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E-27

Marine High Energy Density Supercapacitor

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Foreword

The Product Inspection Guidelines of China Classification Society (hereinafter referred to as "the Society") specify the applicable technical requirements and inspection and testing requirements for ship classification products and authorized statutory products that are to apply for CCS approval/inspection.

The Guidelines do not restrict the user from adopting other test methods and requirements, but the relevant test methods and requirements shall not be lower than the requirements of the Guidelines.

The Guidelines are prepared and updated by the Society and published through the website http://www.ccs.org.cn. If the user has any comments on the Society's guidelines, please send feedback to mp@ccs.org.cn.

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Table of Contents

1 Scope of application 4

2 Normative references 4

3 Terms and definitions 4

4 Drawings and data 5

5 Technical requirements 8

6 Raw materials and parts 21

7 Type test 21

8 Single piece/single batch inspection 30

Marine High Energy Density Supercapacitor

1 Scope of application

The Guidelines apply to the approval and inspection of the high energy density supercapacitor (including capacitor cell, capacitor module, capacitor pack, and capacitor system) as part or all of the power source installed on a ship and the capacitor management system, hereinafter referred to as the "cell", "module", "pack", "system" and "management system" respectively.

2 Normative references

2.1 Rules for Classification of Sea-going Steel Ships of China Classification Society

2.2 Rules for Construction of Inland Steel Ships of China Classification Society

2.3 Specifications for Battery Power of Marine Applications of China Classification Society

2.4 Guidelines for Type Approval Test of Electric and Electronic Products (including IACS UR E10) of China Classification Society (hereinafter referred to as "Guidelines for Type Approval Test")

2.5 SJ/T 11894-2023 General Specification for Supercapacitor of Ship

2.6 GB 38031-2020 Electric Vehicles Traction Battery Safety Requirements

2.7 GB/T 34014-2017 Coding Regulation for Automotive Traction Battery

2.8 GB/T 34131-2023 Battery Management System for Electrical Energy Storage

3 Terms and definitions

3.1 For the definitions of product inspection, approval, type test, sample, single piece/single batch inspection and other terms, please refer to Clause 3.1.2 of Chapter 3 of Part 1 of the Rules for Classification of Sea-going Steel Ships of China Classification Society.

3.2 The definitions in the Specifications for Battery Power of Marine Applications of China Classification Society apply to this section.

3.3 Batch: It refers to the products of the same specification continuously produced

by the same manufacturer on the same production line according to the same production process.

3.4 High Energy Density Supercapacitor: It is a capacitor characterized by high specific energy, mainly used for high energy input and output.

3.5 Supercapacitor cell: It is the smallest structural unit in a capacitor and a basic unit device that directly converts chemical energy into electrical energy. It consists of electrodes, diaphragm, electrolyte, housing and terminals (also known as extremes).

3.6 Supercapacitor module: It is a combination of more than one capacitor cell in series, parallel or series-parallel connection, with only one pair of positive and negative output terminals. It is used as a power supply.

3.7 Supercapacitor pack: It consists of multiple capacitor cells or capacitor modules connected in series or parallel due to voltage or power requirements. The capacitor pack shall contain a monitoring circuit that provides information (such as voltage and temperature) for the capacitor system.

3.8 Management system: It is a system that can control the input and output power of the capacitor, monitor the state of the capacitor (such as temperature, voltage, and state of charge), and provide a communication interface for the capacitor.

3.9 Supercapacitor system: It is an energy storage device, including the integration of capacitor modules or capacitor packs, management system, high-voltage circuit, low-voltage circuit, thermal management equipment and mechanical assembly.

3.10 Thermal runaway: It refers to supercapacitor damage resulting from uncontrollable continuous temperature rise due to the thermal accumulation inside the supercapacitor.

3.11Thermal runaway propagation: It refers to the phenomenon that the thermal runaway of one capacitor cell in a capacitor module, capacitor pack or capacitor system causes consecutive occurrence of thermal runaway of the rest of the capacitor cells.

4 Drawings and data

4.1 Drawings and data to be submitted for review of capacitor cell drawings:

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

(1) General drawing;

(2) Drawings of main parts, including: housing, cover plate, positive/negative electrode, diaphragm, etc;

(3) Technical conditions or technical specifications for products.

4.1.2 The following drawings and data shall be submitted to CCS for future reference:

(1) List of main raw materials;

(2) Product use instructions (at least including an English version if used for international navigation ships);

(3) Capacitor risk assessment report, including the assessment of the safety class of capacitor cells;

(4) Analysis report of key process elements of capacitor cells.

4.2 Drawings and data to be submitted for review of capacitor module drawings:

4.2.1 The following drawings and data 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 technical specifications for products;

(6) Nameplate or identification diagram (not required if the nameplate or identification content is covered by other drawings and technical documents of the capacitor module).

4.2.2 The following drawings and data shall be submitted to CCS for future reference:

(1) List of main parts;

(2) Temperature monitoring analysis and test verification report (if applicable);

(3) Product operation and maintenance instructions (at least including an English version if used for international navigation ships);

(4) Analysis report of key process elements of capacitor modules.

4.3 Drawings and data to be submitted for review of capacitor pack drawings:

4.3.1 The following drawings and data 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 technical specifications for products;

(6) Nameplate or identification diagram (not required if the nameplate or identification content is covered by other drawings and technical documents of the capacitor pack).

4.3.2 The following drawings and data shall be submitted to CCS for future reference:

(1) List of main parts;

(2) Temperature monitoring analysis and test verification report (if applicable);

(3) Product operation and maintenance instructions (at least including an English version if used for international navigation ships);

(4) Analysis report of key process elements of capacitor packs.

4.4 Drawings and data to be submitted for review of management system drawings:

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

(1) General drawing of system;

(2) Principle block diagram;

(3) Housing and assembly drawings;

(4) Technical conditions or technical specifications for products;

(5) Risk assessment report.

4.4.2 The following drawings and data shall be submitted to CCS for future reference:

(1) List of main parts and materials;

(2) Product operation and maintenance instructions (at least including an English version if used for international navigation ships).

4.5 Data to be submitted for review of capacitor system drawings:

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

(1) System schematic diagram;

(2) System connection diagram;

(3) Drawings of outline of each device of the system and the system panel layout;

(4) Protection devices of the system and their parameter settings;

(5) System wiring diagram;

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

(1) List of main parts;

(2) Product operation and maintenance instructions (at least including an English version if used for international navigation ships).

4.5.3 The following drawings and data shall be submitted to CCS:

(1) Some of single line diagrams and/or power system diagrams of the ship capacitor system approved in the ship drawing review;

(2) Some of the tables of monitoring and alarm items of the ship system approved in the ship drawing review;

(3) Short-circuit current calculation and selective analysis of ships approved in the ship drawing review;

(4) Approved ship-related drawings and drawing review comments.

5 Technical requirements

5.1 Operating conditions

It shall be able to work normally under the operating conditions specified in Section 2, Chapter 1, Part 4 of the Rules for Classification of Sea-going Steel Ships. If it is only used for inland ships, the requirement can be lowered to that it shall be able to work normally under the operating conditions specified in Sections 2 and 3 of Chapter 1 of Part 3 of the Rules for Construction of Inland Steel Ships.

5.2 Capacitor cell

5.2.1 Appearance and structure

(1) Appearance

The appearance of the capacitor cell shall be free of deformation and cracks, and the surface shall be dry and free of burrs, external damage and dirt. There should be clear and correct marks on the capacitor surface.

(2) Polarity

The polarity marks of the capacitor cell terminals shall be correct and clear.

(3) Overall dimensions and mass

The overall dimensions and mass of the capacitor cell shall comply with the technical conditions for products provided by the enterprise.

(4) Anti-explosion measures

Capacitor cells with a housing made of rigid metal or plastic shall be provided with safety valves or other anti-explosion measures.

(5) Special requirements for soft-pack capacitors

For installation and use of soft-pack capacitors, a fixing bracket shall be mounted outside each capacitor cell to meet the requirements of effective ventilation and strength.

(6) Code number

The capacitor cell shall be attached with an identifiable code number for easy management, recycling and tracing. The coding rules shall be in accordance with GB/T 34014.

5.2.2 Performance requirements

(1) Capacity

Charging/discharging of the capacitor cell shall be at a constant current of I_1(A), and the capacity of the capacitor cell shall be 90%~110% of the rated capacity.

(2) Stored energy and specific energy

The stored energy of the capacitor cell shall be 90%~110% of the nominal energy; the specific energy shall not be less than 85 Wh/kg and shall be 90%~110% of the nominal specific energy.

(3) DC internal resistance

The DC internal resistance of the capacitor cell shall not be greater than the nominal internal resistance.

(4) Specific power

The specific power of the capacitor cell shall not be less than 10,000 W/kg.

(5) Voltage holding ratio

After the capacitor cell is left open circuit at room temperature at the rated voltage for 72 h, the voltage holding ratio at both ends shall not be less than 98% of the rated voltage.

(6) Characteristics at high temperatures

When a capacitor cell is operating at a working temperature of 55 °C or higher, its capacity shall not be less than 85% of the initial value and its stored energy shall not be less than 85% of the initial value.

(7) Characteristics at low temperatures

When a capacitor cell is operating at a working temperature of -20 °C or lower, its capacity shall not be less than 65% of the initial value and its stored energy shall not be less than 50% of the initial value.

(8) Cycle life

When testing the capacitor cell for cycle life at room temperature:

① Perform 100% DoD cycles, and when the capacitor cell is 80% SOH, the cycle life shall not be less than 10,000 times;

②or perform 80% DoD cycles, when the capacitor cell is 80% SOH, the cycle life shall not be less than 50,000 times.

(9) Insulation performance

The insulation resistance value of the capacitor cell shall not be less than 10 MΩ.

5.2.3 Safety requirements

(1) Over-discharge

When the capacitor cell is going through the over-discharge test, it shall not explode or catch fire, and there shall be no liquid leakage.

(2) Overcharge

When the capacitor cell is going through the overcharge test, it shall not explode or catch fire.

(3) External short circuit

When the capacitor cell is going through the external short circuit test, it shall not explode or catch fire.

(4) Drop

When the capacitor cell is going through the drop test, it shall not explode or catch fire, and there shall be no liquid leakage.

(5) High temperature

When the capacitor cell is going through the high temperature test at 130 ℃, it shall not explode or catch fire.

(6) Extrusion

When the capacitor cell is extruded until its voltage is 0 V or its deformation reaches 30%, or until the extrusion force reaches 100 kN or 1000 times the weight of the test object, it shall not explode or catch fire.

(7) Mechanical shock

When the capacitor cell is going through the mechanical shock test, it shall not explode or catch fire, and there shall be no liquid leakage.

(8) Temperature cycle

When the capacitor cell is going through the temperature cycle test, it shall not explode or catch fire, and there shall be no liquid leakage.

(9) Thermal runaway

During the thermal runaway test of the capacitor cell, when the cell is triggered to meet the thermal runaway judgment conditions, it shall not explode or catch fire.

(10) Flame retardation test (plastic housing only)

The materials of the capacitor cell housing shall be flame-retardant.

5.3 Capacitor module

5.3.1 Appearance and structure

(1) Appearance

The housing of the capacitor module shall be free of deformation and cracks, the surface shall be dry and free of marks of overflow of electrolyte, and shall be arranged neatly, connected reliably, and marked clearly.

(2) Polarity

The polarity marks of the capacitor module terminals shall be clear, complete and accurate.

(3) Overall dimensions and mass

The overall dimensions and mass of the capacitor module shall comply with the technical conditions for products provided by the enterprise.

(4) Anti-explosion measures

If the capacitor module adopts a closed housing, a safety valve or other anti-explosion measures shall be provided.

(5) Materials

The auxiliary materials of the capacitor module shall be flame-retardant.

(7) Monitoring circuit

If the capacitor module is used to form a capacitor system to be used on board, the capacitor module shall contain a monitoring circuit to provide information (such as voltage and temperature) for the capacitor system.

(8) Code number

The capacitor module shall be attached with an identifiable code number for easy management, recycling and tracing. The coding rules shall be in accordance with GB/T 34014.

5.3.2 Performance requirements

(1) Capacity

Charging/discharging of the capacitor module shall be at a constant current of I_1(A), and the capacity of the capacitor cell shall be 90%~110% of the rated capacity.

(2) Stored energy and specific energy

The stored energy of the capacitor module shall be 90%~110% of the nominal energy, and the specific energy shall be 90%~110% of the nominal specific energy.

(3) DC internal resistance

The DC internal resistance of the capacitor module shall not be greater than the nominal internal resistance.

(4) Specific power

The specific power of the capacitor module shall not be less than the nominal specific power.

(5) Voltage holding ratio

After the capacitor module is left open circuit at room temperature at the rated voltage for 72 h, the voltage holding ratio at both ends shall not be less than 98% of the rated voltage.

(6) Characteristics at high temperatures

When a capacitor module is operating at a working temperature of 55 °C or higher, its capacity shall not be less than 85% of the initial value and its stored energy shall not be less than 85% of the initial value.

(7) Characteristics at low temperatures

When a capacitor module is operating at a working temperature of -20 °C or lower, its capacity shall not be less than 65% of the initial value and its stored energy shall not

be less than 50% of the initial value.

(8) Insulation resistance

The insulation resistance value of the capacitor module shall not be less than 10 MΩ.

5.3.3 Safety requirements

(1) Over-discharge

When the capacitor module is going through the over-discharge test, it shall not explode or catch fire, and there shall be no liquid leakage.

(2) Overcharge

When the capacitor module is going through the overcharge test, it shall not explode or catch fire.

(3) External short circuit

When the capacitor module is going through the external short circuit test, it shall not explode or catch fire.

(4) Drop

When the capacitor module is going through the drop test, it shall not explode or catch fire, and there shall be no liquid leakage.

(5) High temperature

When the capacitor module is going through the high temperature test at 130 ℃, it shall not explode or catch fire.

(6) Extrusion

When the capacitor module is going through the extrusion test, it shall not explode or catch fire.

(7) Mechanical shock

When the capacitor module is going through the mechanical shock test, it shall not explode or catch fire, and there shall be no liquid leakage.

(8) Temperature cycle

When the capacitor module is going through the temperature cycle test, it shall not explode or catch fire.

(9) Thermal runaway propagation

When a capacitor cell at a specific location in the capacitor module is triggered to meet the thermal runaway judgment conditions, there shall be no fire, explosion or thermal runaway propagation.

5.4 Capacitor pack

5.4.1 Appearance and structure

(1) Appearance

The housing of the capacitor pack shall be free of deformation and cracks, and shall be connected reliably and marked clearly.

(2) Polarity

The polarity marks of the capacitor pack terminals shall be correct and clear.

(3) Overall dimensions and mass

The overall dimensions and mass of the capacitor pack shall comply with the technical conditions for products provided by the enterprise.

(4) Anti-explosion measures

The capacitor pack shall be provided with safety valves or other anti-explosion measures.

(5) Housing materials

The materials of the capacitor pack housing (except connectors) shall be non-combustible. If the capacitor pack may be mounted directly on the bracket, its housing shall be made of steel with a thickness of not less than 1 mm. The housing of external connectors shall be of flame-retardant material.

(6) IP rating of housing

The IP rating of soft-pack capacitor packs or capacitor packs of safety class 1 shall not be lower than IP67. Except for soft-pack capacitor packs, the IP rating of capacitor packs of safety class 2 shall be at least IP22. The capacitor pack for passenger ships with a length of more than 50 m or a number of passengers of more than 150, all ships carrying (bulk and packaged) dangerous goods and fiber-reinforced plastic ships shall consist of capacitors of safety class 2, and the IP rating of the capacitor pack shall not

be lower than IP67.

(7) Temperature regulating measures

The capacitor pack shall be provided with temperature regulating measures. The capacitor pack composed of soft-pack capacitor packs and capacitor cells or modules of safety class 1 shall be provided with a temperature regulating device independent of the capacitor compartment (room) / capacitor box (cabinet).

(8) Monitoring circuit

The capacitor pack shall contain a monitoring circuit that provides information (such as voltage and temperature) for the capacitor system.

(9) Nameplate

The capacitor pack housing shall be securely attached with a firm nameplate, which shall include at least the product name, capacitor cell model, capacitor cell voltage (V), capacitor cell capacity (F), nominal voltage of the capacitor pack (V), nominal power of the capacitor pack (kWh), weight of the capacitor pack (kg), model of the capacitor pack, product code number, and date of manufacture (MM/DD/YYYY).

(10) Code number

The capacitor pack shall be attached with an identifiable code number for easy management, recycling and tracing. The coding rules shall be in accordance with GB/T 34014.

5.4.2 Performance requirements

(1) AC internal resistance

The AC internal resistance of the capacitor pack shall be measured, and the internal resistance value shall be in accordance with the technical conditions for products provided by the enterprise.

(2) Capacity and stored energy

The capacitor pack shall be tested for capacity and stored energy, and the measured values shall be in accordance with the technical conditions for products provided by the enterprise.

(3) Voltage holding ratio

After the capacitor pack is left open circuit at room temperature at the rated voltage for 72 h, the voltage holding ratio at both ends shall not be less than 98% of the rated voltage.

(4) Insulation resistance

The insulation resistance value of the capacitor pack shall not be less than 100 MΩ.

(5) Withstanding voltage performance

When the corresponding voltage is applied between the positive electrode of the capacitor pack and the external exposed conductive part, and between the negative electrode of the capacitor pack and the external exposed conductive part, no breakdown or flashover shall occur. When the corresponding voltage is applied between the external interface terminal (except for the positive and negative electrodes of the capacitor pack) and the external exposed conductive part, no breakdown or flashover shall occur. The insulation resistance value after the test shall not be less than 10 MΩ.

5.4.3 Safety requirements

(1) Over-discharge

When the capacitor pack is going through the over-discharge test, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage. The insulation resistance value after the test shall not be less than 10 MΩ.

(2) Overcharge

When the capacitor pack is going through the overcharge test, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage. The insulation resistance value after the test shall not be less than 10 MΩ.

(3) External short circuit

When the capacitor pack is going through the external short circuit test, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage. The insulation resistance value after the test shall not be less than 10 MΩ.

(4) Drop

When the capacitor pack is going through the drop test, it shall not explode or catch

fire, and there shall be no housing rupture or liquid leakage.

(5) High temperature

When the capacitor pack is going through the high temperature test at 130 ℃, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage.

(6) Extrusion

When the capacitor pack is extruded until the extrusion force reaches 100 kN or the deformation due to extrusion reaches 30% of the overall size in the extrusion direction, it shall not explode or catch fire.

(7) Mechanical shock

When the capacitor pack is going through the mechanical shock test, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage. The insulation resistance value after the test shall not be less than 10 MΩ.

(8) Temperature cycle

When the capacitor pack is going through the temperature cycle test, it shall not explode or catch fire, and there shall be no housing rupture or liquid leakage. The insulation resistance value after the test shall not be less than 10 MΩ.

(9) Thermal runaway propagation

When a capacitor cell at a specific location in the capacitor pack is triggered to meet the thermal runaway judgment conditions, there shall be no fire, explosion or thermal runaway propagation.

5.5 Management system

5.5.1 Functional requirements

(1) Power supply

The management system shall be powered by two power supplies, one of which shall be the power supply outside the capacitor it monitors.

(2) Structure

The management system shall be equipped with a capacitor control unit and a capacitor monitoring circuit according to the capacitor level. The capacitor control

unit shall be able to receive information (such as voltage and temperature) contained in the monitoring circuit in the capacitor module / capacitor pack.

(3) The design and function of the management system shall be in accordance with the requirements of Section 5 "Battery management system (BMS)" of the Specifications for Battery Power of Marine Applications of China Classification Society.

5.5.2 Performance requirements

(1) Measurement accuracy of state parameters

The requirements for measurement accuracy of the state parameters monitored by the management system are shown in Table 5.5.2 (1)

Requirements for Measurement Accuracy of State Parameters Table 5.5.2 (1)

Parameters	Accuracy requirements	Sampling period requirements
Capacitor cell voltage	≤±0.2%FS, and maximum error ≤±5 mV	≤100 ms
Total voltage of capacitor cluster	≤±1%FS (<1000 V), ≤±0.5%FS (≥1000 V) and maximum error ≤±5 V	≤100 ms
Current of capacitor cluster	≤±0.5%FS, and maximum error ≤±3 A	≤50 ms
Capacitor cell temperature	Resolution ≤1 ℃, measurement error ≤±1 ℃; Not more than ±2 °C within the range of -40 °C ~ -20 °C and +65 °C ~ +125 °C	≤5 s
Insulation resistance	Total voltage of capacitor ≥400 V, and relative error ≤20%. Total voltage of capacitor <400 V, and relative error ≤30%. When the insulation resistance ≤50 kΩ, the maximum error ≤10 kΩ When the insulation resistance ≥1 MΩ, the negative error ≤20%, and the positive error ≤200%.	/

(2) Energy state estimation

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

(3) Resistance to reverse polarity of power supply

The management system shall be able to withstand the specified test of resistance to reverse polarity of power supply. It shall be able to work normally after the test and shall meet the requirements for measurement accuracy of state parameters.

(4) Insulation performance

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

(5) Withstanding voltage performance

When the corresponding voltage is applied between the acquisition terminal of the battery management system connected to the battery and the grounding terminal, between the communication terminal and the grounding terminal, between the acquisition terminal and the power supply resistance, and between the power supply terminal and the communication terminal, there shall be no insulation breakdown or flashover, and the leakage current shall be less than 10 mA.

5.6 Capacitor system

5.6.1 Housing

The relevant equipment of the capacitor system shall generally be made of durable, flame-retardant and moisture-resistant materials.

5.6.2 Function

The control function of the capacitor system shall be in accordance with the requirements in Table 6.5.2.14 of Specifications for Battery Power of Marine

Applications of China Classification Society.

5.6.3 Emergency shutdown

A capacitor system with a nominal energy exceeding 50 kWh shall be equipped with an independent emergency shutdown device to disconnect the capacitor system and meet the following requirements: the emergency shutdown device shall be located at an easily accessible place outside the cab and capacitor compartment, and shall send out visual and audible signals at the same time; The capacitor system shall have a hardware circuit independent of the control, display and alarm systems to perform the emergency shutdown function.

6 Raw materials and parts

The raw materials and parts of the product shall be controlled in accordance with the relevant requirements of the current specifications of the Society.

7 Type test

7.1 Unless otherwise specified, the test shall be carried out within the following standard atmospheric conditions:

（1） Temperature range: 25 °C ± 5 °C;

（2） Relative humidity: 15% ~ 90%;

（3） Air pressure: 96 kPa ± 10 kPa.

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: ±0.1% FS

(5) Dimensions measuring device: ±0.1% FS

(6) Mass measuring device: ±0.1% FS

7.3 Test process error

The requirements for 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 Data recording and recording interval

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

7.5 See Table 7.5 for the test items, technical requirements and test methods of the type test of capacitor cells:

Type Test Items of Capacitor Cell Table 7.5

No.	Test category	Test items	Technical requirements of test	Test methods (test standard: SJ/T 11894-2023)	Sample and No.
1.	Performance test	Appearance and structure	5.2.1 (1),(4),(5)	Clause 6.2.2	1#~28#
2.		Polarity	5.2.1 (2)	Clause 6.2.3	
3.		Overall dimensions and mass	5.2.1 (3)	Clause 6.2.4	
4.		Capacity	5.2.2 (1)	Clause 6.2.5.1	
5.		Stored energy and specific energy	5.2.2 (2)	Clause 6.2.5.2	
6.		DC internal resistance	5.2.2 (3)	Clause 6.2.5.3	
7.		Specific power	5.2.2 (4)	Clause 6.2.5.4	
8.		Voltage holding ratio	5.2.2 (5)	Clause 6.2.5.5	

9.		Characteristics at high temperatures	5.2.2 (6)	Clause 6.2.5.6	1#, 2#
10.		Characteristics at low temperatures	5.2.2 (7)	Clause 6.2.5.7	3#, 4#
11.		Cycle life	5.2.2 (8)	Clause 6.2.5.8	5#, 6#
12.		Insulation resistance	5.2.2 (9)	Clause 6.2.5.9	7#, 8#
13.	Safety test	Over-discharge	5.2.3 (1)	Clause 6.2.7.1	9#, 10#
14.		Overcharge	5.2.3 (2)	Clause 6.2.7.2	11#, 12#
15.		External short circuit	5.2.3 (3)	Clause 6.2.7.3	13#, 14#
16.		Drop	5.2.3 (4)	Clause 6.2.7.4	15#, 16#
17.		High temperature	5.2.3 (5)	Clause 6.2.7.5	17#, 18#
18.		Extrusion	5.2.3 (6)	Clause 6.2.7.6	19#, 20#
19.		Mechanical shock	5.2.3 (7)	Clause 6.2.7.9	21#, 22#
20.		Temperature cycle	5.2.3 (8)	Clause 8.1.6 of GB 38031	23#, 24#
21.		Thermal runaway	5.2.3 (9)	Clause 6.2.7.11	25#, 26#
22.	Environmental adaptability test	Vibration test	Clause 2.7 of Guidelines for Type Approval Test	Clause 2.7 of Guidelines for Type Approval Test	27#, 28#
23.		Flame retardation test (plastic housing only)	Clause 2.16 of Guidelines for Type Approval Test	Clause 2.16 of Guidelines for Type Approval Test	Housing components

7.5.1 Selection of typical samples of capacitor cell

(1) Typical sample selection principle

If the manufacturer applies for the approval of multiple models of capacitor cells at

the same time, the model with the largest capacity under each production process can be selected as the typical sample according to the differences in the manufacturing process and capacity of capacitor cells. For the capacitor cells of other models under the same production process, a safety test report that meets the relevant standards shall be provided for verification.

(2) Approval change

If the approval of different models of capacitor cells is applied at different times, for each application, typical samples of the models submitted for approval shall be selected according to the typical sample selection principle, and type tests shall be carried out according to the requirements in Table 7.5.

7.6 See Table 7.6 for the test items, technical requirements and test methods of the type test of capacitor modules:

Type Test Items of Capacitor Module Table 7.6

No.	Test category	Test items	Technical requirements of test	Test methods (test standard: SJ/T 11894-2023)	Sample and No.
1.	Performance test	Appearance and structure	5.3.1	Clause 6.2.2	1#~14#
2.		Polarity	5.3.1 (2)	Clause 6.2.3	
3.		Overall dimensions and mass	5.3.1 (3)	Clause 6.2.4	
4.		Capacity	5.3.2 (1)	Clause 6.2.5.1	
5.		Stored energy and specific energy	5.3.2 (2)	Clause 6.2.5.2	
6.		DC internal resistance	5.3.2 (3)	Clause 6.2.5.3	
7.		Specific power	5.3.2 (4)	Clause 6.2.5.4	
8.		Voltage holding ratio	5.3.2 (5)	Clause 6.2.5.5	

9.		Characteristics at high temperatures	5.3.2 (6)	Clause 6.2.5.6	1#
10.		Characteristics at low temperatures	5.3.2 (7)	Clause 6.2.5.7	2#
11.		Insulation resistance	5.3.2 (8)	Clause 6.2.5.9	3#
12.	Safety test	Over-discharge	5.3.3 (1)	Clause 6.2.7.1	4#
13.		Overcharge	5.3.3 (2)	Clause 6.2.7.2	5#
14.		External short circuit	5.3.3 (3)	Clause 6.2.7.3	6#
15.		Drop	5.3.3.(4)	Clause 6.2.7.4	7#
16.		High temperature	5.3.3.(5)	Clause 6.2.7.5	8#
17.		Extrusion	5.3.3.(6)	Clause 6.2.7.6	9#
18.		Mechanical shock	5.3.3.(7)	Clause 6.2.7.9	10#
19.		Temperature cycle	5.3.3.(8)	Clause 8.1.6 of GB 38031	11#
20.		Thermal runaway propagation	5.3.3 (9)	Clause 6.3.6.9	12#
21.	Environmental adaptability test	Vibration test	Clause 2.7 of Guidelines for Type Approval Test	Clause 2.7 of Guidelines for Type Approval Test	13#
22.		Alternating damp heat cycle	Clause 2.10 of Guidelines for Type Approval Test	Clause 2.10 of Guidelines for Type Approval Test	14#
23.		Flame	Clause 2.16	Clause 2.16 of	Housing

		retardation test (plastic housing only)	of Guidelines for Type Approval Test	Guidelines for Type Approval Test	components

7.6.1 Selection of typical samples of capacitor module

(1) Typical sample selection principle

If the manufacturer applies for the approval of multiple models of capacitor modules at the same time, the model with the largest capacity under each production process can be selected as the typical sample according to the differences in the manufacturing process of capacitor modules, capacity of capacitor modules, and connection modes (series/parallel). For the capacitor modules of other models under the same production process, a safety test report that meets the relevant standards shall be provided for verification.

(2) Approval change

If the approval of different models of capacitor modules is applied at different times, for each application, typical samples of the models submitted for approval shall be selected according to the typical sample selection principle, and type tests shall be carried out according to the requirements in Table 7.6.

(3) Others

If the factory applies for approval of capacitor cell and capacitor module at the same time, the capacitor module can be used as the test sample for the same test items and test methods in Tables 7.5 and 7.6, which do not need to be carried out on the capacitor cell. The number of samples may be reduced depending on the test.

7.7 See Table 7.7 for the test items, technical requirements and test methods of the type test of capacitor packs:

Type Test Items of Capacitor Pack Table 7.7

No.	Test category	Test items	Technical requirements of test	Test methods (test standard: SJ/T 11894-2023)	Sample and No.

1.	Performance test	Appearance and structure	5.4.1	Clause 6.3.1	1#~3#
2.		Polarity and mark	5.4.1 (2)	Clause 6.3.2	
3.		Overall dimensions and mass	5.4.1 (3)	Clause 6.3.3	
4.		AC internal resistance	5.4.2 (1)	Clause 6.3.4.1	
5.		Capacity and stored energy	5.4.2 (2)	Clause 6.3.4.2	
6.		Voltage holding ratio	5.4.2 (3)	Clause 6.3.4.3	
7.		Insulation resistance	5.4.2 (4)	Clause 6.3.4.4	
8.		Withstanding voltage performance	5.4.2 (5)	Clause 6.3.5.1	
9.	Safety test	Over-discharge	5.4.3 (1)	Clause 6.3.6.1	1#
10.		Overcharge	5.4.3 (2)	Clause 6.3.6.2	2#
11.		External short circuit	5.4.3 (3)	Clause 6.3.6.5	3#
12.		Drop	5.4.3 (4)	Clause 6.2.7.4	4#
13.		High temperature	5.4.3 (5)	Clause 6.2.7.5	5#
14.		Extrusion	5.4.3 (6)	Clause 6.3.6.7	6#
15.		Mechanical shock	5.4.3 (7)	Clause 6.3.6.8	7#
16.		Temperature cycle	5.4.3 (8)	Clause 6.3.6.6	8#
17.		Thermal runaway propagation	5.4.3 (9)	Clause 6.3.6.9	9#

18.	Environmental adaptability test	Vibration test	Clause 2.7 of Guidelines for Type Approval Test	Clause 2.7 of Guidelines for Type Approval Test	10#
19.		Alternating damp heat cycle	Clause 2.10 of Guidelines for Type Approval Test	Clause 2.10 of Guidelines for Type Approval Test	11#
20.		Flame retardation test (plastic housing only)	Clause 2.16 of Guidelines for Type Approval Test	Clause 2.16 of Guidelines for Type Approval Test	Housing components
21.		Housing protection test	Clause 2.15 of Guidelines for Type Approval Test	Clause 2.15 of Guidelines for Type Approval Test	12#
22.		Salt spray test Kb㊟	Clause 2.12 of Guidelines for Type Approval Test	Clause 2.12 of Guidelines for Type Approval Test	13#

Note: ㊟ The salt spray test Kb is only applicable to capacitor packs installed on the open deck of a sea-going ship.

7.7.1 Selection of typical samples of capacitor pack

(1) Typical sample selection principle

For the application for approval of capacitor packs of the same series of models, if they are based on the same capacitor cell and consistent in connection mode (series/parallel), spacing, packaging material, etc., the capacitor pack with the maximum energy shall be selected. The number of samples may be reduced depending on the test.

(2) Approval change

If the approval of the series of models are not applied at the same time, all type tests shall be carried out in principle according to the differences in the energy and structure of the capacitor packs. However, if the capacitor packs are consistent in energy and structure, and only inconsistent in the connection mode (series/parallel) of capacitor cells or modules, only the performance test items in Table 7.7 need to be carried out. At the same time, the necessity of the test items can be evaluated according to the change of the capacitor packs, and the relevant test items can be exempted.

(3) Others

If the factory applies for approval of capacitor module and capacitor pack at the same time, the capacitor pack can be used as the test sample for the same test items and test methods in Tables 7.6 and 7.7, which do not need to be carried out on the capacitor module.

7.8 See Table 7.8 for the test items, technical requirements and test methods of the type test of management systems:

Type Test Items of Management System Table 7.8

No.	Test items	Technical requirements	Test method
1	Appearance and structure inspection	5.5.1	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	SOC estimation accuracy	5.5.2 (2)	GB/T 34131 7.8
5	Resistance to reverse polarity of power supply	5.5.2 (3)	GB/T 34131 7.13.3
6	Insulation resistance measurement	5.5.2 (4)	2.3 of Guidelines for Type Approval Test
7	Withstanding voltage test	5.5.2 (5)	2.14 of Guidelines for Type Approval Test
8	Energy source	2.4 of Guidelines for	2.4 of Guidelines for Type Approval

	fluctuation test	Type Approval Test	Test
9	Energy source failure test	2.5 of Guidelines for Type Approval Test	2.5 of Guidelines for Type Approval Test
10	Vibration test	2.7 of Guidelines for Type Approval Test	2.7 of Guidelines for Type Approval Test
11	High temperature test	2.8 of Guidelines for Type Approval Test	2.8 of Guidelines for Type Approval Test
12	Low temperature test	2.9 of Guidelines for Type Approval Test	2.9 of Guidelines for Type Approval Test
13	Alternating damp heat test	2.10 of Guidelines for Type Approval Test	2.10 of Guidelines for Type Approval Test
14	Housing protection test	2.15 of Guidelines for Type Approval Test	2.15 of Guidelines for Type Approval Test
15	Salt spray test Kbф	2.12 of Guidelines for Type Approval Test	2.12 of Guidelines for Type Approval Test
16	Flame retardation test (plastic housing only)	2.16 of Guidelines for Type Approval Test	2.16 of Guidelines for Type Approval Test
17	Electromagnetic compatibility test	Chapter 3 of Guidelines for Type Approval Test	Chapter 3 of Guidelines for Type Approval Test

Note:ф The salt spray test Kb is only applicable to management systems installed on the open deck of a sea-going ship.

8 Single piece/single batch inspection

8.1 Capacitor cell

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

8.1.2 During the single piece/single batch inspection, the capacitor cells of each specification shall be spot-checked by batch, with at least 1% of the total number of cells of each specification in each batch and no less than 10 cells; The inspection items shall include at least:

(1) Appearance and structure inspection

(2) Polarity

(3) Overall dimensions and mass

(4) Capacity (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(5) Stored energy and specific energy

(6) DC internal resistance

(7) Voltage holding ratio (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(8) Insulation resistance measurement

8.2 Capacitor module

8.2.1 After the type approval B is obtained, the single piece/single batch inspection shall be carried out after the factory test of the manufacturer is completed, and the relevant process data shall be submitted to CCS for review.

8.2.2 During the single piece/single batch inspection, the capacitor modules shall be spot-checked by batch, with at least 5% of the total number of modules in each batch and no less than 5 modules. The inspection items shall include at least:

(1) Appearance and structure inspection

(2) Polarity

(3) Overall dimensions and mass

(4) Capacity (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(5) Stored energy and specific energy

(6) DC internal resistance

(7) Voltage holding ratio (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(8) Insulation resistance measurement

8.3 Capacitor pack

8.3.1 After the type approval B is obtained, the single piece/single batch inspection shall be carried out after the factory test of the manufacturer is completed, and the

relevant process data shall be submitted to CCS for review.

8.3.2 During the single piece/single batch inspection, the capacitor packs shall be spot-checked by batch, with at least 5% of the total number of packs in each batch and no less than 2 packs. The inspection items shall include at least:

(1) Appearance and structure inspection

(2) Polarity and mark

(3) Overall dimensions and mass

(4) AC internal resistance

(5) Capacity and stored energy (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(6) Voltage holding ratio (the sampling rate and test method may be in accordance with the requirements of the enterprise)

(7) Insulation resistance measurement

(8) Withstanding voltage test

8.3.3 If the manufacturer of the capacitor pack and the final integrator of the capacitor system are the same enterprise, the capacity test of the capacitor pack can be carried out in combination with the single piece/single batch inspection of the capacitor system.

8.4 Management system

8.4.1 After the type approval B is obtained, the single piece/single batch inspection shall be carried out after the factory test of the manufacturer is completed.

8.4.2 In case of single piece/single batch inspection, the management systems shall be spot-checked by batch, with 20% of the main controls in each batch and no less than 2 pieces. The inspection items shall include at least:

(1) Appearance and structure inspection

(2) Functional test

(3) Measurement accuracy of state parameters

(4) Insulation resistance measurement

(5) Withstanding voltage test

8.4.3 If the manufacturer of the management system and the final integrator of the capacitor system are the same enterprise, the functional test of the management system can be carried out in combination with the single piece/single batch inspection of the capacitor system.

8.5 Capacitor system

8.5.1 The single piece/single batch inspection shall be carried out after the factory test of the manufacturer is completed, and the factory test report of the enterprise shall be submitted to CCS together with the product inspection notice.

8.5.2 The power distribution and/or control appliances used in the capacitor system shall be in accordance with the relevant requirements of the Rules for Classification of Sea-going Steel Ships or the Rules for Construction of Inland Steel Ships. Power distribution and/or control appliances shall be subject to temperature rise test, utility test, withstanding voltage test and insulation resistance measurement, of which the temperature rise test shall be carried out under the rated working condition, but for products of the same model and specification, it is acceptable that only the first piece of the products is subject to the temperature rise test.

8.5.3 In case of single piece/single batch inspection, the capacitor systems shall be inspected set by set. The inspection items shall include at least:

(1) Appearance and structure inspection

(2) Management system functional test

(3) Over-temperature protection

(4) Overcurrent protection

(5) External short circuit protection simulation

(6) Overcharge protection

(7) Over-discharge protection

(8) Insulation resistance measurement

(9) Emergency shutdown functional test (more than 50 kWh)

(10) Capacity test (at least one cluster shall be selected for one test at the rated

charging/discharging current of the capacitor pack)