period;

5) Repeat 1) ~ 4) charge and discharge cycle. Record the discharge termination voltage for each cycle.

b) When the final discharge voltage of the cell for three consecutive cycles during a certain shadow period is lower than 3.0 V or the value specified by the product technical conditions provided by the manufacturer, the charge cut-off voltage is increased in steps of 0.05 V. After the charging cut-off voltage is adjusted to 4.1 V or the value specified in the product technical conditions provided by the manufacturer, if the final discharge voltage for 5 consecutive cycles is lower than 2.75 V or the specified value in the product technical conditions provided by the manufacturer, the test shall end. The accumulated number of cycles at this time shall be the cycling life.

The inspection items, technical requirements, inspection methods and inspection sequences of Group B shall be carried out in accordance with the provisions of Table 7.

For Group B inspection, randomly select 4 products from Group A inspection. After the four cells have completed high-temperature capacity, low-temperature capacity, pulse test, steady-state acceleration, random vibration, sinusoidal vibration, impact, thermal vacuum and other inspection items, one of each of the four cells will be selected for short circuit, overcharge, over-discharge, over-discharge and over temperature inspection.

The inspection cycle is 2 years.

8 Packaging, transportation and storage

8.1 Packaging

Cells shall be packed with moisture-proof materials. Shock absorption and insulation measures shall be taken for packing.

The marks on the packaging box shall comply with GB/T 191 and the following regulations:

a) The content of the mark shall include product model and batch number;

b) The packaging box shall have the manufacturer’s logo.

8.2 Transportation

During transportation, the state of charge of the cell shall be between 40% and 60%.

Cells can be transported by road, railway, etc. The maximum mechanical magnitude experienced by the cell during transportation shall be lower than the magnitudes in 6.6.1, 6.6.2, 6.6.3, and 6.6.4.

The ambient temperature of the cell during transportation is generally maintained at -5℃ ~ +30℃. When the temperature exceeds 30℃, the transportation time shall be less than 10 d. The time at this high temperature shall not exceed 4 h a day.

Temperature, humidity and abnormal mechanical magnitudes shall be recorded during transportation.

8.3 Storage

When storing cells, the state of charge of the cell shall be between 40% and 60%.

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