Guideline No.E-24(202511)

E-24 Marine Lithium-ion Batteries

Issued date: November 1, 2025

Foreword:

The CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed service@ccs.org.cn。

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Main:

1. Update of referenced standards. GB/T 31467-2023 "Test Methods for Electrical Performance of Lithium-ion Power Battery Packs and Systems for Electric Vehicles" and GB/T 36276-2023 "Lithium-ion Batteries for Power Energy Storage.".

2. Modify the requirements for battery cell crush tests and the methods for battery cell thermal runaway tests.

3. Editorial revisions

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1 Application

The Guideline applies to the lithium-ion batteries (including battery cells, battery modules, battery packs and battery systems) and their battery management systems that are used as part or all power source of a ship.

2 Normative reference

2.1 CCS *Rules for Classification of Sea-going Steel Ships*

2.2 CCS *Rules for Construction of Steel Inland Waterway Ships*

2.3 CCS Rules for Ships Applying Battery as a Power

2.4 CCS *Guidelines for Type Approval Test of Electric and Electronic Products*

2.5 GB/T 34131-2023 "Battery Management System for Power Storage"

3 Terms and definitions

3.1 For definitions of terms such as product inspection, approval, type test, sample, and single piece/single lot inspection, please refer to Section 3.1.2 of Chapter 3 in Part 1 of the CCS *Rules for Classification of Sea-going Steel Ships*;

3.2 Batch: The products of the same specifications continuously produced by the same producer in the same production line according to the same production process.

3.3 Lithium-ion battery: Battery that uses lithium ions as conductive ions to move between the positive and negative electrode, so as to achieve charging and discharging through the mutual conversion of chemical energy and electrical energy. It is hereinafter referred to as “battery”.

3.4 Battery cell: The smallest structural unit in the battery, which is a basic unit device that directly converts chemical energy into electrical energy, including electrodes, separator, electrolyte, housing, and terminals (also known as pole terminals).

3.5 Battery module: Combination of one or more battery cells in series, parallel, or both, which has only one pair of positive and negative output terminals and is used as a power supply.

3.6 Battery pack: Consisting of multiple battery cells or battery modules in series or parallel due to the voltage or power requirements. The battery pack

should contain a monitoring circuit that provides information (such as voltage, temperature, etc.) to the battery system.

3.7 Battery management system (BMS): A system that monitors the status of batteries (such as temperature, voltage and state of charge), serves for communication, safety, battery cell balance and management control of batteries, and provides communication interfaces with the application devices.

3.8 Battery system: An energy storage device, including battery module or battery pack integration, battery management system, high voltage circuit, low voltage circuit, thermal management equipment and mechanical assembly.

3.9 Battery capacity (C): The amount of power stored in the battery. The battery capacity provided by the manufacturer (the battery is discharged with constant current I_n (A) at room temperature and can continuously operate for n hours) is generally the rated battery capacity C_n: the rated capacity at n hour rate (Ah). I_n: the discharge current at n hour rate, the value of which is equal to C_n/n (A). The initial capacity is the capacity (Ah) released when the new power battery that leaves the factory is fully charged at room temperature and then discharged with $1I_1$(A) current to the end-of-discharge conditions specified by the manufacturer.

3.10 State of health (SOH): The degree to which the current battery performance deviates from the normal design index.

3.11 State of charge (SOC): The percentage of the capacity that can be released in the current battery cell, module, pack or system according to the discharge conditions specified by the manufacturer in the battery capacity, also known as the remaining capacity.

3.12 Thermal runaway: uncontrolled intensive increase in the temperature of a cell driven by exothermic reaction.

3.13 Thermal runaway propagation: The phenomenon of thermal runaway of other battery cells that occur in succession in a battery module, battery pack or system, as a result of the thermal runaway of one battery cell.

3.14 Leakage: The leakage of liquid inside the battery cell to the outside of the battery cell housing.

3.15 Venting: Release of the excessive internal pressure from the battery cell, battery module, battery pack, or battery system by explosion-proof valve action to prevent rupture or explosion.

3.16 Rupture: mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage but not

ejection of materials

3.17 Explosion: failure that occurs when a cell container or battery case opens violently and solid components are forcibly expelled.

3.18 Fire: Combustion at any part of the battery cell, battery module, or battery pack for a duration over 1s. Sparks and arcs do not belong to combustion.

3.19 Room temperature (RT): 25℃±2℃.

3.22 Battery at safety level 1: Battery with high risk of combustion (explosion) due to the release of oxygen and toxic combustible gases from the positive electrode material under thermal runaway.

3.23 Battery at safety level 2: Battery with low risk of combustion (explosion) due to the release of only toxic combustible gases from the positive electrode material under thermal runaway.

3.24 Pouch cell: Battery with a housing made of a composite film and a connecting element (electrode).

4 Drawings

4.1 Drawings submitted for plan approval of battery cell:

4.1.1 The following drawings shall be submitted to CCS for approval:

(1) General drawing;

(2) Drawing of main components, including: housing, cover plate, positive/negative plate, separator, etc.;

(3) Technical specifications of products.

4.1.2 The following drawings shall be submitted to CCS for information:

(1) List of main raw materials;

(2) Product operation and maintenance instructions (which, if used for ships engaged in international voyage, shall include at least English edition);

(3) Battery risk assessment report. At least an assessment of the safety level of battery cell shall be included;

(4) Analysis report of process key elements of the battery cell.

4.2 Drawings submitted for plan approval of battery module:

4.2.1 The following drawings shall be submitted to CCS for approval:

(1) General drawing;

(2) Electrical schematic diagram;

(3) Monitoring sensor layout;

(4) External interface diagram;

(5) Technical conditions or specifications of products.

(6) Nameplate or identification drawings (which may not be submitted if other drawings and technical documents of the battery module have covered the content of the nameplate or identification).

4.2.2 The following drawings shall be submitted to CCS for information:

(1) List of main parts and components;

(2) Temperature monitoring analysis and test verification report (only applicable to the situation where the one-by-one monitoring is not adopted, while equivalent temperature monitoring means is adopted);

(3) Product operation and maintenance instructions (which, if used for ships engaged in international voyage, shall include at least the English edition);

(4) Analysis report of process key elements of the battery module.

4.3 Drawings submitted for plan approval of battery pack:

4.3.1 The following drawings shall be submitted to CCS for approval:

(1) General drawing;

(2) Electrical schematic diagram;

(3) Monitoring sensor layout;

(4) External interface diagram;

(5) Technical conditions or specifications of products.

(6) Nameplate or identification drawings (which may not be submitted if other drawings and technical documents of the battery pack have

covered the content of the nameplate or identification).

4.3.2 The following drawings shall be submitted to CCS for information:

(1) List of main parts and components;

(2) Temperature monitoring analysis and test verification report (only applicable to the situation where the one-by-one monitoring is not adopted, while equivalent temperature monitoring means is adopted);

(3) Product operation and maintenance instructions (which, if used for ships engaged in international voyage, shall include at least the English edition);

(4) Analysis report of process key elements of the battery pack.

4.4 Drawings submitted for plan approval of Battery Management System (BMS)

4.4.1 The following drawings shall be submitted to CCS for approval:

(1) General drawing of BMS;

(2) Schematic block diagram of BMS;

(3) Housing and assembly drawing of BMS;

(4) Product technical specifications for BMS;

(5) Risk assessment report of BMS.

4.4.2 The following drawings shall be submitted to CCS for information :

(1) List of main parts, components and materials of BMS;

(2) Operation and maintenance instructions of BMS products (which, if used for ships engaged in international voyage, shall include at least the English edition).

4.5 Materials submitted for plan approval of battery system:

4.5.1 The following drawings shall be submitted to CCS for approval:

(1) Schematic diagram of the battery system;

(2) Connection diagram of the battery system;

(3) Equipment panel layout and outline diagram of the battery system;

(4) Diagrams of protection devices of the battery system and their setting parameters;

(5) Wiring diagram of the battery system;

(6) Test outline of the battery system (approved by the on-site inspection unit).

4.5.2 The following drawings shall be submitted to CCS for reference:

(1) List of main parts and components of the battery system;

(2) Operation and maintenance instructions of the battery system (which, if used for ships engaged in international voyage, shall include at least the English edition).

4.5.3 The following drawings shall be submitted to CCS:

(1) The single line diagrams and/or power system diagrams of the ship's battery system part approved in ship plan approval;

(2) The ship system monitoring and alarm item list part approved in ship plan approval;

(3) Ship short-circuit current calculation and selectivity analysis approved in ship plan approval;

(4) Approved ship-related drawings and plan approval comments.

4.6 To apply for approval of the battery cell, battery module, battery pack, battery management system, etc., the following data shall also be submitted:

(1) Technical characteristics of the product;

(2) Product-related manufacturing processes and technical documents, including the process flow;

(3) Type test outline;

(4) List of suppliers of raw materials and main parts and components of the product;

(5) Necessary quality assurance system documents;

(6) List of the main product production equipment and the inspection and test equipment;

(7) Other valid documents, reports and certificates showing that the customer has the capability of production and could reach the quality level of the products within the approved range;

(8) manufacturer registration certificates, business licenses, qualification certificates and/or production licenses (if any, such as the *Specification Conditions for Lithium Ion Battery Industry (Version 2021)* and the *Management Measures for Announcement of Specification for Lithium Ion Battery Industry (Version 2021)* of MIIT);

(9) Certificates of quality of marine products subject to CCS product inspection (including information on the applicable standards, product performance, quality assurance and liability, etc.) shall be prepared in the language specified by the Purchaser, including at least in English, in the case of ships engaged in international voyage.

5 Technical requirements

5.1 Operating conditions

The battery shall be capable of operating normally under the operating conditions specified in Section 2 of Chapter 1 in Part 4 of the *Rules for Classification of Sea-going Steel Ships*. If only used for inland waterway ships, the battery can only meet the requirement for normal operation under the operating conditions specified in Section 2 and Section 3 of Chapter 1 in Part 3 of the *Code for Construction of Steel Inland Waterway Ships*.

5.2 Battery cell

5.2.1 Appearance and structure

(1) Appearance

The appearance of the battery cell shall not be deformed or cracked, and the surface must be dry and free of burrs, external damage and dirt. The battery cell should be marked clearly and correctly.

(2) Polarity

The polarity labels of battery cell terminals shall be correct and clear.

(3) Dimensions and mass

The dimensions and mass of the battery cell shall meet the technical conditions provided by the manufacturer.

(4) Explosion-proof measures

Battery cells with hard metal or plastic housings shall be provided with safety valves or other explosion-proof measures.

(5) Special requirements for pouch cells

For installation and use of pouch cells, a fixed support shall be provided to meet the requirements of effective ventilation.

(6) Code number

An identifiable product code number shall be attached to the battery cell for easy management, recovery and traceability. The product coding rules shall be implemented in accordance with GB/T 34014.

5.2.2 Performance requirements

(1) Discharging capacity at room temperature

The battery cell is discharged at a $1I_1$(A) current, and its discharging capacity shall not be lower than the rated capacity but not exceed 110% of the rated capacity. Besides, the initial capacity range of all test objects shall not be greater than 5% of the average initial capacity.

(2) Discharging capacity at high temperature

The battery cell is discharged at 55 ℃ ± 2 ℃ at $1I_1$(A), and its discharging capacity shall not be less than 95% of the initial capacity.

(3) Discharging capacity at low temperature

The battery cell is discharged at -20 ℃ ± 2 ℃ at $1I_1$(A), and its discharging capacity shall not be less than 70% of the initial capacity. The end-of-discharge voltage at low temperature specified by the manufacturer shall not be less than 80% of the end-of-discharge voltage at room temperature.

(4) High rate discharging capacity at room temperature

The battery cell is discharged at $3I_1$(A) (maximum current not exceeding 400A), and its discharging capacity shall not be less than 90% of the initial capacity.

(5) High rate charging capacity at room temperature

After the battery cell is charged at $2I_1$(A) (maximum current not exceeding 400A), its discharging capacity shall not be less than 80% of the initial capacity.

(6) Charge retention and capacity recovery

The charge retention rate of the battery cell at room temperature and high temperature shall not be lower than 95% of the initial capacity, and the capacity recovery shall not be less than 96% of the initial capacity.

(7) Storage

After storage at 45℃±2℃ for 28 days, the capacity recovery of the battery cell shall not be less than 96% of the initial capacity.

(8) Standard cycle life

When the battery cell is tested for standard cycle life, the capacity retention rate corresponding to the number of cycles shall meet the requirements in Table 5.2.2. (8).

Correspondence between the number of cycles and the capacity retention rate Table 5.2.2. (8)

S/N	Number of cycles	Capacity retention rate
1	500	≥93%
2	1000	≥90%
3	1500	≥88%
4	2000	≥86%
5	2500	≥84%
6	3000	≥82%
7	3500	≥81%
8	4000	≥80%

(9) Insulation performance

The insulation resistance between the positive and negative electrodes of the battery cell and the exposed conductive part shall not be less than 1000Ω/V before and after the low temperature discharging capacity and temperature cycle.

5.2.3 Safety requirements

(1) Overdischarge

When the battery cell is discharged for 90min or the voltage is 0V, no fire, no explosion.

(2) Overcharge

When the battery cell is charged until the voltage reaches 1.5 times

the end-of-charge voltage or the time reaches 1h, no fire no explosion.

(3) External short circuit

After the positive and negative electrodes of the battery cell are short-circuited externally for 10min, no fire, no explosion.

(4) Mechanical shock

The battery cell under the specified half-sine shock wave shall have no risk, no explosion, no leakage.

(5) Crush

After initialization charging of the battery cell, it shall withstand a compression force of 50 kN for 10 minutes without leakage, smoking, ignition, explosion, or cracking outside the explosion-proof valve or pressure relief point.

(6) Thermal runaway

When the determination condition of thermal runaway is triggered, no fire, no explosion

(7) Vibration

When the test is carried out under the general vibration conditions specified in Section 2.7 of the *Guidelines for Approval Test*, the battery cell shall be able to operate normally, and no fire, no explosion.

(8) Temperature cycle

During the temperature cycle test, no fire, no explosion.

(9) Flame retardation requirements

The housing material of the battery cell shall be flame-retardant.

5.3 Battery module

5.3.1 Appearance and structure

(1) Appearance

The appearance of the battery module is smooth without obvious scratches, deformations or other defects. If the battery module is designed with heat dissipation at the bottom, the flatness deviation at the bottom shall not be greater than 0.5mm, except for those filled with

thermal conductive adhesive. Battery module components shall be fastened reliably without corrosion, burrs, cracks, other defects and external damages. Labels on the battery module shall be correct, complete and clear.

(2) Polarity

The polarity labels of battery module terminals shall be correct and clear.

(3) Dimensions and mass

The overall dimensions and mass of the battery module shall conform to the product technical conditions provided by the manufacturer.

(4) Explosion-proof measures

If the battery module is designed with an enclosed housing, a safety valve or other explosion-proof measures shall be provided.

(5) Materials

Auxiliary materials of the battery module shall be flame-retardant.

(6) Monitoring circuit

If the battery system composed of battery modules is used on board, the battery module shall be designed with a monitoring circuit that provides information (such as voltage, temperature, etc.) for the battery system.

(7) Code number

An identifiable code number shall be attached to the battery module for easy management, recovery and traceability. The coding rules shall be implemented according to GB/T 34014.

(8) Structure

The battery cell shall be firmly fixed in the battery module. The battery module shall be applied with sufficient pretension force to prevent deformation or cracking caused by the battery cell.

5.3.2 Performance requirements

(1) Discharging capacity at room temperature

The battery module is discharged at I_1(A), and its discharging

capacity shall not be lower than the rated capacity, and shall not exceed 110% of the rated capacity. The initial capacity range of all test objects shall not be greater than 7% of the average initial capacity.

(2) Discharging capacity at high temperature

The battery module is discharged at 55℃±2℃ at I_1(A), and its discharging capacity shall not be less than 90% of the initial capacity.

(3) Discharging capacity at low temperature

The battery module is discharged at -20℃±2℃ at I_1(A), and its discharging capacity shall not be less than 70% of the initial capacity. The end-of-discharge voltage at low temperature specified by the manufacturer shall not be less than 80% of the end-of-discharge voltage at room temperature.

(4)High rate discharging capacity at room temperature

The battery module is discharged at $3I_1$(A) (maximum current not exceeding 400A), and its discharging capacity shall not be less than 90% of the initial capacity.

(5) High rate charging capacity at room temperature

After the battery module is charged at $2I_1$(A) (maximum current not exceeding 400A), its discharging capacity shall not be less than 80% of the initial capacity.

(6) Charge retention and capacity recovery

The charge retention rate of the battery module at room temperature and high temperature shall not be less than 85% of the initial capacity, and the capacity recovery shall not be less than 90% of the initial capacity.

(7) Storage

After storage at 45℃±2℃ for 28 days, the capacity recovery of the battery module shall not be less than 90% of the initial capacity.

(8) Insulation performance

The insulation resistance between the positive and negative electrodes and the exposed conductive part of the battery module shall not be less than 1000Ω/V.

5.3.3 Safety requirements

(1) Overcharge

When the battery module is charged until the voltage of any battery cell reaches 1.5 times its end-of-charge voltage or the time reaches 1h, no fire, no explosion.

(2) Overdischarge

When the battery module is discharged until the time reaches 90min or the voltage of any battery cell reaches 0V, no fire, no explosion.

(3) Thermal runaway propagation

If a battery cell at a specific position in the battery module is triggered to reach the determination condition of thermal runaway, no fire, no explosion, no thermal runaway propagation.

(4) Vibration

When the test is carried out under the general vibration conditions in Section 2.7 of the *Guidelines for Approval Test*, the battery module shall be able to operate normally and no fire, no explosion.

5.4 Battery pack

5.4.1 Appearance and structure

(1) Appearance

The appearance of the battery pack shall not be deformed or cracked, and the surface shall be dry, free of external damage and dirt. The battery pack shall be arranged neatly, connected reliably, and marked clearly.

(2) Polarity

The polarity labels of battery pack terminals shall be correct and clear.

(3) Dimensions and mass

The dimensions and mass of the battery pack shall conform to the product technical conditions provided by the manufacturer.

(4) Explosion-proof measures

The battery pack shall be provided with safety valves or other

explosion-proof measures.

(5) Housing material

The housing material of the battery pack (except connectors) shall be non-combustible. If the battery pack may be mounted directly on the bracket, its housing shall be made of steel material with a thickness no less than 1mm. The housing material of external connectors shall be flame-retardant.

(6) Protection rating of housing

The protection rating should not be less than IP67 for the battery pack of pouch cell or the battery pack with the safety level of 1. In terms of the battery pack with the safety level of 2 (except the pouch cell), the he protection rating should be at least IP22. For the passenger ships with a length over 50 meters or a capacity for over 150 passengers, as well as the ships carrying hazardous goods (including the bulk and packaged hazardous goods), the tourist ships, the liquefied gas carriers and GFRP ships, the battery with the safety level of 2 shall be adopted, and the protection rating of battery packs shall not be less than IP67.

(7) Temperature control measures

Temperature control measures shall be adopted for the battery packs. The battery pack with the protection rating of IP67 shall be provided with a temperature control device separated from the battery compartment (chamber)/battery box (cabinet). For the battery packs equipped with temperature control devices, the performance shall be as declared by the manufacturer. The pipeline of the temperature control device shall be free of deformation and leakage under 1.5 times the design pressure.

(8) Monitoring circuit

The battery pack should contain a monitoring circuit that provides information (such as voltage, temperature, etc.) to the battery system.

(9) Nameplate

The battery pack housing shall be securely attached with a firm nameplate. The contents of the nameplate shall at least include the product name, the model, voltage (V) and capacity (Ah) of battery cell, the nominal voltage (V), nominal power (kWh), weight (kg) and model of battery pack, the product code number, and the production date (yyyy-mm-dd).

(10) Code number

An identifiable code number shall be attached to the battery pack for easy management, recovery and traceability. The coding rules shall be implemented according to GB/T 34014.

(11) interface

The battery pack interface shall be clearly marked. In addition, the positive and negative electrodes should be equipped with fool-proofing connectors.

(12) Grounding device

The battery pack should be equipped with an effective grounding device.

5.4.2 Performance requirements

(1) Capacity at room temperature and maximum discharge current

The battery pack shall be discharged at the standard continuous discharge current (not less than I_3(A)) stipulated by the manufacturer, and the discharging capacity shall not be less than the rated capacity. When the battery pack is discharged at the maximum discharge current specified by the manufacturer, the battery temperature shall not exceed the limit value specified by the manufacturer before reaching the cut-off condition specified by the manufacturer.

(2) Insulation performance

Calculated according to the nominal voltage, the insulation resistance between the positive electrode of the battery pack and the exposed conductive part, and that between the negative electrode of the battery pack and the exposed conductive part shall not be less than 1000Ω/V before and after the damp heat test, low temperature test, salt spray test Kb and withstand voltage test. The insulation resistance between the external interface terminals except the positive and negative electrodes of the battery pack sand the exposed conductive part shall not be less than 10MΩ (Un≤65V)/100MΩ (>65V) before the damp heat test, low temperature test, salt spray test Kb and withstand voltage test, and shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V) after these tests.

(3) Withstand voltage

When the specified voltage is applied between the positive electrode of the battery pack and the exposed conductive part, and between the

negative electrode of the battery pack and the exposed conductive part, no breakdown or flash-over shall occur. When the specified voltage is applied between the external interface terminals except the positive and negative electrodes of the battery pack and the exposed conductive part, no breakdown or flash-over shall occur.

5.4.3 Safety requirements

(1) Crush

When the deformation of the battery pack reaches 30% or the crush force reaches 100kN, no fire nor explosion shall occur.

(2) External fire

When an external fire test is performed for the battery pack, there shall be no explosion.

(3) Thermal runaway propagation

If a battery cell at a specific position in the battery pack is triggered to reach the determination condition of thermal runaway, there shall be no thermal runaway of other battery cells. There shall be no leakage, rupture, fire or explosion of the battery pack (except the battery cell triggered to reach the thermal runaway condition) in the thermal runaway propagation test.

(4) External short circuit protection

When an external short circuit test is performed for the battery pack, there shall be no leakage, housing rupture, fire or explosion.

(5) Inclination and rolling

The battery pack with liquid cooling device and free liquid surface shall operate normally under the condition of inclination and rolling, and there shall be no leakage, housing rupture, fire or explosion, without triggering the abnormal end conditions. The insulation resistance after the test shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V). .

(6) Vibration

The battery pack shall be able to operate normally during the vibration test in accordance with the general vibration conditions in Section 2.7 of the *Guidelines for Approval Test*, and there shall be no leakage, housing rupture, fire or explosion, without triggering the abnormal end conditions. The insulation resistance after the test shall not

be less than 1MΩ (Un≤65V)/10MΩ (>65V).

(7) High temperature

The battery pack shall be able to operate normally at 55℃±2℃, and there shall be no leakage, housing rupture, fire, or explosion, without triggering the abnormal end conditions. The insulation resistance after the test shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V). The capacity recovered from the test shall not be lower than the rated capacity.

(8) Low temperature

The battery pack shall be able to operate normally at -25℃±2℃, and there shall be no leakage, housing rupture, fire, or explosion, without triggering the abnormal end conditions. The insulation resistance after the test shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V). The capacity recovered from the test shall not be lower than the rated capacity.

(9) Damp heat

There shall be no leakage, housing rupture, fire, or explosion of the battery pack under alternating damp heat test conditions. The insulation resistance within 30min after the test shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V). The capacity recovered from the test shall not be less than 95% of the initial capacity.

(10) Salt mist

After the salt spray test is performed for the battery pack used on the open deck of a sea-going vessel in accordance with Section 2.12 of the *Guidelines for Approval Test*, there shall be no leakage, housing rupture, fire, or explosion. The insulation resistance after the test shall not be less than 1MΩ (Un≤65V)/10MΩ (>65V). The capacity recovered from the test shall not be less than 95% of the initial capacity.

5.5 Battery management system (BMS)

5.5.1 Functional requirements

(1) Power supply

The BMS shall be powered by two power supplies.

(2) Structure

The BMS should be equipped with a battery control unit and a battery monitoring circuit according to the battery level. The battery control unit shall be able to receive information (such as voltage, temperature, etc.) contained in the monitoring circuit in the battery module/battery pack. The BMS must have the function of summarizing the information of the battery control unit of the battery box (cabinet), and shall have a data transmission interface with the ship management system, through which the information that needs to be displayed remotely in Table 5.5.1 can be fed back to the ship management system and is under the management of the system. The remote display and alarm function of BMS can be realized through the ship management system.

(3) Monitoring parameters, display, alarm, and protection

The functional requirements of BMS are shown in Table 5.5.1:

List of functional requirements of BMS Table 5.5.1

S/N	Parameter	Monitoring	Display		Alarm		Protection	Protection action
			Local	Remote	Local	Remote		
1	Battery system voltage	√	√	√				
2	Battery cell voltage	√	√	√				
2.1	Imbalance of battery cell voltage						√	Implement equalization control
2.2	Battery cell overvoltage				√	√	√	Disconnect the charging device
2.3	Battery cell undervoltage				√	√	√	Reduce the power, and stop the battery (sub) system
3	Battery serial circuit current	√	√	√				
3.1	Overcurrent of battery serial circuit current				√	√	√	Reduce power/Stop the battery (sub) system
4	Temperature of battery cell	√	√	√				
4.1	High temperature of battery cell				√	√	√	Control the temperature/Reduce the power/Stop the

								battery (sub) system
5	Ambient temperature	√	√	√				
5.1	Too high ambient temperature				√	√	√	Control the temperature and reduce the power
5.2	Too low ambient temperature				√	√	√	Control the temperature and reduce the power
6	Electrical insulation resistance	√	√	√				
6.1	Low electrical insulation resistance				√	√	√	Stop the battery (sub) system
7	State of Charge (SOC)		√	√				
7.1	Low remaining capacity (SOC)				√	√	√	Reduce the power, and stop running the battery (sub) system
8	State of Health (SOH)		√	√				
9	Battery energy flow state		√	√				
10	Overcurrent protection				√	√	√	Reduce the power, and stop the battery (sub) system
11	Overcharge protection				√	√	√	Disconnect the charging device
12	Overtemperature protection (temperature of battery cell)	√	√	√	√	√	√	Control the temperature, reduce the power, and stop the battery (sub) system
13	Overtemperature protection (ambient temperature)	√	√	√	√	√	√	Control the temperature, reduce the power, and stop the battery (sub)

								system
14	Thermal management failure of battery pack/box (cabinet) (if any)				√	√		
15	Emergency exhaust failure of battery box (cabinet) (if any)				√	√		
16	Protection functional failure				√	√	√	Stop running the battery (sub) system
17	Temperature detection failure				√	√	√	Stop running the battery (sub) system
18	Charging failure				√	√	√	Reduce power and stop charging
19	Voltage imbalance between battery modules				√	√	√	Start balance control/Reduce power, and stop running the battery (sub) system
20	The battery system stops due to a failure				√	√		
21	The battery circuit breaker/relay does not operate properly				√	√		
22	The communication between BMS and PMS/EMS/IAS fails				√	√	√	Power reduction
23	BMS power supply indicator and	√	√	√	√	√		

	failure							

In the case of a battery failure (see Table 5.5.1) that may cause the battery (sub)system to stop running, a pre-alarm shall be given before the limit state is reached. The BMS shall be able to realize the whole life cycle monitoring of the battery used as marine power on the ship. During the period when the battery is not operating, the system shall at least be able to measure and display the temperature of the battery cell and the ambient temperature, and be able to issue visual and auditory alarms locally and remotely (in the manned areas on the ship) when the temperature is abnormal. The BMS shall be able to monitor the temperature of the battery cells one by one. If equivalent monitoring means are used, supporting materials shall be provided for CCS approval.

Overtemperature protection shall be able to control the battery to a safe state, such as ventilation, power reduction, and load disconnection measures. Overtemperature protection shall be independent of other components with temperature indication, alarm and control functions.

The BMS shall have a self-check function. Self-check failures include but are not limited to: protection failure, voltage monitoring failure, temperature detection failure, battery pack/battery box (cabinet) cooling failure, and charging failure. When the protection failure and the temperature detection failure occur, the battery system shall stop running; In case of charging failure, the BMS shall control the charging device to stop charging.

5.5.2 Performance requirements

(1) Measurement accuracy of state parameters

The requirements for measurement accuracy of the state parameters monitored through the BMS are shown in Table 5.5.2.

Requirements for measurement accuracy of state parameters Table 5.5.2

Parameter	Accuracy requirement	Sampling period requirement
Battery cell voltage	≤5mV	≤100 ms
Total voltage of the battery system (or battery cluster)	≤5V(<500V); ≤±1%FS(≥500V)	≤100 ms
Current of the battery system (or battery	≤2A(＜200A); Or ≤±1% (≥200A)	≤50 ms

cluster)		
Temperature of battery cell	≤1℃(-20℃～+65℃); Or 2℃ (-40℃≤T＜-20℃, 65℃＜T≤125℃)	≤1 s
Insulation resistance	1. Total voltage ≥400V: 1) ≤±15kΩ(R≤75kΩ) 2) ≤±20%(R＞75kΩ) 2. 60V<Total voltage<400V: 1) ≤±15kΩ(R≤50kΩ) 2) ≤±30%(R＞50kΩ)	/

(2) Energy state estimation

The battery management system shall estimate the energy state in real time. The maximum allowable error in the energy state estimation of the battery management system shall be ±5%.

(3) Reverse voltage

The battery management system shall withstand the reverse voltage for 1min.

(4) Insulation performance

The insulation resistance between the collection terminal and the ground terminal, between the communication terminal and the ground terminal, between the collection terminal and the communication terminal, and between the power supply terminal and the communication terminal of the battery management system connected with the battery shall not be less than 10MΩ (Un≤65V)/100MΩ(＞65V) before the damp heat test, low temperature test, salt mist test Kb and withstand voltage test, and shall not be less than 1MΩ (Un≤65V)/10MΩ(＞65V) after these tests.

(5) Withstand voltage

When the specified voltage is applied between the collection terminal and the ground terminal, between the communication terminal and the ground terminal, between the collection terminal and the power supply resistor, and between the power supply terminal and the communication terminal of the battery management system connected with the battery, there shall be no insulation breakdown or flash-over, and the leakage current shall be less than 10mA.

5.6 Battery system

5.6.1 Housing

Battery system related equipment is generally made of durable, flame retarding and moisture resistant materials.

5.6.2 Functions

The control function of battery system shall comply with the requirements in Table 5.5.1.

5.6.3 Emergency shut-off

The battery system with a nominal energy of more than 50kWh shall be provided with a separate interface for the emergency shut-off device.

6 Material and Components

The raw materials, parts and components of the products shall be controlled in accordance with the relevant requirements of current CCS rules.

7 Type test

7.1 Unless otherwise specified, the test shall be carried out under the following environmental conditions:

(1) Temperature range: 25℃±5℃;

(2) Relative humidity: 15% ~ 90%;

(3) Atmospheric pressure: 96kPa±10kPa.

7.2 Accuracy of measuring instruments and meters

The accuracy of measuring instruments and meters shall meet the following requirements:

(1) Voltage measuring device: ±0.5% FS

(2) Current measuring device: ±0.5% FS

(3) Temperature measuring device: ±0.5℃

(4) Time measuring device: ±0.1s

(5) Dimension measuring device: ±0.1% FS

(6) Mass measuring device: ±0.1% FS

7.3 Test process error

The requirements for the error between the control value (actual value) and the target value are as follows:

(1) Voltage: ±1%

(2) Current: ±1%

(3) Temperature: ±2℃

7.4 Other descriptions:

7.4.1 Data recording and recording interval

Unless otherwise stated in some specific test items, the recording interval of test data (such as time, temperature, current and voltage, etc.) shall not be greater than 100s.

7.4.2 Requirements for environmental adaptation

When the target ambient temperature of test changes, the test object shall have an environmental adaptation process before the test; The difference between the battery cell temperature and the target ambient temperature shall not exceed 2℃, and the change rate of the battery cell temperature shall be <1℃/h. If contained in the test object, the battery control unit shall be turned off during the environmental adaptation process.

7.4.3 Specified charging method

(1) Battery cell

At room temperature, the battery cell is first discharged at a $1I_1$(A) current to the end-of-discharge voltage specified in the technical conditions of the manufacturer, set aside for 1h (or for no more than 1h as provided by the manufacturer), and then charged with the method provided by the manufacturer. If the manufacturer does not provide a charging method, the battery cell shall be charged with the following methods:

Charge at a constant current of $1I_1$(A) to the end-of-charge voltage specified in the technical conditions of the manufacturer, turn to constant voltage charging, then stop charging when the charge current drops to $0.05I_1$(A), and set aside for 1h after charging (or for no more than 1h as provided by the manufacturer).

(2) Battery module

At room temperature, the battery module is first discharged at a $1I_1$(A) current to the end-of-discharge voltage specified in the technical conditions of

the manufacturer, set aside for 1h (or for no more than 1h as provided by the manufacturer), and then charged with the method provided by the manufacturer. If the manufacturer does not provide a charging method, the battery cell shall be charged with the following methods:

Charge at a constant current of $1I_1$(A) to the end-of-charge voltage specified in the technical conditions of the manufacturer, turn to constant voltage charging, and then stop charging when the charge current drops to $0.051I_1$(A). Stop charging if the battery cell voltage is 0.1V higher than the end-of-charge voltage during the charging process. Set aside for 1h after charging (or for no more than 1h as provided by the manufacturer).

(3) Battery pack

Discharge in the discharge mechanism recommended by the manufacturer until the discharge cut-off conditions specified by the manufacturer are reached; Let stand for 30min; Charge in the charge mechanism recommended by the manufacturer until the charge cut-off conditions specified by the manufacturer are reached; Set aside for 30min.

7.5 The type test items, technical requirements and test methods of the battery cell are shown in Table 7.5:

Type test items of the battery cell Table 7.5

S/N	Type of test	Test items	Technical requirement	Test method	Sample quantity and number
1.	Performance test	Inspection of appearance and structure	5.2.1 (1),(4),(5)	7.5.2 (1)	1#~26#
2.		Polarity	5.2.1 (2)	7.5.2 (2)	
3.		Dimensions and mass	5.2.1 (3)	7.5.2 (3)	
4.		Discharging capacity at room temperature	5.2.2 (1)	7.5.2 (4)	
5.		Discharging capacity at high temperature	5.2.2 (2)	7.5.2 (5)	1#, 2#
6.		Discharging capacity at low temperature	5.2.2 (3)	7.5.2 (6)	
7.		High rate discharging capacity at room temperature	5.2.2 (4)	7.5.2 (7)	
8.		High rate charging capacity at room temperature	5.2.2 (5)	7.5.2 (8)	

9.		Charge retention and capacity recovery at room temperature	5.2.2 (6)	7.5.2 (9)	3#, 4#
10.		Charge retention and capacity recovery at high temperature	5.2.2 (6)	7.5.2 (10)	5#, 6#
11.		Storage	5.2.2 (7)	7.5.2 (11)	7#, 8#
12.		Standard cycle life	5.2.2 (8)	7.5.2 (12)	9#, 10#
13.		Insulation resistance measurement	5.2.2.(9)	7.5.2 (13)	1#~26#
14.	Safety test	Overdischarge	5.2.3 (1)	7.5.2 (14)	11#, 12#
15.		Overcharge	5.2.3 (2)	7.5.2 (15)	13#, 14#
16.		External short circuit	5.2.3 (3)	7.5.2 (16)	15#, 16#
17.		Mechanical shock	5.2.3 (4)	7.5.2 (17)	17#, 18#
18.		Crush	5.2.3 (5)	7.5.2 (18)	19#, 20#
19.		Thermal runaway	5.2.3 (6)	7.5.2 (19)	21#, 22#
20.	Environmental adaptation test	Vibration test	5.2.3 (7)	7.5.2 (20)	23#, 24#
21.		Temperature cycle	5.2.3 (8)	7.5.2 (21)	
22.		Flame retardation test (plastic housing only)	5.2.3 (9)	7.5.2 (22)	Housing component

7.5.1 Selection of typical samples for battery cells

(1) Principle for selection of typical samples

If the manufacturer applies for the approval of battery cells of multiple models at the same time, the model with the largest capacity under each production process can be selected as a typical sample according to the differences in the manufacturing process and the capacity of battery cells, and the other models of battery cells under the same production process shall be at least tested for safety. The number of samples can be reduced according to the test situation.

(2) Changes of approved products

If different models of battery cells are applied for approval several times, typical samples shall be selected from the models in each approval application on the

principle of selecting the typical samples, and shall be subject to the type test according to the requirements of Table 7.5.

7.5.2 Type test method for battery cells

(1) Inspection of appearance and structure

Check the appearance of battery cells in a good light by visual inspection, and record the inspection results.

(2) Polarity

Detect the polarity of battery cells with a voltmeter and record the measurement results.

(3) Dimensions and mass

Measure the dimensions and mass of battery cells with appropriate measuring tools and weighing apparatus, and record the measurement results.

(4) Discharging capacity at room temperature

① Charge the battery cell with the specified method;

② Discharged the battery cell at room temperature at a $1I_1$(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

③ Measure the discharging capacity (Ah), and calculate the discharge specific energy (Wh/kg);

④ Repeat the steps ①～ ③for 5 times. When the range of three consecutive test results is less than 3% of the rated capacity, the test can be terminated in advance, and the average value of the last three test results is taken.①③

(5) Discharging capacity at high temperature

① Charge the battery cell with the specified method;

② Set aside the battery cell at 55℃±2℃ for 5h;

③ Discharge the battery cell at 55℃±2℃ at a $1I_1$(A) current until it reaches the end-of-discharge voltage at room temperature specified in the technical conditions of the manufacturer;

④ Measure the discharging capacity (Ah).

(6) Discharging capacity at low temperature

① Charge the battery cell with the specified method;

② Set aside the battery cell at -20℃±2℃ for 24h;

③ Discharge the battery cell at -20℃±2℃ at 1I_1(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer (the voltage value is no less than 80% of the end-of-discharge voltage at room temperature);

④ Measure the discharging capacity (Ah).

(7) High rate discharging capacity at room temperature

① Charge the battery cell with the specified method;

② Discharge the battery cell at t room temperature at a 3I_1(A) current (maximum current not exceeding 400A) until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

③ Measure the discharging capacity (Ah).

(8) High rate charging capacity at room temperature

① Discharge the battery cell at room temperature at 1I_1(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer, and then set it aside for 1h;

② Charge the battery cell at room temperature at a 2I_1(A) current (the maximum current not exceeding 400A) until the voltage of any cell reaches the end-of-charge voltage, or meets the end-of-charge conditions specified by the manufacturer, with the total charging time not exceeding 30min or C/400h, whichever is larger. Then, set aside the battery cell for 1h;

③ Discharge the battery cell at room temperature at a 1I1(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

④ Measure the discharging capacity (Ah).

(9) Charge retention and capacity recovery at room temperature

① Charge the battery cell with the specified method;

② Store the battery cell at room temperature for 28d;

③ Discharge the battery cell at a 1I_1(A) current at room temperature to the end voltage;

④ Measure the charge retention capacity (Ah).

⑤ Charge the battery cell with the specified method;

⑥ Discharge the battery cell at a 1I1(A) current at room temperature to the

end voltage;

⑦ Measure the recovery capacity (Ah).

(10) Charge retention and capacity recovery at high temperature

① Charge the battery cell with the specified method;

② Store the battery cell at 55℃±2℃ for 7d;

③ Set aside the battery cell at room temperature for 5h, and then discharge at a $1I_1$(A) current until any cell reaches the end-of-discharge voltage;

④ Measure the charge retention capacity (Ah).

⑤ Charge the battery cell with the specified method;

⑥ Discharge the battery cell at a $1I_1$(A) current at room temperature until any cell reaches the end-of-discharge voltage.

⑦ Measure the recovery capacity (Ah).

(11) Storage

① Charge the battery cell with the specified method;

② Discharge the battery cell at a $1I_1$(A) current for 30min at room temperature;

③ Store the battery cell at 45℃±2℃ for 28d;

④ Set aside the battery cell at room temperature for 5h;

⑤ Charge the battery cell with the specified method;

⑥ Discharge the battery cell at a 1I1(A) current at room temperature until any cell reaches the end-of-discharge voltage.

⑦ Measure the discharging capacity (Ah).

(12) Standard cycle life

① Discharge the battery cell at a $1I_1$(A) current until the end-of-discharge conditions specified by the manufacturer are reached;

② Set aside the battery cell for no less than 30min or meeting the conditions specified by the manufacturer;

③ Charge the battery cell with the specified method;

④ Set aside the battery cell for no less than 30min or meeting the conditions specified by the manufacturer;

⑤ Discharge the battery cell at a $1I_1$(A) current to reach the end-of-discharge conditions specified by the manufacturer, and record the discharging capacity;

⑥ Make continuous cycles as per ②～⑤, and conduct discharging capacity determination every 500 times. If the capacity retention rate meets the results specified in Table 5.2.2. (8), the test shall be terminated; If the discharging capacity is lower than that specified in Table 5.2.2. (8), the cycle continues.

⑦ Measure the discharging capacity and discharge energy at room temperature.

(13) Insulation resistance measurement

The test shall be carried out in accordance with Section 2.3 of the *Guidelines for Approval Test*.

(14) Overdischarge

① Charge the battery cell with the specified method;

② Discharge the battery cell at a $1I_1$(A) current for 90min;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(15) Overcharge

① Charge the battery cell with the specified method;

② After the battery cell is charged at the constant current specified by the manufacturer but not less than $1I_3$(A) until the voltage reaches 1.5 times the end-of-charge voltage specified by the manufacturer or the time reaches 1h, stop charging;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(16) External short circuit

① Charge the battery cell with the specified method;

② After the positive and negative terminals of the battery cell are short-circuited externally for 10min, the resistance of the external line shall be less than 5mΩ;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(17) Mechanical shock

① Charge the battery cell with the specified method;

② Apply the half-sine shock wave to the battery cell at an acceleration of 50g

for a duration of 6ms, with 10 times in the ±x, ±y, and ±z directions, respectively.

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(18) Crush

① Charge the battery cell with the specified method;

② Crush direction: perpendicular to the battery cell plate;

③ Crush plate form: a half cylinder with a radius of 75mm, and the length of the half cylinder L is greater than the size of the battery cell to be extruded;

④ Initial crushspeed: (5±1)mm/s

⑤ Crush degree: Stop extrusion when the voltage reaches 0V or the deformation reaches 30% or the crush force reaches50kN;

⑥ Hold for 10min.

⑦ After completing the above test steps, observe at the test ambient temperature for 1h.

(19) Thermal runaway

① The test sample that has completed initialization charging is placed in the thermal runaway test device;

② Select heating components and temperature sensors according to the requirements of Table 7.5.2 (19) and place them on the surface of the test sample. Set the temperature sampling period to 1 second, and set the continuous monitoring of three temperature rise rate values ≥ 3 ℃/s or fire or explosion as the criteria for thermal runaway;

③ Connect the test sample to the charging and discharging device and its voltage data sampling line;

④ Charge with 1I3 (A) constant current, start heating, record time, voltage, current, temperature, temperature rise rate, and record test phenomena, including expansion, leakage, smoking, fire, explosion, shell rupture, and rupture location;

⑤ When the condition for triggering thermal runaway occurs or the temperature reaches 300 ℃ or the test time reaches 4 hours, stop charging and heating, observe for 1 hour, record the time, voltage, temperature,

temperature rise rate, and record the test phenomena, including expansion, leakage, smoking, fire, explosion, shell rupture, and rupture location;

⑥ Disconnect the test sample from the charging and discharging device, remove the heating component and data sampling line, and take out the test sample;

⑦ Record the temperature at which thermal runaway occurs as the thermal runaway temperature;

Heating and sampling requirements for thermal runaway performance test

Table 7.5.2 (19)

Rated discharge energy E of the test sample W·h	Heating component power W	Shape and arrangement position of heating components		Temperature sensor specifications and layout location	
		Prism shaped or soft pack test sample	Cylindrical test sample	Prism shaped or soft pack test sample	Cylindrical test sample
E＜50	250	Sheet shaped, arranged on a flat surface with a larger area of the test sample, with a size not greater than the size of the heated surface	Linear, arranged on the side of the test sample, covering the height Not greater than the height of the heated surface	The diameter of the temperature sensing head is ≤ 1mm, and it is arranged at the center position of the heated side	Temperature sensing head diameter ≤ 1mm, arranged at the center position of the bottom or top of the test sample
50≤E＜100	450				
100≤E＜400	650				
400≤E＜800	800				
800≤E＜1000	1000				
E≥1000	＞1000				

② After the battery cell is charged with the specified method, continue charging at a $1I_1$ (A) constant current for 12min;

③ Start the heating device and heat the test object continuously with its maximum power. When thermal runaway occurs, stop triggering and close the heating device;

④ Determination conditions for thermal runaway:

a) The trigger object generates a voltage drop, and the drop value exceeds 25% of the initial voltage;

b) The temperature of the monitoring point reaches the protection temperature of the battery;

c) The temperature rise rate of the monitoring point is ≥1℃/s and lasts for more than 3s;

d) If (a)+(c) or (b)+(c) occurs, it is determined that thermal runaway occurs to the battery cell;

e) During the heating process and within 1h after heating, if fire or explosion occurs, the test shall be terminated and it is determined that thermal runaway occurs.

(20) Vibration test

① Charge the battery cell with the specified method;

② The test shall be performed in accordance with Section 2.7 of the *Guidelines for Approval Test*;

③ The battery cell voltage and temperature shall be monitored during the test.

④ After completion of the test, the capacity at room temperature shall be tested according to 7.5.2 (4).

(21) Temperature cycle

① Charge the battery cell with the specified method;

② Put the battery cell into the temperature box, adjust the temperature box according to Table 7.5.2 (21), and make temperature cycles 5 times;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

Temperature and time of a cycle during the temperature cycle test Table 7.5.2 (21)

Temperature ℃	Time increment min	Accumulated time min	Rate of temperature change ℃/min
25	0	0	0
-40	60	60	13/12
-40	90	150	0
25	60	210	13/12
85	90	300	2/3
85	110	410	0
25	70	480	6/7

(22) Flame retardation test (plastic housing only)

The test shall be performed in accordance with Section 2.16 of the *Guidelines for Approval Test*;

7.6 The type test items, technical requirements and test methods of the battery module are shown in Table 7.6

Type test items of the battery module Table 7.6

S/N	Type of test	Test items	Technical requirement	Test method	Reference standard	Sample quantity and number
1.	Performance test	Inspection of appearance and structure	5.3.1 (1), (4), (7)	7.6.2 (1)	GB/T 31486 6.3.1	1#~8#
2.		Polarity	5.3.1 (2)	7.6.2 (2)	GB/T 31486 6.3.2	
3.		Dimensions and mass	5.3.1 (3)	7.6.2 (3)	GB/T 31486 6.3.3	
4.		Discharging capacity at room temperature	5.3.2 (1)	7.6.2 (4)	GB/T 31486 6.3.5	
5.		Discharging capacity at high temperature	5.3.2 (2)	7.6.2 (5)	GB/T 31486 6.3.9	1#
6.		Discharging capacity at low temperature	5.3.2 (3)	7.6.2 (6)	GB/T 31486 6.3.8	
7.		High rate discharging capacity at room temperature	5.3.2 (4)	7.6.2 (7)	GB/T 31486 6.3.6.1	
8.		High rate charging capacity at room temperature	5.3.2 (5)	7.6.2 (8)	GB/T 31486 6.3.7	
9.		Charge retention and capacity recovery at room temperature	5.3.2 (6)	7.6.2 (9)	GB/T 31486 6.3.10.1	2#
10.		Charge	5.3.2 (6)	7.6.2	GB/T	3#

		retention and capacity recovery at high temperature		(10)	31486 6.3.10.2	
11.		Storage	5.3.2 (7)	7.6.2 (11)	GB/T 31486 6.3.12	4#
12.		Insulation resistance measurement	5.3.2.(8)	7.6.2 (12)	Guidelines for Approval Test 2.3	1#~8#
13.	Safety test	Overcharge	5.3.3 (1)	7.6.2 (13)	GB/T 36276 A.3.13	5#
14.		Overdischarge	5.3.3 (2)	7.6.2 (14)	GB/T 36276 A.3.14	6#
15.		Thermal runaway propagation	5.3.3 (3)	7.6.2 (15)	GB/T 36276 A.3.19/ISO 6469-1	7#
16.	Environmental adaptation test	Vibration test	5.3.3 (4)	7.6.2 (16)	Guidelines for Approval Test 2.7	8#
17.		Flame retardation test	5.3.1 (5)	7.6.2 (17)	Guidelines for Approval Test 2.16	Housing component

7.6.1 Selection of typical samples for battery modules

(1) Principle for selection of typical samples

If the manufacturer applies for the approval of multiple models of battery modules at the same time, the model with the largest capacity under each production process can be selected as a typical sample according to the differences in the battery module manufacturing process, battery module capacity, series and parallel mode, and battery cell manufacturing manufacturers. For the other models of battery modules under the same production process, safety test reports in line with relevant standards shall be provided for verification.

(2) Changes of approved products

If different models of battery modules are applied for approval several times,

typical samples shall be selected from the models in each application for approval according to the principle for selection of typical samples, and shall be subject to the type test according to the requirements of Table 7.6.

(3) Others

If battery cells and battery modules are applied for approval at the same time, battery modules can be selected as samples for testing of items 5 to 11 in Table 7.5, without the need to perform repeated tests on battery cells. The number of samples can be reduced according to the test situation.

7.6.2 Type test method for battery modules

(1) Inspection of appearance and structure

Check the appearance of battery modules in a good light by visual inspection, and record the inspection results.

(2) Polarity

Detect the polarity of battery modules with a voltmeter and record the measurement results.

(3) Dimensions and mass

Measure the dimensions and mass of battery modules with appropriate measuring tools and weighing apparatus, and record the measurement results.

(4) Discharging capacity at room temperature

① Charge the battery module with the specified method;

② Discharge the battery module at room temperature at a $1I_1$(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

③ Measure the discharging capacity (Ah), and calculate the discharge specific energy (Wh/kg);

④ Repeat the steps ①～③ for 5 times. When the range of three consecutive test results is less than 3% of the rated capacity, the test can be terminated in advance, and the average value of the last three test results is taken.①③

(5) Discharging capacity at high temperature

① Charge the battery module with the specified method;

② Set aside the battery module at 55℃±2℃ for 5h;

③ Discharge the battery module at 55℃±2℃ at a $1I_1$(A) current until it reaches the end-of-discharge voltage at room temperature specified in the

technical conditions of the manufacturer;

④ Measure the discharging capacity (Ah).

(6) Discharging capacity at low temperature

① Charge the battery module with the specified method;

② Set aside the battery module at -20℃±2℃ for 24h;

③ Discharge the battery module at -20℃±2℃ at a $1I_1$(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer (the voltage value is not less than 80% of the end-of-discharge voltage at room temperature);

④ Measure the discharging capacity (Ah).

(7) High rate discharging capacity at room temperature

① Charge the battery module with the specified method;

② Discharge the battery module at room temperature at a $3I_1$(A) current (maximum current not exceeding 400A) until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

③ Measure the discharging capacity (Ah).

(8) High rate charging capacity at room temperature

① Discharge the battery module at room temperature at a $1I_1$(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer, and set it aside for 1h;

② Charge the battery module at room temperature at a $2I_1$(A) current (maximum current not exceeding 400A) until the voltage of any cell reaches the end-of-charge voltage or the end-of-charge conditions specified by the manufacturer is met, with the total charging time not exceeding 30min or C/400h, whichever is larger. Then, set aside the battery module for 1h;

③ Discharge the battery module at room temperature at a 1I1(A) current until it reaches the end-of-discharge voltage specified in the technical conditions of the manufacturer;

④ Measure the discharging capacity (Ah).

(9) Charge retention and capacity recovery at room temperature

① Charge the battery module with the specified method;

② Store the battery module at room temperature for 28d;

③ Discharge the battery module at a $1I_1$(A) current at room temperature until the voltage of any cell reaches the end-of-discharge voltage;

④ Measure the charge retention capacity (Ah).

⑤ Charge the battery module with the specified method;

⑥ Discharge the battery module at a 1I1(A) current at room temperature until the voltage of any cell reaches the end-of-discharge voltage;

⑦ Measure the recovery capacity (Ah).

(10) Charge retention and capacity recovery at high temperature

① Charge the battery module with the specified method;

② Store the battery module at 55℃±2℃ for 7d;

③ Set aside the battery module at room temperature for 5h, and discharge at a $1I_1$(A) current until the voltage of any cell reaches the end-of-discharge voltage;

④ Measure the charge retention capacity (Ah).

⑤ Charge the battery module with the specified method;

⑥ Discharge the battery module at a 1I1(A) current at room temperature until the voltage of any cell reaches the end-of-discharge voltage;

⑦ Measure the recovery capacity (Ah).

(11) Storage

① Charge the battery module with the specified method;

② Discharge the battery module at a $1I_1$(A) current for 30min at room temperature;

③ Store the battery module at 45℃±2℃ for 28d;

④ Set aside the battery module at room temperature for 5h;

⑤ Charge the battery module with the specified method;

⑥ Discharge the battery module at a 1I1(A) current at room temperature until the voltage of any cell reaches the end-of-discharge voltage;

⑦ Measure the discharging capacity (Ah).

(12) Insulation resistance measurement

The test shall be carried out in accordance with Section 2.3 of the Guidelines for Approval Test.

(13) Overcharge

① Charge the battery module with the specified method;

② After the battery module is charged at the constant current specified by the manufacturer, which is not less than $1I_3$(A), until the voltage reaches 1.5 times the end-of-charge voltage specified by the manufacturer or the time reaches 1h, stop charging;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(14) Overdischarge

① Charge the battery module with the specified method;

② After the battery module is discharged at a $1I_1$(A) current for 90min or when the voltage of any battery cell reaches 0V, stop discharging;

③ After completing the above test steps, observe at the test ambient temperature for 1h.

(15) Thermal runaway propagation

The thermal runaway propagation test of the battery module shall be carried out in the following steps:

① Charge the battery module with the specified method.

② Test under the following conditions:

(a) Trigger mode of thermal runaway: one of the two modes of overcharge and heating can be selected as the trigger mode of thermal runaway;

(b) Trigger object of thermal runaway: A battery cell that can achieve thermal runaway trigger is selected as a trigger object of thermal runaway, in which the heat generated by its thermal runaway should be easily transferred to adjacent battery cells, including the battery cell closest to the center of the battery module, or the battery cell surrounded by other battery modules and difficult to generate thermal radiation.

③ Overcharge trigger mode of thermal runaway: Charge the trigger object at a constant current, with the minimum current being 1/3C and the maximum current not greater than the maximum current that the product can continue to work, until the thermal runaway occurs or the state-of-charge of the trigger object reaches 200%SOC; The overcharge trigger requires that extra wires be connected to the trigger object to achieve overcharge. Other battery cells in the battery module shall not be overcharged. If no thermal runaway occurs, continue to observe for 1h.

④ Heating trigger mode of thermal runaway: The SOC of the battery module is adjusted to not less than 95% of the normal SOC operating range specified by the manufacturer. If a planar or bar heating device is used, the surface shall be covered with a ceramic, metal or insulating layer. A block heating device with the same size as the battery cell can be used to replace one of the battery cells; A block heating device with its size smaller than the battery cell can be installed in the battery module and directly in contact with the surface of the trigger object; A film heating device shall always be attached to the surface of the trigger object; The heating area of the heating device shall not be larger than the surface area of the battery cell. When the heating surface of the heating device is directly in contact with the surface of the battery cell, the position of the heating device shall be corresponding to the position of the temperature sensor specified in the next step; After installation, start the heating device to heat the trigger object continuously with the maximum power of the heating device, and then start the heating device to heat the test object continuously with its maximum power; The power of the heating device shall comply with the provisions of Table 7.5.2 (20). When thermal runaway occurs or the temperature of the monitoring point reaches 300℃, stop triggering and close the heating device; If no thermal runaway occurs, continue to observe for 1h;

⑤ Voltage and temperature monitoring shall meet the following requirements:

(a) Monitor the voltage and temperature of the trigger object and the two nearest battery cells to determine whether thermal runaway occurs in the trigger object and adjacent battery cells, and thus determine whether thermal runaway propagation occurs in the battery module; To monitor the voltage, the original circuit shall not be altered; The sampling interval of temperature data shall not be greater than 1s, the accuracy shall be ±2℃, and the diameter of the temperature sensor tip shall be less than 1mm;

(b) When the overcharge trigger mode is adopted, the temperature sensor shall be arranged on the surface of the battery cell at the same distance from and closest to the positive and negative poles;

(c) When the heating trigger mode is adopted, the temperature sensor shall be arranged on the side away from heat conduction, i.e., installed on the opposite side of the heating device. If it is difficult to install the temperature sensor directly, it shall be arranged in a position where the continuous temperature rise of the trigger object can be detected.

⑥The test results shall be recorded.

⑦ The occurrence of thermal runaway propagation shall be determined according to the following conditions:

(a) The trigger object generates a voltage drop, and the drop value exceeds 25% of the initial voltage;

(b) The temperature of the monitoring point reaches the protection temperature of the battery;

(c) The temperature rise rate of the monitoring point is ≥1℃/s and lasts for more than 3s;

(d) If (a)+(c) or (b)+(c) occurs, it is determined that thermal runaway occurs to the battery cell;

(e) When thermal runaway occurs in the battery cell adjacent to the trigger object, it is determined that thermal runaway propagation occurs in the battery module; During the process of thermal runaway triggering and within 1h after the triggering, if fire or explosion occurs, the test shall be terminated and it is determined that thermal runaway propagation occurs in the battery module.

(16) Vibration test

① Charge the battery module with the specified method;

② The test shall be performed in accordance with Section 2.7 of the Guidelines for Approval Test;

③ The battery module voltage and temperature shall be monitored during the test.

④ After completion of the test, the capacity at room temperature shall be tested according to 7.5.2 (4).

(17) Flame retardation test

The test shall be performed in accordance with Section 2.16 of the *Guidelines for Approval Test*;

7.7 The type test items, technical requirements and test methods of the battery pack are shown in Table 7.7.

Type test items of the battery pack Table 7.7

S/N	Type of test	Test items	Technical requirement	Test method	Reference standard	Sample quantity and number
1.	Performance	Inspection of	5.4.1	7.7.2 (1)	GB/T 31486	1#~6#

	test	appearance and structure	(1),(4), (5), (8)~(12)		6.3.1	
2.		Polarity	5.4.1 (2)	7.7.2 (2)	GB/T 31486 6.3.2	
3.		Dimensions and mass	5.4.1 (3)	7.7.2 (3)	GB/T 31486 6.3.3	
4.		Insulation resistance measurement	5.4.2 (2)	7.7.2 (4)	Guidelines for Approval Test 2.3	
5.		Withstand voltage test	5.4.2 (3)	7.7.2 (5)	Guidelines for Approval Test 2.14	
6.		Discharging capacity at room temperature	5.4.2 (1)	7.7.2 (6)	GB/T 31467.2 7.1.2	
7.		Maximum discharge current test	5.4.2(1)	7.7.2(7)	GB/T 31467.2 7.1.2	
8.		Temperature control device test	5.4.1(7)	7.7.2(8)	/	
9.	Safety test	Crush	5.4.3 (1)	7.7.2 (9)	GB 38031 8.2.4	1#
10.		External fire	5.4.3(2)	7.7.2 (10)	GB 38031 8.2.7.1	2#
11.		Thermal runaway propagation	5.4.3 (3)	7.7.2 (11)	ISO 6469-1 6.7	3#
12.		External short circuit protection	5.4.3 (4)	7.7.2 (12)	GB 38031 8.2.13	4#
13.	Environmental adaptation test	Inclination and Rolling	5.4.3 (5)	7.7.2(13) and 7.7.2(14)	Guidelines for Approval Test 2.6	5#
14.		Vibration test	5.4.3 (6)	7.7.2 (15)	Guidelines for Approval Test 2.7	
15.		High temperature test	5.4.3 (7)	7.7.2 (16)	Guidelines for Approval Test 2.8	
16.		Low temperature test	5.4.3 (8)	7.7.2 (17)	Guidelines for Approval Test 2.9	
17.		Damp heat test	5.4.3 (9)	7.7.2 (18)	Guidelines for Approval Test 2.10	
18.		Enclosure test	5.4.1 (6)	7.7.2 (19)	Guidelines for Approval	

					Test 2.15	
19.		Salt spray test Kb①	5.4.3 (10)	7.7.2 (20)	Guidelines for Approval Test 2.13	6#

Note: ① The salt spray test Kb is only applicable to battery packs installed on open decks of sea-going vessels.

7.7.1 Selection of typical samples for battery packs

When the battery packs of the series models are applied for approval at the same time, the battery pack with the maximum energy is selected if they are based on the same battery cell, with same connection mode (series and parallel), spacing, and packaging materials. The number of samples can be reduced according to the test situation.

When the series models are not applied for approval at the same time, all type tests shall be carried out in principle according to the difference in energy and structure of the battery pack. However, if the energy and structure of battery packs are consistent, and only the series and parallel connection modes of battery cells or modules are inconsistent, some of the performance test items can be carried out only according to Table 7.7. At the same time, the necessity of test items can be evaluated based on the actual situation of battery pack changes, and relevant test items can be reduced.

7.7.2 Type test method for battery packs

(1) Inspection of appearance and structure

Check the appearance of battery packs in a good light by visual inspection, and record the inspection results.

(2) Polarity

Detect the polarity of battery packs with a voltmeter and record the measurement results.

(3) Dimensions and mass

Measure the dimensions and mass of battery packs with appropriate measuring tools and weighing apparatus, and record the measurement results.

(4) Insulation resistance measurement

The test shall be performed with the method specified in Section 2.3 of the *Guidelines for Approval Test*.

(5) Withstand voltage test

The test shall be performed with the method specified in Section 2.14 of the *Guidelines for Approval Test*.

(6) Discharging capacity at room temperature

① Charge the battery pack with the specified method;

② Discharge the battery pack at room temperature at the current specified by the manufacturer and not less than I_3(A) until it reaches the end-of-discharge voltage of the cell specified in the technical conditions of the manufacturer;

③ Measure the discharging capacity (Ah), and calculate the discharge specific energy (Wh/kg);

④ Repeat the steps ① ～ ③ for 5 times. When the range of three consecutive test results is less than 3% of the rated capacity, the test can be terminated in advance, and the average value of the last three test results is taken.

(7) Maximum discharge current test

① Charge the battery pack with the specified method;

② Discharge the battery pack at room temperature at the maximum discharge current declared by the manufacturer, I_{max}(T), until the cut-off condition specified by the manufacturer is reached;

③ The temperature and voltage of the battery cell shall be monitored during the test.

(8) Temperature control device test

① Connect the temperature control device interface of the battery pack to the hydraulic test equipment;

② Inject liquid into the pipeline of the temperature control device in the battery pack. The test pressure shall not be less than 1.5 times the design pressure, and the time for the pressure hold test shall not be less than 5min;

③ Visually observe the connection points and the pipeline of the temperature control device to confirm whether there is leakage or pressure relief.

④ When the temperature control device is not enabled, a

charge-discharge cycle shall be carried out on the battery pack at the rated charge and discharge current specified by the manufacturer, and the temperature of the battery cell and the ambient temperature during the test shall be recorded. The battery pack shall be set aside for enough time before the test.

⑤ When the temperature control device is enabled, a charge-discharge cycle shall be carried out on the battery pack at the rated charge and discharge current specified by the manufacturer, and the temperature of the battery cell and the ambient temperature during the test shall be recorded. The battery pack shall be set aside for enough time before the test.

⑥ Compare the temperature data recorded in the two charge-discharge cycles, which shall meet the requirements of the manufacturer's technical conditions.

(9) Crush

① Charge the battery pack with the specified method;

② Crush direction: the direction where the structural strength of the battery pack is the weakest; If the direction cannot be determined, extrude the battery pack in two perpendicular directions, one of which shall be perpendicular to the side of the battery cell with the largest area.

③Crush plate form:

(a) A half cylinder with a radius of 75mm. The length of the half cylinder L is greater than the size of the battery pack to be extruded but does not exceed 1m, as shown in Figure 1, or

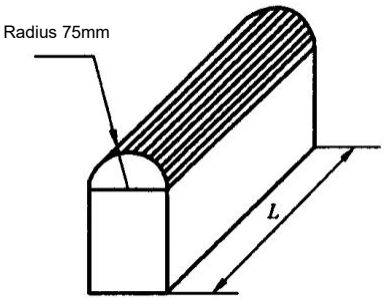
(b) 600mm×600mm (L×W) or less, including three half cylinders with a radius of 75mm at a spacing of 30mm, as shown in Figure 2.

④Crush speed: ≤2mm/s

⑤ Crush degree: Stop extrusion when the extrusion force reaches 100kN or the extrusion deformation reaches 30% of the overall size in the extrusion direction;

⑥ Hold for 10min.

⑦After the above test steps are completed, observe for 2h at the test ambient temperature.



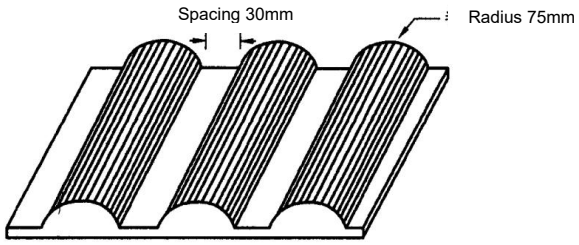


Figure 1 Extrusion plate form I

Figure 2 Extrusion plate form II

10) External fire

① The test ambient temperature is above 0℃ and the wind speed is no more than 2.5km/h. Test battery packs shall be in the fully charged state specified by the manufacturer.

② In the test, the size of the flat plate containing gasoline shall exceed the projected size of the test object by 20cm and does not exceed 50cm. The height of the flat plate shall not be higher than 8cm above the gasoline surface. The test object shall be placed in the center. The distance between the gasoline level and the bottom mold of the test object shall be set to 50cm. Water is injected into the bottom of the flat plate.

③ Preheating. Ignite the gasoline at least 3m away from the test object, and after 60s of preheating, place the oil pan under the test object. If the size of the oil pan is too large to move, the test object and the support can be moved.

④ Direct combustion. The test object is directly exposed to the flame for 70s.

⑤ Indirect combustion. The refractory partition is covered on the oil pan. The test object is tested in this state for 60s. The refractory partition is made of standard firebricks, and the specific screen size is in accordance with the relevant requirements of GB 38031 8.2.7.1.

⑥ Keep away from the fire. Remove the oil pan or the test object, and observe for 2h at the test ambient temperature or until the surface temperature of the test object drops below 45℃.

(11) Thermal runaway propagation

When the battery pack is tested for thermal runaway propagation, its layout shall be as consistent as possible with the actual state of use, and the test

shall be performed according to the following steps:

① The battery pack shall be charged with the specified method.

② Test under the following conditions:

(a) Trigger mode of thermal runaway: one of the two modes of overcharge and heating can be selected as the trigger mode of thermal runaway;

(b) Trigger object of thermal runaway: A battery cell that can achieve thermal runaway trigger is selected as a trigger object of thermal runaway, in which the heat generated by its thermal runaway should be easily transferred to adjacent battery cells, including the battery cell closest to the center of the battery pack, or the battery cell surrounded by other battery packs and difficult to generate thermal radiation.

③ Overcharge trigger mode of thermal runaway: Charge the trigger object at a constant current, with the minimum current being 1/3C and the maximum current not greater than the maximum current that the product can continue to work, until the thermal runaway occurs or the state-of-charge of the trigger object reaches 200%SOC; The overcharge trigger requires that extra wires be connected to the trigger object to achieve overcharge. Other battery cells in the battery pack shall not be overcharged; If no thermal runaway occurs, continue to observe for 1h.

④Heating trigger mode of thermal runaway: The SOC of the battery pack is adjusted to not less than 95% of the normal SOC operating range specified by the manufacturer. If a planar or bar heating device is used, the surface shall be covered with a ceramic, metal or insulating layer. The heating device may be located inside the battery cell triggered for thermal runaway. A block heating device with the same size as the battery cell can be used to replace one of the battery cells; A block heating device with its size smaller than the battery cell can be installed in the battery pack and directly in contact with the surface of the trigger object; A film heating device shall always be attached to the surface of the trigger object; The heating area of the heating device shall not be larger than the surface area of the battery cell. When the heating surface of the heating device is directly in contact with the surface of the battery cell, the position of the heating device shall be corresponding to the position of the temperature sensor specified in the next step; After installation, start the heating device to heat the trigger object continuously with the maximum power of the heating device, and then start the heating device to heat the test object continuously with its maximum power; The power of the heating device shall comply with the provisions of Table 7.5.2 (20). When thermal runaway occurs or the temperature of the monitoring point reaches 300℃, stop triggering and close the heating device; If no thermal runaway occurs, continue to observe for

1h;

⑤ Voltage and temperature monitoring shall meet the following requirements:

(a) Monitor the voltage and temperature of the trigger object and the two nearest battery cells to determine whether thermal runaway occurs in the trigger object and adjacent battery cells, and thus determine whether thermal runaway propagation occurs in the battery pack; To monitor the voltage, the original circuit shall not be altered; The sampling interval of temperature data shall not be greater than 1s, the accuracy shall be ±2℃, and the diameter of the temperature sensor tip shall be less than 1mm;

(b) When the overcharge trigger mode is adopted, the temperature sensor shall be arranged on the surface of the battery cell at the same distance from and closest to the positive and negative poles;

(c) When the heating trigger mode is adopted, the temperature sensor shall be arranged on the side away from heat conduction, i.e., installed on the opposite side of the heating device. If it is difficult to install the temperature sensor directly, it shall be arranged in a position where the continuous temperature rise of the trigger object can be detected.

⑥ The test results shall be recorded.

⑦ The occurrence of thermal runaway propagation shall be determined according to the following conditions:

(a) The test object generates a voltage drop, and the drop value exceeds 25% of the initial voltage;

(b) The temperature of the monitoring point reaches the protection temperature of the battery;

(c) The temperature rise rate of the monitoring point is ≥1℃/s and lasts for more than 3s;

(d) If (a)+(c) or (b)+(c) occurs, it is determined that thermal runaway occurs to the battery cell;

(e) When thermal runaway occurs in the battery cell adjacent to the trigger object, it is determined that thermal runaway propagation occurs in the battery pack; During the process of thermal runaway triggering and within 1h after the triggering, if fire or explosion occurs, the test shall be terminated and it is determined that thermal runaway propagation occurs in the battery pack.

(12) External short circuit protection

① Charge the battery pack with the specified method;

②At the beginning of the test, the relevant main switching devices for charging and discharging shall be closed to ensure that the battery pack is in a state of being able to be charged and discharged.

③The positive and negative terminals of the test object are connected to each other. The short circuit resistance does not exceed 5mΩ.

④Maintain the short circuit condition until any of the following conditions is met, and end the test:

(a) The protection function of the battery pack works and the short circuit current is terminated;

(b) After the housing temperature of the test object is stable (the temperature change is less than 4℃ within 2h), continue to short-circuit for at least 1h.

⑤ After the above steps are completed, observe at the test ambient temperature for 1h.

(13) Inclination

After the battery pack is fully charged with the prescribed charging method, secure the battery pack on the test bench, ensure that the battery pack is working in the charging and discharging conditions as specified by the manufacturer, and tilt the battery pack in front, back, left and right directions under the following conditions. The results shall meet the requirements of 5.4.3 (4):

① The battery pack is tilted from the horizontal position to 15° within 1s (for emergency power supply, the battery pack shall be tilted to 22.5°);

②Hold the battery pack in this position for 15min;

③Recover the battery pack to the horizontal position within 1s;

④Ensure that the battery pack is fully charged with the specified method before tilting in each direction.

(14) Rolling

After the battery pack is fully charged with the specified method, secure it on the test bench, and ensure that it is working in the charging and discharging conditions as specified by the manufacturer. Swing it for 15min in the

front-back and left-right horizontal axial directions of ±22.5° respectively, with the cycle of 10s. The results shall meet the requirements of 5.4.3 (4).

(15) Vibration test

After the battery pack is fully charged with the specified method, secure it on the test bench for testing in accordance with the requirements of general vibration conditions in Section 2.7 of the *Guidelines for Approval Test*. During the test, ensure that the battery pack is working in the charging and discharging conditions as specified by the manufacturer.

(16) High temperature test

After the battery pack is fully charged with the specified method, the high temperature test is carried out in accordance with the requirements of Section 2.8 of the *Guidelines for Approval Test*. During the test, ensure that the battery pack is working in the charging and discharging conditions as specified by the manufacturer.

(17) Low temperature test

After the battery pack is fully charged with the specified method, the low temperature test is carried out in accordance with the requirements of Section 2.9 of the *Guidelines for Approval Test*. During the test, ensure that the battery pack is working in the rated charging and discharging conditions as specified by the manufacturer.

(18) Damp heat test

After the battery pack is fully charged with the specified method, the alternating damp heat test is carried out with the method specified in Section 2.10 of the *Guidelines for Approval Test*. During the first cycle of the test, ensure that the battery pack is working in the rated charging and discharging conditions as specified by the manufacturer. Within the last two hours of the high temperature and high humidity phase of the second cycle, ensure that the battery pack is working in the rated charging and discharging conditions as specified by the manufacturer. At other times, disconnect the battery pack from the external electrical connection. The connectors can be kept connected. After recovery, the room temperature capacity test shall be carried out in accordance with the method specified in Section 7.6.2. (6), and the results shall comply with the provisions of Section 5.4.3 (8).

(19) Enclosure test

The enclosure protection class test shall be performed with the method specified in Section 2.15 of the *Guidelines for Approval Test*.

(20) Salt mist test Kb

After the battery pack is charged with the specified method, the salt spray test is carried out in accordance with the method specified in Section 2.12 of the *Guidelines for Approval Test*. During the test, the open circuit voltage of the battery pack shall be continuously monitored through the same interface connection as in actual use. On the 7th day of each storage cycle, the battery pack is monitored for low-voltage power-on. After the test, the battery pack shall be placed under the normal atmospheric conditions for recovery for 4 - 6h. Then, the insulation resistance shall be measured, the room temperature capacity test shall be carried out with the method specified in Section 7.6.2 (6), and the results shall comply with the provisions of Section 5.4.3. (7).

7.8 The type test items, technical requirements and test methods of the battery management system (BMS) are shown in Table 7.8:

Type test items of the battery management system (BMS) Table 7.8

S/N	Test items	Technical requirement	Test method and reference standard
1	Inspection of appearance and structure	5.5.1 (2)	Visual inspection
2	Functional test	5.5.1 (3)	GB/T 34131 7.5~7.7, 7.9
3	Measurement accuracy of state parameters	5.5.2 (1)	GB/T 34131 7.4
4	Energy state estimation	5.5.2 (2)	GB/T 34131 7.8
	Insulation resistance detection	5.5.2(1)	GB/T 34131 7.10
5	Reverse voltage	5.5.2 (3)	GB/T 34131 7.13.3
6	Insulation resistance measurement	5.5.2 (4)	Guidelines for Approval Test 2.3
7	Withstand voltage test	5.5.2 (5)	Guidelines for Approval Test 2.14
8	Power supply variation test	Guidelines for Approval Test 2.4	Guidelines for Approval Test 2.4
9	Power supply failure test	Guidelines for Approval Test 2.5	Guidelines for Approval Test 2.5
10	Vibration test	Guidelines for Approval Test 2.7	Guidelines for Approval Test 2.7
11	High temperature test	Guidelines for Approval Test 2.8	Guidelines for Approval Test 2.8
12	Low temperature test	Guidelines for Approval Test 2.9	Guidelines for Approval Test 2.9
13	Damp heat test	Guidelines for Approval Test 2.10	Guidelines for Approval Test 2.10

14	Housing protection test	Guidelines for Approval Test 2.15	Guidelines for Approval Test 2.15
15	Salt mist test Kb①	Guidelines for Approval Test 2.12	Guidelines for Approval Test 2.12
16	Flame retardation test (plastic housing only)	Guidelines for Approval Test 2.16	Guidelines for Approval Test 2.16
17	Electromagnetic compatibility test	Guidelines for Approval Test Chapter 3	Guidelines for Approval Test Chapter 3

Note:① The salt spray test Kb is only applicable to BMS installed on open decks of sea-going vessels.

7.8.1 The typical samples of BMS shall be selected and the test items shall be added in accordance with the requirements of electric and electronic products.

7.9 Eligibility criteria

7.9.1 The inspection items to be assessed based on the inspection conditions shall be assessed based on the inspection conditions.

7.9.2 In the safety test of battery cells and battery packs, if any of the test items does not meet the requirements of the Guideline, the product will be judged unqualified.

8 Unit/Batch inspection

8.1 Battery cell

8.1.1 After type approval B is obtained, the unit/batch inspection shall be carried out after the manufacturer completes the factory test, and the relevant process data shall be submitted to CCS for review.

8.1.2 For unit/batch inspection, at least 1% battery cells of each specification shall be sampled and inspected by each batch, which shall not be less than 10 pieces; The inspection items shall include at least:

(1) Inspection of appearance and structure

(2) Polarity

(3) Dimensions and mass

(4) Capacity test (The sampling ratio and test method shall be as required by the manufacturer)

(5) Insulation resistance measurement

8.2 Battery module

8.2.1 After type approval B is obtained, the unit/batch inspection shall be carried out after the manufacturer completes the factory test.

8.2.2 For unit/batch inspection, at least 5% battery modules shall be sampled and inspected by lot, which shall not be less than 5 modules; The inspection items shall include at least:

(1) Inspection of appearance and structure

(2) Polarity

(3) Dimensions and mass

(4) Insulation resistance measurement

8.3 Battery pack

8.3.1 After type approval B is obtained, the unit/batch inspection shall be carried out after the manufacturer completes the factory test.

8.3.2 For unit/batch inspection, at least 5% battery packs shall be sampled and inspected by lot, which shall not be less than 2 packs; The inspection items shall include at least:

(1) Inspection of appearance and structure

(2) Capacity test (only perform the capacity test at the rated charge and discharge current once)

(3) Insulation resistance measurement

(4) Withstand voltage test

8.3.3 If the manufacturer of the battery pack and the final integrator of the battery system are the same manufacturer, the capacity test of the battery pack can be combined with the unit/batch inspection of the battery system.

8.4 Battery management system (BMS)

8.4.1 After type approval B is obtained, the unit/batch inspection shall be carried out after the manufacturer completes the factory test.

8.4.2 For unit/batch inspection, sampling inspection shall be carried out for battery management systems by lot, with 20% under the main control, and the number not less than 2 pieces. The inspection items shall include at least:

(1) Inspection of appearance and structure

(2) Functional test

(3) Measurement accuracy of state parameters

(4) Insulation resistance measurement

(5) Withstand voltage test

8.4.3 If the manufacturer of the battery management system and the final integrator of the battery system are the same manufacturer, the functional test of the battery management system (BMS) can be combined with the unit/batch inspection of the battery system.

8.5 Battery system

8.5.1 The unit/batch inspection shall be carried out after the manufacturer completes the factory test, and the factory test report of the manufacturer shall be submitted to CCS together with the product inspection notice.

8.5.2 The high-voltage compartment (cabinet) and/or control box (cabinet) used in the battery system shall comply with the relevant requirements of the *Rules for Classification of Sea-going Steel Ships* or the *Code for Construction of Steel Inland Waterway Ships*. Temperature rise test, functional test, withstand voltage test and insulation resistance measurement shall be carried out for distribution apparatus and/or control apparatus, of which temperature rise test shall be carried out under rated working conditions, but for products of the same model and specification, temperature rise test may only be required for the first piece of product.

8.5.3 For unit/batch inspection, battery systems shall be inspected one by one. The inspection items shall include at least:

(1) Inspection of appearance and structure

(2) Functional test of BMS

(3) Overtemperature protection

(4) Overcurrent protection

(5) Simulation of external short-circuit protection

(6) Overcharge protection

(7) Overdischarge protection

(8) Insulation resistance measurement

(9) Emergency shut-off functional test (over 50kWh)

(10) Capacity test (at least one cluster shall be selected for testing, and the test shall be performed once at the rated charge and discharge current of the battery pack)

Appendix Reference Standards

GB/T 34014-2017 "Coding Rules for Automotive Power Batteries"

GB/T 31486-2015 "Requirements and Test Methods for Electrical Performance of Power Batteries for Electric Vehicles"

GB/T 31484-2015 "Cycle Life Requirements and Test Methods for Power Batteries for Electric Vehicles"

GB 38031-2020 "Safety Requirements for Power Batteries for Electric Vehicles"

GB/T 31467-2023 "Test Methods for Electrical Performance of Lithium ion Power Battery Packages and Systems for Electric Vehicles"

GB/T 36276-2023 "Lithium ion batteries for electric energy storage"

GB/T 34131-2023 "Battery Management System for Electric Energy Storage"

IEC 62660-2:2018 Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 2: Reliability and abuse testing

ISO 6469-1:2019/Amd1:2022 Electrically propelled road vehicles — Safety specifications — Part 1: Rechargeable energy storage system (RESS) — Amendment 1: Safety management of thermal propagation