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ICS 43.080

T 47

GB/T 38661-2020

Technical Specifications of Battery Management System for Electric Vehicles

电动汽车用电池管理系统技术条件

Issued on: March 31, 2020 **Implemented on: October 1, 2020**

Issued by: State Administration for Market Regulation;

Standardization Administration of the People's Republic of China.

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Technical Specifications of Battery Management System for Electric Vehicles

1 Scope

This Standard specifies the technical requirements, test methods and inspection rules of power storage battery management system for electric vehicles (hereinafter referred to as battery management system).

This Standard is applicable to li-ion power battery and nickel-hydrogen power battery management system for electric vehicles. The management system of other types of power storage battery may take this as a reference.

2 Normative References

The following documents are indispensable to the application of this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 4365 *Electrotechnical Terminology - Electromagnetic Compatibility*

GB/T 17626.4-2018 *Electromagnetic Compatibility - Testing and Measurement Techniques - Electrical Fast Transient / Burst Immunity Test*

GB/T 18384.3-2015 *Electrically Propelled Road Vehicles - Safety Specifications - Part 3: Protection of Persons against Electric Shock*

GB/T 18655-2018 *Vehicles, Boats, and Internal Combustion Engines - Radio Disturbance Characteristics - Limits and Methods of Measurement for the Protection of On-board Receivers*

GB/T 19596-2017 *Terminology of Electric Vehicles*

GB/T 19951 *Road Vehicles - Disturbances Test Methods for Electrical / Electronic Component from Electrostatic Discharge*

GB/T 21437.2-2008 *Road Vehicles - Electrical Disturbances from Conduction and Coupling - Part 2: Electrical Transient Conduction along Supply Lines Only*

GB/T 21437.3-2012 *Road Vehicles - Electrical Disturbances from Conduction and Coupling - Part 3: Electrical Transient Transmission by Capacitive and Inductive Coupling via Lines other than Supply Lines*

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GB/T 27930 *Communication Protocols between Off-board Conductive Charger and Battery Management System for Electric Vehicle*

GB/T 28046.1-2011 *Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 1: General*

GB/T 28046.2-2011 *Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 2: Electrical Loads*

GB/T 28046.3-2011 *Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 3: Mechanical Loads*

GB/T 28046.4-2011 *Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 4: Climatic Loads*

GB/T 33014.2 *Road Vehicles - Component Test Methods for Electrical / Electronic Disturbances from Narrowband Radiated Electromagnetic Energy - Part 2: Absorber-lined Shielded Enclosure*

GB/T 33014.4 *Road Vehicles - Component Test Methods for Electrical / Electronic Disturbances from Narrowband Radiated Electromagnetic Energy - Part 4: Bulk Current Injection (BCI)*

ISO 11452-8:2015 *Road Vehicles - Component Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy - Part 8: Immunity to Magnetic Fields*

3 Terms and Definitions

What is defined in GB/T 4365, GB/T 19596-2017 and GB/T 28046.1-2011, and the following terms and definitions are applicable to this document. For ease of use, some terms and definitions in GB/T 19596-2017 are repeatedly listed out.

3.1 Battery Electronics

Battery electronics refers to an electronic device that collects or simultaneously monitors electrical and thermal data of secondary cells or modules. If necessary, it may include electronic components used for secondary cell equilibrium.

NOTE: battery electronics may include secondary cell controller; the equilibrium between secondary cells may be controlled by battery electronics, or, through battery control unit.

[GB/T 19596-2017, Definition 3.3.2.1.5]

3.2 Battery Control Unit

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BCU: Battery Control Unit

BMS: Battery Management System

FS: Full Scale

NOTE: FS refers to the absolute value of the maximum measurable value of the battery management system.

SOC: State of Charge

SOP: State of Power

4.2 Symbols

The following symbols are applicable to this document.

C_1: 1 h rated capacity (Ah).

I_1: 1 h discharging current (A), whose value equals to the rated capacity.

5 Technical Requirements

5.1 Service Environment

5.1.1 Operating Temperature

-20 °C ~ 65 °C, or, negotiated and determined by OEMs and manufacturers in accordance with the stipulations of GB/T 28046.4-2011, and the installation location of the battery management system.

5.1.2 Storage temperature

-40 °C ~ 85 °C, or, negotiated and determined by OEMs and manufacturers in accordance with the stipulations of GB/T 28046.4-2011, and the installation location of the battery management system.

5.1.3 Operating humidity

5% ~ 95%, or, negotiated and determined by OEMs and manufacturers in accordance with the stipulations of GB/T 28046.4-2011, and the installation location of the battery management system.

5.2 Supply Voltage

The range of supply voltage is shown in Table 1, or, negotiated and determined by OEMs and manufacturers.

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should have SOP estimation and equilibrium function.

5.4 State Parameter Measurement Accuracy

5.4.1 Total voltage

The detection accuracy of total voltage shall satisfy ± 1% FS.

5.4.2 Total current

5.4.2.1 In terms of li-ion power battery, the detection accuracy of total current shall satisfy ± 2% FS.

5.4.2.2 In terms of nickel-hydrogen power battery, the detection accuracy of total current shall satisfy ± 3% FS.

5.4.3 Secondary cell (cell group) voltage

5.4.3.1 In terms of li-ion power battery, the detection accuracy of secondary cell (cell group) voltage shall satisfy ± 0.5% FS; the absolute value of the maximum error shall be not more than 10 mV.

5.4.3.2 In terms of nickel-hydrogen power battery, the detection accuracy of secondary cell (cell group) voltage or module voltage shall satisfy ± 1% FS.

5.4.4 Temperature

5.4.4.1 In terms of li-ion power battery, within the range of -20 °C ~ 65 °C (including -20 °C and 65 °C), the temperature detection accuracy shall satisfy ± 2 °C; within the range of -40 °C ~ -20 °C and 65 °C ~ 125 °C (or the highest measured temperature calibrated by the battery management system), the temperature detection accuracy shall satisfy ± 3 °C.

5.4.4.2 In terms of nickel-hydrogen power battery, within the range of -20 °C ~ 65 °C (including -20 °C and 65 °C), the temperature detection accuracy shall satisfy ± 3 °C; within the range of -40 °C ~ -20 °C and 65 °C ~ 125 °C (or the highest measured temperature calibrated by the battery management system), the temperature detection accuracy shall satisfy ± 5 °C.

5.4.5 Insulation resistance

In terms of battery management system equipped with the insulation resistance value detection function, when the total battery voltage (nominal) is above 400 V (including 400 V), the relative error of insulation resistance detection shall be -20 % ~ +20%; when the total battery voltage (nominal) is below 400 V, the relative error of insulation resistance detection shall be -30% ~ +30%.

When the insulation resistance is less than, or equals to 50 kΩ, the detection accuracy

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The battery management system shall be tested in accordance with 6.6.1. The functional status shall reach Level-A specified in Appendix A.

5.8.2 Overvoltage

The battery management system shall be tested in accordance with 6.6.2. The functional status shall reach Level-C specified in Appendix A.

5.8.3 Superimposed AC voltage

The battery management system shall be tested in accordance with 6.6.3. When the nominal voltage is 12 V, the system test severity level is 2. When the nominal voltage is 24 V, the system test severity level is 3. The functional status shall reach Level-A specified in Appendix A.

5.8.4 Slow drop and rise of supply voltage

The battery management system shall be tested in accordance with 6.6.4. Within the range of the supply voltage, the functional status shall reach Level-A as specified in Appendix A. Beyond the range of the supply voltage, the functional status shall at least reach Level-C specified in Appendix A.

5.8.5 Transient changes of supply voltage

The battery management system shall be tested in accordance with 6.6.5. The functional status shall reach Level-C specified in Appendix A.

5.8.6 Reverse voltage

The battery management system shall be tested in accordance with 6.6.6. The functional status shall reach Level-C specified in Appendix A.

5.8.7 Short-circuit protection

The battery management system shall be tested in accordance with 6.6.7. The functional status shall reach Level-C specified in Appendix A.

5.9 Environmental Adaptability

5.9.1 Sinusoidal vibration

The battery management system shall be able to endure the vibration test specified in 6.7.1. After the test, it shall be able to normally function and satisfy the requirements for state parameter measurement accuracy in 5.4. In addition, it shall pass visual inspection and there shall be no falling-off of components and parts.

5.9.2 Random vibration

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The battery management system shall receive the salt mist resistance test in accordance with 6.7.8; no saltwater is allowed to enter the housing. Under the operating mode specified in GB/T 28046.1-2011 in 3.2, the functional status shall reach Level-A specified in Appendix A. For test objects completely placed in the passenger compartment, luggage compartment or cargo compartment, the salt mist resistance test is not required. For test objects installed inside the battery compartment, if the compartment's protection level reaches IP 67, the salt mist resistance test may not be performed.

5.9.9 Damp heat cycle

The battery management system shall receive the damp heat cycle test in accordance with 6.7.9. The functional status shall reach Level-A specified in Appendix A.

5.10 Electromagnetic Compatibility Performance

5.10.1 Conduction disturbance

The battery management system shall be tested in accordance with 6.8.2. If OEMs and the manufacturers do not have special stipulations, the limit value of conduction disturbance shall comply with the requirements of Level-3 specified in GB/T 18655-2018.

5.10.2 Radiation disturbance

The battery management system shall be tested in accordance with 6.8.3. If OEMs and the manufacturers do not have special stipulations, the limit value of radiation disturbance shall comply with the requirements of Level-3 specified in GB/T 18655-2018.

5.10.3 Transient conduction immunity of power line

The battery management system shall be tested in accordance with 6.8.4. If OEMs and the manufacturers do not have special stipulations, the requirements for functional status in the test result are shown in Table 4.

Table 4 -- Requirements for Transient Conduction Immunity of Power Line of Battery Management System

Test Pulse	1	2a	2b	3a	3b	4
System's Functional Status	C	B	C	A	A	B

5.10.4 Transient conduction immunity of signal line / control line

The battery management system shall be tested in accordance with 6.8.5. If OEMs

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6.2.4.1 In terms of li-ion battery, at -20 °C ± 2 °C, 25 °C ± 2 °C and 65 °C ± 2 °C (or, it may be determined by OEMs and the manufacturers through negotiation in accordance with the practical application), respectively detect 1.5 V, 3 V and 4.5 V secondary cell voltage (the number of channels is not less than the number of sampling units of one independent power supply). Compare the data collected by the battery management system with the data monitored by the detection equipment.

6.2.4.2 In terms of nickel-metal hydride battery, at -20 °C ± 2 °C, 25 °C ± 2 °C and 65 °C ± 2 °C (or, it may be determined by OEMs and the manufacturers through negotiation in accordance with the practical application), respectively detect module voltage $n \times 1.0$ V, $n \times 1.2$ V, $n \times 1.6$ V (n is the number of secondary cells connected in series in the module, where the number of channels is not less than the number of sampling units of one independent power supply). Compare the data collected by the battery management system with the data monitored by the detection equipment.

6.2.5 Temperature

At -20 °C ± 2 °C, 25 °C ± 2 °C and 65 °C ± 2 °C (or, it may be determined by OEMs and the manufacturers through negotiation in accordance with the practical application), simultaneously place the probe of the temperature measurement device of the battery management system and the probe of the sensor of the detection equipment at -40 °C, 0 °C, 25 °C, 40 °C and 125 °C (or the highest measured temperature calibrated by the battery management system); measure the temperature value. Compare the data collected by the battery management system with the data monitored by the detection equipment.

6.2.6 Insulation resistance

Under 50%, 75% and 100% full-scale voltage, respectively connect the total positive to ground and the total negative to ground of the battery to the insulation resistance array. In accordance with 80 Ω/V, 100 Ω/V, 300 Ω/V, 500 Ω/V and 2 Ω/V, respectively control the insulation resistance array to different resistance values. Compare the data collected by the battery management system with the actual resistance value of the insulation resistance array.

6.3 SOC Estimation Accuracy

In this Standard, SOC estimation accuracy test includes SOC accumulative error test and SOC error correction speed test. SOC accumulative error test shall be conducted in accordance with Appendix B. SOC error correction speed test may be conducted in accordance with Appendix C. SOC estimation error test caused by battery aging or other factors shall be negotiated by OEMs and the manufacturers.

6.4 Battery Fault Diagnosis

Through the simulation system, establish triggering conditions that satisfy the fault

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Or, DC test voltage may also be applied; the equivalent DC test voltage is 1.41 times of the AC voltage value.

6.6 Electrical Adaptability

6.6.1 DC supply voltage

In accordance with the stipulations of 4.2 in GB/T 28046.2-2011, conduct DC supply voltage test.

6.6.2 Overvoltage

In accordance with the stipulations of 4.3 in GB/T 28046.2-2011, conduct overvoltage test.

6.6.3 Superimposed AC voltage

In accordance with the stipulations of 4.4 in GB/T 28046.2-2011, conduct superimposed AC voltage test.

6.6.4 Slow drop and rise of supply voltage

In accordance with the stipulations of 4.5 in GB/T 28046.2-2011, conduct supply voltage slow drop and rise test.

6.6.5 Transient changes of supply voltage

In accordance with the stipulations of 4.6 in GB/T 28046.2-2011, conduct supply voltage transient change test.

6.6.6 Reverse voltage

In accordance with the stipulations of 4.7 in GB/T 28046.2-2011, conduct reverse voltage test.

6.6.7 Short-circuit protection

In accordance with the stipulations of 4.10.2 in GB/T 28046.2-2011, conduct short-circuit protection test.

6.7 Environmental Adaptability

6.7.1 Sinusoidal vibration

In accordance with the stipulations of GB/T 28046.3-2011, conduct sinusoidal vibration test. The test method and test level shall be determined by OEMs and the manufacturers in accordance with the installation location of the battery management system through negotiation.

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resistance test. In accordance with the requirements of Table 4 and Appendix A in GB/T 28046.4-2011, and the installation location, determine whether salt mist resistance test shall be conducted.

6.7.9 Damp heat cycle

In accordance with the requirements of Table 4 and Appendix A in GB/T 28046.4-2011, and the installation location, determine whether damp heat cycle test shall be conducted in accordance with the stipulations of 5.6.2.2 in GB/T 28046.4-2011; the maximum temperature is 65 °C; cycle for 5 times.

6.8 Electromagnetic Compatibility

6.8.1 General rules

6.8.1.1 The battery shall be provided by the manufacturer of the battery management system; constitute a basic test unit together with the battery management system to simulate the actual installation for tests.

6.8.1.2 During the test process, record the data collected by the battery management system (the number of secondary cell or cell group voltage acquisition channels is not less than the number of sampling units of one independent power supply; the number of temperature acquisition channels is not less than 2). Compare it with the corresponding data detected by the detection equipment.

6.8.1.3 Isolation devices shall be used to isolate auxiliary equipment (such as: upper computer and monitoring software).

6.8.1.4 Charging and discharging current shall be not less than 2% of the full scale of current measurement of the battery management system.

6.8.2 Conduction disturbance

In accordance with the test method in GB/T 18655-2018, and specific test object, select the voltage method and the current probe method to conduct conduction disturbance test.

6.8.3 Radiation disturbance

In accordance with the test method in GB/T 18655-2018, conduct radiation disturbance test.

6.8.4 Transient conduction immunity of power line

In accordance with the test method in GB/T 21437.2-2008, conduct transient conduction immunity test of power line. The test severity shall be Level-III.

6.8.5 Transient conduction immunity of signal line / control line

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Appendix B

(normative)

Test Method for SOC Accumulative Error

B.1 General

B.1.1 In accordance with the requirements of normal operation, assemble the battery system to be tested (the smallest battery system suitable for the battery management system may be selected), or, adopt the battery simulation system.

B.1.2 At three temperature points: -20 °C ± 2 °C, 25 °C ± 2 °C, 65 °C ± 2 °C, respectively conduct the test. During the test, place the battery management system and its accessories related to ampere-hour integration under the selected test environment and temperature conditions; the battery pack may be placed at room temperature through the negotiation by OEMs and the manufacturers. Firstly, the battery system shall carry out the test content specified in B.2, then, the test content specified in B.3.

B.1.3 In addition to the environmental adaptation process, when it is placed still during the test, in accordance with the manufacturer's technical specifications, it can be determined whether the battery management is in the operating state.

B.1.4 When the battery system is tested at a low temperature or other situations where the conditions are not met, the charging and discharging rate may be appropriately reduced. However, at the same time, the charging and discharging time needs to be adjusted, so as to ensure smooth progress of the test.

B.1.5 When the target ambient temperature of the test changes, before the test, the battery system needs to complete the environmental adaptation process: the battery management system and accessories of the test object must be placed still for at least 1 h in the new test environment; the battery pack must be placed still in the new test environment, till the difference between the surface temperature of the secondary cell in the battery pack and the ambient temperature is less than 2 °C, then, it can be considered that the environmental adaptation process of the battery system is completed. During the process, the battery management system shall be in a non-working state.

B.1.6 If the calculation mode of SOC submitted value is different from the actual definition of SOC, before the test, the manufacturer shall explain the mapping relationship.

B.1.7 The differential content of the test conditions must be stated in the test report.

B.2 Available Capacity Test

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Appendix C

(informative)

SOC Error Correction Speed Test

C.1 General

C.1.1 In accordance with the requirements of normal operation, assemble the battery system to be tested (the smallest battery system suitable for the battery management system may be selected).

C.1.2 Within the range of -20 °C ~ 65 °C, OEMs and the manufacturers shall, in accordance with the practical application, select at least three temperature points and respectively conduct the test. In principle, low temperature (≤ 15 °C), normal temperature (25 °C ± 5 °C) and high temperature (≥ 35 °C) need to be included.

C.1.3 In addition to the environmental adaptation process, when it is placed still during the test, in accordance with the manufacturer's technical specifications, it can be determined whether the battery management is in the operating state.

C.1.4 When the battery system is tested at a low temperature or other situations where the conditions are not met, the charging and discharging rate may be appropriately reduced. However, at the same time, the charging and discharging time needs to be adjusted, so as to ensure smooth progress of the test.

C.1.5 When the target ambient temperature of the test changes, before the test, the battery system needs to complete the environmental adaptation process: the battery management system and accessories of the test object must be placed still for at least 1 h in the new test environment; the battery pack must be placed still in the new test environment, till the difference between the surface temperature of the secondary cell in the battery pack and the ambient temperature is less than 2 °C, then, it can be considered that the environmental adaptation process of the battery system is completed. During the process, the battery management system shall be in a non-working state.

C.1.6 When calculating $SOC_{true\ value}$ ($SOC_{true\ value}$), Q_0 is obtained through the available capacity test in B.2. If the calculation mode of SOC submitted value is different from the actual definition of SOC, before the test, the manufacturer shall explain the mapping relationship.

C.1.7 The manufacturer may, in accordance with the differences in the type of vehicle used in the battery system, the rate of charging and discharging capacity of the battery and the temperature of the test environment, select the charging and discharging working conditions in Appendix F, or negotiated and determined by OEMs for tests. In

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charging and discharging capacity Q_1 (charging is negative; discharging is positive) of the test equipment; real-time SOC true value shall be calculated by $(\frac{Q_0-Q_1}{Q_0}\times 100\%)$;

n) During the full test process, calculate SOC error. The formula for the calculation of SOC error is $|SOC_{True\ Value}-SOC_{BMS}|$.

C.2.2 30% < SOC < 80%

C.2.2.1 In accordance with the following steps, test the error correction speed and accuracy of upper biased estimated value when SOC is close to 80%:

a) In accordance with the charging specifications adopted in B.2, charge the battery system;

b) Place it still for 30 min, or the shelving time specified by the manufacturer;

c) The test equipment begins to accumulate cyclic charging and discharging capacity;

d) With 1 Q_0 (A), discharge for 15 min;

e) Place it still for 30 min, or the shelving time specified by the manufacturer;

f) Modify the submitted SOC_{BMS} value of the battery management system into 90%;

g) Adopt specific working conditions (see Appendix F, or, be determined by OEMs and the manufacturers through negotiation); discharge, till the actual SOC is 30%;

h) Place it still for 30 min, or the shelving time specified by the manufacturer;

i) In accordance with the charging specifications adopted in B.2, charge the battery system, till the actual SOC is 80%;

j) Place it still for 30 min, or the shelving time specified by the manufacturer;

k) Repeat g) ~ j) twice;

l) During the test, implement real-time recording of the submitted SOC_{BMS} value of the battery management system;

m) During the test, implement real-time recording of the accumulative cyclic charging and discharging capacity Q_1 (charging is negative; discharging is positive) of the test equipment; real-time SOC true value shall be calculated

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calculation of SOC error is $|SOC_{True\ Value} - SOC_{BMS}|$.

C.2.2.3 In accordance with the following steps, test the error correction speed and accuracy of upper biased estimated value when SOC is close to 30%:

a) In accordance with the charging specifications adopted in B.2, charge the battery system;

b) Place it still for 30 min, or the shelving time specified by the manufacturer;

c) The test equipment begins to accumulate cyclic charging and discharging capacity;

d) With 1 Q_0 (A), discharge for 39 min;

e) Place it still for 30 min, or the shelving time specified by the manufacturer;

f) Modify the submitted SOC_{BMS} value of the battery management system into 50%;

g) Adopt specific working conditions (see Appendix F, or, be determined by OEMs and the manufacturers through negotiation); discharge, till the actual SOC is 30%;

h) Place it still for 30 min, or the shelving time specified by the manufacturer;

i) In accordance with the charging specifications adopted in B.2, charge the battery system, till the actual SOC is 80%;

j) Place it still for 30 min, or the shelving time specified by the manufacturer;

k) Repeat g) ~ j) twice;

l) During the test, implement real-time recording of the submitted SOC_{BMS} value of the battery management system;

m) During the test, implement real-time recording of the accumulative cyclic charging and discharging capacity Q_1 (charging is negative; discharging is positive) of the test equipment; real-time SOC true value shall be calculated by $(\frac{Q_0 - Q_1}{Q_0} \times 100\%)$;

n) During the full test process, calculate SOC error. The formula for the calculation of SOC error is $|SOC_{True\ Value} - SOC_{BMS}|$.

C.2.2.4 In accordance with the following steps, test the error correction speed and

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Appendix D

(informative)

SOP Estimation Error Test Method

D.1 General

D.1.1 In accordance with the requirements of normal operation, assemble the battery system to be tested (the smallest battery system suitable for the battery management system may be selected).

D.1.2 Within the range of -20 °C ~ 65 °C, and the interval of 0 ~ 100%, OEMs and the manufacturers shall, in accordance with the practical application, select at least three temperature points. The three SOC points shall respectively receive pulse charging and discharging test. In principle, the temperature points need to include low temperature (≤ 15 °C), room temperature (25 °C ± 5 °C) and high temperature (≥ 35 °C). SOC points need to include high end (≥ 80%), low end (≤ 30 °C) and intermediate interval (30% < SOC < 80%). Under the selected test conditions, conduct the test content specified in D.2.

D.1.3 In addition to the environmental adaptation process, when it is placed still during the test, in accordance with the manufacturer's technical specifications, it can be determined whether the battery management is in the operating state.

D.1.4 When the target ambient temperature of the test changes, before the test, the battery system needs to complete the environmental adaptation process: the battery management system and accessories of the test object must be placed still for at least 1 h in the new test environment; the battery pack must be placed still in the new test environment, till the difference between the surface temperature of the secondary cell in the battery pack and the ambient temperature is less than 2 °C, then, it can be considered that the environmental adaptation process of the battery system is completed. During the process, the battery management system shall be in a non-working state.

D.1.5 During the test, if the battery management system triggers fault alarm or safety protection, testing organizations and the manufacturers need to negotiate and determine a processing scheme, so as to ensure that the test is normally carried out.

D.1.6 The differential content of the test conditions must be stated in the test report.

D.2 SOP Estimation Error Test

In accordance with the following steps, conduct the test:

a) At 25 °C ± 2 °C, in accordance with the charging specifications adopted in B.2,

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Appendix E

(informative)
Equilibrium Test Method

For equilibrium test, the minimum equilibrium management unit of the li-ion battery management system may be selected; the number of batteries in series is not less than 5. Q_N is the rated capacity of the battery.

a) With 1 I_1 (A) current, at a constant current, charge each battery to the charge cut-off conditions specified by the manufacturer.

b) Place it still for 30 min, or the shelving time specified by the manufacturer.

c) With 1 I_1 (A) current, at a constant current, discharge each battery, till the discharging capacity reaches 0.5 Q_N.

d) Place it still for 30 min, or the shelving time specified by the manufacturer.

e) Respectively handle four of the secondary cells as follows: with 1 I_1 (A) current, discharge one secondary cell for 4 min; with 1 I_1 (A) current, discharge one secondary cell for 2 min; with 1 I_1 (A) current, charge one secondary cell for 4 min; with 1 I_1 (A) current, charge one secondary cell for 2 min.

f) Place it still for 30 min, or the shelving time specified by the manufacturer.

g) Connect to the battery management system.

h) In accordance with the charging specifications adopted in B.2, charge the battery module.

i) Place it still for 30 min, or the shelving time specified by the manufacturer.

j) With 1 I_1 (A) current, discharge, till one of the following conditions are met: the lower limit of secondary cell (cell group) voltage protection of the battery system, or, other discharge cut-off conditions specified in the manufacturer's technical specifications

k) Place it still for the shelving time specified by the manufacturer (not more than T_{rest}).

l) In accordance with the charging specifications adopted in B.2, charge the battery module.

m) Place it still for the shelving time specified by the manufacturer (not more than T_{rest}).

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