Guideline No.E-26(202501)

E-26

Fire Prevention and Control Device for Lithium Iron Phosphate Battery Pack

Issue date: 2025.01.01

Foreword

The CCS Product Inspection Guidelines 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 CCS 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.

Historical release versions and release dates: first version

Main modifications in this version and issue date of this version:

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3 Terms and definitions

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

3.2 Battery pack: It consists of multiple battery cells or modules in series or parallel connection due to voltage or power requirements. The battery pack shall contain a monitoring circuit that provides information (such as voltage, temperature, etc.) for the battery system.

3.3 Thermal runaway: It refers to the uncontrollable temperature rise of a cell caused by exothermic chain reaction in the battery cell.

3.4 Thermal runaway propagation: It refers to the sequential occurrence of thermal runaway within a battery pack or system triggered by the thermal runaway of a battery cell in that system.

3.5 Fire prevention and control device for battery pack: It refers to the special fire prevention and control device set for the battery pack, which can detect the hazard sources that may cause fire in the battery pack, and send out an alarm to automatically and/or manually start the spraying of fire extinguishing medium. It is composed of fire monitoring and alarm device and fire suppression device.

3.6 Fire monitoring and alarm device: It is used for early monitoring of thermal runaway and fire in the battery pack, and is equipped with modules for alarm signal and output control. Generally, it includes composite fire detectors, controllers and audible and visual alarms.

3.7 Fire suppression device: It is a device that sprays suppression medium into the

battery pack to extinguish the fire in the battery pack, significantly decreases the cell temperature in the battery pack, and maintains a certain suppression time. It is generally composed of a storage device for fire suppression medium, a drive unit, a container valve , a control valve, connecting pipeline fittings, a nozzle, etc.

3.8 Start-up time: It refers to the time from the fire prevention and control device receiving the detection and sending the signal to the spraying of the suppression medium.

4 Drawings and documents

4.1 To apply for approval for the fire prevention and control device for battery pack, the following drawings and documents shall be submitted:

4.1.1 The following drawings and documents are to be submitted to CCS for approval:

(1) Technical conditions or technical specifications for products;

(2) General drawing of system;

(3) Schematic of system (including: pipelines, electrical units);

(4) Diagram of main components (including: storage device for fire suppression medium, drive unit, container valve, control valve, connecting pipeline fittings, nozzle, fire detector, controller, audible and visual alarm etc.);

(5) Dose calculation sheet of fire suppression medium;

(6) Type test program.

4.1.2 The following drawings and documents are to be submitted to CCS for reference:

(1) External wiring diagram;

(2) External pipeline connection diagram (if applicable);

(3) List of main parts and materials;

(4) Nameplate diagram;

(5) System software specification;

(6) Product operation and maintenance instructions;

(7) Risk assessment report of system;

(8) Technical Appraisal Certificate for Fire Products (issued by China Certification Center for Fire Products of MEM).

5 Technical requirements

5.1 Operating conditions

5.1.1 The fire prevention and control device for battery pack shall be able to work normally under the working conditions specified in Section 2 and 3 of Chapter 1 of Part 3 of the Rules for Construction of Inland Steel Ships. If used for sea-going ships, it shall be able to work normally under the working conditions specified in Section 2 of Chapter 1 of Part 4 of the Rules for Classification of Sea-going Steel Ships.

5.2 Licensing requirements

5.2.1 The fire prevention and control device for battery pack shall be approved by CCS and hold a marine product certificate. All main components shall comply with the relevant provisions of national and industrial standards. The specific certification requirements for raw materials and components are detailed in Clause 6.

5.2.2 The fire prevention and control device for battery pack shall meet the requirements of the market access system for national fire products. In principle, the main components (fire monitoring and alarm device, fire suppression device) shall obtain the "Technical Appraisal Certificate for Fire Products" issued by China Certification Center for Fire Products of MEM or have the equivalent certification.

5.2.3 The fire prevention and control device for battery pack shall be verified by the entity fire test of classical battery pack model, which shall be implemented by a national authorized institution or witnessed by CCS on site and provided with an inspection test report.

5.3 System composition

The fire prevention and control device for battery pack shall generally be composed of a storage device for fire suppression medium, a drive unit, a container valve, a control valve, pipeline fittings, a nozzle, a composite fire detector, audible and visual alarm, a controller, wires and cables, etc.

5.4 General requirements

5.4.1 Except for the special provisions in the Guidelines, the requirements for the provision, installation, and licensing of the fire prevention and control device for battery pack shall be consistent with the relevant requirements for the fire prevention and control device in the Specifications for Battery Power of Marine Applications.

5.4.2 The fire prevention and control device for battery pack shall be able to detect the potential fire hazards in the battery pack and give an alarm in time.

5.4.3 The fire prevention and control device for battery pack shall be able to monitor the typical thermal runaway gas composition/characteristic parameters in battery pack in real time, and shall immediately issue fire alarm signal when detecting the alarm threshold is reached. When fire alarm signal is detected, a visual and audible alarm shall be given in the corresponding battery cabins, and the fire location shall be displayed on the main controller of fire prevention and control device with a visual and audible alarm.

5.4.4 The fire prevention and control device for battery pack shall be able to timely spray fire suppression medium based on the detection of fire alarm signal, and shall have automatic and/or manual spraying function.

5.4.5 The fire suppression medium shall be compatible with the physical and chemical characteristics of the lithium iron phosphate battery and shall meet the requirements of recognized international/national standards. Generally, C_3HF_7 and $C_6F_{12}O$ can be used. Any new type of suppression medium adopted shall be evaluated and approved by the Society.

5.4.6 The physical and chemical properties of the fire suppression medium shall be suitable for the fire prevention and control of the lithium iron phosphate battery pack, and shall not cause secondary harm to the protected objects; After the fire suppression medium sprays, it shall be easy to clean the protected object and not affect other zones.

5.5 Layout and zoning

5.5.1 Composite fire detectors and fire suppression medium nozzles shall be set in each battery pack. It shall be designed and installed to facilitate the timely detection of hazardous gases in the battery pack and ensure the uniform spraying and complete coverage of the fire suppression medium.

5.5.2 The storage device for fire suppression medium (including container valve, drive unit, etc.), main pipeline for release, and main controller shall generally be set outside the battery cabins. The electrical components shall be explosion-proof when being set inside the battery cabins.

5.5.3 The control valve can be set near the storage device for fire suppression medium or near the protected battery pack. The electrical components shall be explosion-proof when being set inside the battery cabins.

5.5.4 The battery cabins shall be equipped with an audible and visual alarm, which shall be explosion-proof.

5.5.5 The ship control room (such as the fire control room and bridge room) shall be equipped with a display and alarm control unit for the fire prevention and control device.

5.5.6 When the number of battery packs protected by the fire prevention and control device exceeds 8, the battery packs shall be divided into different zones for control. The number of battery packs protected by each zone shall not exceed 8.

5.5.7 Battery packs installed on the same bracket can generally be considered to be in the same protection zone; In principle, battery packs installed on different brackets shall not be considered to be in the same protection zone. If the battery packs installed on the same bracket exceeds 8 pcs, they shall be divided into at least 2 protection zones.

5.5.8 When it comes to the zone setting, it is also possible to configure a control valve to protect each battery pack.

5.5.9 If the liquid fire suppression medium is used, the fire prevention and control device shall be provided with necessary measures (such as low liquid level alarm for the storage device for fire suppression medium) to send an alarm in time for system failure, and the layout of zone components shall prevent the damage to the battery and electrical equipment caused by liquid leakage.

5.6 Fire suppression medium, storage devices and control valve

5.6.1 The fire suppression medium shall at least be insulating.

5.6.2 The containers, valves, gaskets, sealing rings and other parts in the fire suppression device that are in contact with the fire suppression medium shall be

compatible with the fire suppression medium and made of materials adaptable to the temperature and pressure.

5.6.3 The design concentration of the fire suppression medium shall be at least 9% when C_3HF_7 is adopted.

5.6.4 The design amount of fire suppression medium shall be calculated theoretically. The total design amount shall comprehensively consider the number of battery packs and pipeline layout in the system zone design, and be corrected through the physical fire suppression test. The total amount of fire suppression medium shall be calculated and determined according to the demand of the single largest protection zone of the fire protection and control device.

For gas suppression medium, the theoretical design amount shall be calculated according to GB 50370-2005 Code for Design of Gas Fire Extinguishing Systems or relevant requirements of the revised MSC/Circ.848.

5.6.5 The spraying time of gas suppression medium shall meet the requirements of Clause 5.9.7.

5.6.6 The storage device for gas suppression medium shall meet the following requirements:

(1) The storage device shall consist of a storage container, a container valve, and a manifold;

(2) The design and use of the storage containers for gas suppression medium and the storage cylinders for drive gas shall comply with recognized standards;

(3) The storage container shall be equipped with an overpressure protection device to ensure that the fire suppression medium inside the cylinder can be safely diffused when the cylinder is heated;

(4) The storage container with internal pressurization shall be equipped with a pressure monitoring device, so that an audible and visual alarm signal will be sent in the constantly manned place when the driving gas is abnormally lost.

5.6.7 If the liquid suppression medium is used, it shall be evaluated and approved by the Society as per physical and chemical properties, electrical properties, corrosion, toxicity, etc., and be verified through fire prevention and control test to check whether it is suitable for lithium iron phosphate battery pack.

5.6.8 The drive unit shall be designed according to XF 61-2010 General Technical Conditions for Drive and Control Devices of Fixed Fire Extinguishing Systems to meet the requirements for working reliability.

5.6.9 The container valve and control valve shall be able to be enabled both automatically and manually.

5.7 Release pipeline and nozzle

5.7.1 The pipeline and accessories shall not be made of aluminum.

5.7.2 Seamless steel pipes shall be adopted for the pipeline to convey gas suppression medium, and stainless steel pipes shall be used in places with high corrosivity.

5.7.3 The pipeline to convey control gas shall be made of copper.

5.7.4 The size of the pipeline shall be determined by calculation according to the release volume and release time.

5.7.5 When the pipeline diameter is not more than 80 mm, threaded connection can be adopted. When the pipeline diameter is greater than 80 mm, flange connection shall be adopted.

5.7.6 The battery pack nozzle shall be made of corrosion-resistant metal, and the recommended size of the corresponding installation opening is Φ16. The installation of the nozzle shall not affect the IP rating of the battery pack.

5.8 Fire monitoring and alarm device

5.8.1 The fire detector shall be equipped with composite detection functions to continuously monitor typical thermal runaway gas composition/characteristic parameters in lithium iron phosphate battery pack, which generally include temperature, CO, H_2, smoke density , etc. The fire alarm signal shall be issued immediately when it detects the alarm threshold is reached, and the data collection cycle shall not exceed 1s.

5.8.2 The fire detector shall be intrinsically safe, and its working current shall not be greater than 50 mA.

5.8.3 When detecting a fire alarm signal, it shall activate visual and audible alarms on the main controller of fire prevention and control device, and enable the audible

and visual alarm in the corresponding battery cabins to issue continuous alarms.

5.8.4 The main controller of fire prevention and control device shall be able to locate the fire and fault in the battery pack, and display the working status and alarm information of the fire detector in each battery pack.

5.8.5 The main controller of fire prevention and control device shall support at least one of CAN, Modbus, and Ethernet communication, and be able to communicate with the remote controller. It shall be able to transmit the alarm signal to the ship control room (such as the fire control room and bridge room). And the fault signal, alarm signal, and start signal shall be significantly different from each other.

5.8.6 The fire detector shall have multi-level alarm function (at least two levels):

(1) Level 1 alarm signal: It shall at least include the detection of CO concentration, and the recommended set value is 190 ppm ± 50 ppm;

(2) Level 2 alarm signal: It shall at least include the detection of the surface temperature of the battery or battery bank (or the equivalent temperature measured in the temperature field method). The recommended setting value is 80℃±5℃, and any one of CO, H_2 or smoke density signals shall be comprehensively considered.

5.8.7 The automatic spraying start signal shall be a reasonable logic alarm signal combination, which shall fully consider at least two parameters among temperature, CO, H_2, smoke density, etc. in the battery pack. The Level 2 alarm threshold in 5.8.6 (2) shall be reached when the automatic signal is triggered.

5.8.8 The fire prevention and control device can also communicate with the ship's battery management system (BMS) and use the relevant data to determine whether to trigger the spraying start signal.

5.8.9 The fire prevention and control device shall be able to store data, and the main controller shall be able to store abnormal messages for no less than 24 h, which shall at least include alarm information, alarm time, alarm equipment number, alarm data collected by the sensor, fault information, etc.

5.8.10 The main controller and the fire detector of fire prevention and control device shall be equipped with a built-in test to send a fault signal that is obviously different from the alarm signal when it is in abnormal operation.

5.8.11 When the fire prevention and control device starts spraying, it shall send out

continuous audible and visual alarms in the protected battery cabins and the ship control room (such as the fire control room and the bridge room).

5.8.12 The sound pressure level of the audible and visual alarm shall not be less than 75 dB (A), the flash frequency shall be 1 Hz ~ 2 Hz, and it shall be able to flash clearly.

5.9 Control function

5.9.1 The system controller, composite fire detector , audible and visual alarm, and release drive unit shall be equipped with two power supplies. The backup power supply can be the system's own battery or the ship's emergency power supply, and the power supply time must meet the requirements of relevant rules for the emergency power supply time.

5.9.2 The working voltage range of the fire prevention and control device shall be DC9~36 V.

5.9.3 The spraying control function of the fire prevention and control device shall be enabled both automatically and manually. And it shall be set to automatic mode during normal operation. If the automatic start fails, the device shall issue an alarm and be able to switch to manual mode.

5.9.4 The automatic spraying start signal shall meet the requirements of 5.8.7 and shall be automatically triggered by the system main controller.

5.9.5 The manual spraying start signal shall be triggered through operation on the system main controller and extended display control device (such as the ship's fire control room and bridge room), and measures shall be taken to prevent misoperation.

5.9.6 The spraying shall start immediately after the automatic or manual spraying start signal is triggered, and the control valve and container valve of the corresponding protection area shall be opened.

5.9.7 After the fire prevention and control device starts spraying, if the gas fire suppression medium is used, the set fire extinguishing concentration shall be reached within 10 s; If a liquid suppression medium is used, it shall be able to fill the battery pack within 3 min and maintain such status.

5.9.8 The fire prevention and control device can also be designed with the function of quantitative spraying for multiple times at short intervals.

5.9.9 The fire prevention and control device shall only spray on one zone each time it is activated, and the spraying object shall be consistent with the fire alarm signal source object without misoperation.

5.9.10 The main controller of fire prevention and control device can be set with manual emergency stop function to immediately stop the fire suppression medium spraying.

5.9.11 The fire prevention and control device shall be provided with the communication function with the BMS or ship management system, and shall be able to cut off the external circuit of the battery pack in the protection zone to stop charging/discharging when a Level 2 alarm in 5.8.6(2) is reached.

5.9.12 The fire prevention and control device shall be provided with the communication function with the remote controller and the fire protection system of the ship's battery cabins. Generally, the device shall be enabled preferentially.

5.10 Interface requirements

5.10.1 The fire prevention and control device shall not be equipped with other interfaces at battery pack except nozzle and fire detector, and its installation shall not affect the IP rating of battery pack.

5.10.2 The interface surfaces of battery pack shall be free of burrs, foreign matters, burrs, or similar sharp edges.

5.10.3 The pipeline and electrical interface shall be installed to be easily replaced or repaired.

5.10.4 The pipeline joints of the fire suppression medium of the fire prevention and control device shall be as few as possible to avoid leakage; In case of leakage, it shall not cause system failure or other safety hazards.

5.10.5 A communication interface shall be provided between the fire detector, main controller, and control valve of the fire prevention and control device, and it shall support at least one of CAN, Modbus, and Ethernet communications.

5.11 Performance requirements for fire prevention and control device

5.11.1 Initial thermal runaway suppression requirements

The test shall be carried out according to the methods specified in 8.4.1~8.4.2, and the

fire prevention and control device shall meet the following requirements:

(1) Within 30 min after the fire suppression medium starts spraying, the safety diaphragms of other batteries do not act except for the batteries that trigger thermal runaway;

(2) Within 30 min after the fire suppression medium starts spraying, there shall be no deflagration or flame when igniting in the battery pack every 3 min;

(3) Within 30 min after the fire suppression medium starts spraying, except for the temperature measuring points on both sides of the battery that triggers thermal runaway, the temperature of other temperature measuring points in the battery pack shall not be greater than 90°C.

5.11.2 Basic functional requirements

The test shall be carried out according to the method specified in 8.4.2, and the fire prevention and control device shall meet the following requirements:

(1) Display function: the main controller can display alarm signal, spraying object status, etc;

(2) Alarm function: when the multi-level alarm signal and automatic spraying start signal in 5.8.6~5.8.7 are detected, the fire detector, audible and visual alarm and main controller can send out sound and light alarm;

(3) Automatic spraying function: when the automatic spraying start signal specified in 5.8.7 is detected, the fire suppression medium shall be started immediately;

(4) Manual spraying function: in manual mode, the main controller shall be able to start spraying fire suppression medium immediately, and there shall be a function to prevent incorrect operation;

(5) Control function: relevant requirements of 5.9;

(6) Data information storage, transmission and feedback functions: communication with remote controller and battery management system (BMS).

5.11.3 Initial physical fire suppression requirements

The test shall be carried out according to the method specified in 8.4.3, and the fire prevention and control device shall meet the following requirements:

(1) The open flame shall be extinguished within 90 seconds after the fire suppression medium starts spraying;

(2) There shall be no re-ignition within 30 minutes after the open fire is extinguished;

(3) Within 30 minutes after the fire is extinguished, ignite the battery pack every 3 minutes, and no deflagration or explosion shall occur;

(4) Within 30 minutes after the fire is extinguished, the safety diaphragms of other batteries do not act except for the batteries that trigger thermal runaway;

(5) 30 minutes after the fire is extinguished, except for the temperature measuring points on both sides of the battery that triggers thermal runaway, the temperature of other temperature measuring points in the battery pack shall not be greater than 90°C.

6 Raw materials and parts

In principle, the main components of the fire prevention and control device for battery pack shall obtain the Technical Appraisal Certificate of Fire Products issued by the Fire Product Conformity Assessment Center of the Ministry of Emergency Management, and the whole shall be subject to CCS type approval. At the same time, attention shall be paid to the modification and adjustment of some parts that may occur in ship applications, and necessary evaluation shall be carried out. In case of major principle changes, the drawings shall be reviewed and approved again.

In general, the licensing requirements for the fire prevention and control device for battery pack and its components are as follows:

No.	Product name	Certificate category		Approval mode				Drawing review	Remarks
		C/E	W	DA	TA-B	TA-A	WA	PA	
1	Fire prevention and control device	X	—	—	X	—	—	X	Refer to Table 1.3.1.3 of Rules for Ships Applying Battery as a Power
2	Fire prevention and control device (inside								

	the battery pack)								
2.1	Nozzle	X	—	—	X	O	—	X	
2.2	Fire detector	X	—	—	X	O	—	X	
3	Fire prevention and control device (outside the battery pack)								
3.1	Suppression medium storage container	X	—	—	X	O	—	X	
3.2	Drive unit	—	X	—	—	—	—	X	
3.3	Container valve	X	—	—	X	O	—	X	See Appendix 2B of Chapter 3 of Part 1 of the Rules for Classification of Sea-going Steel Ships (such as fixed gas fire extinguishing devices, etc.)
3.4	Control valve	X	—	—	X	O	—	X	
3.5	Pipeline fittings	—	X	—	—	—	X	—	
3.6	Controller	X	—	—	X	O	—	X	
3.7	Audible and visual alarm	—	X	—	X	O	—	X	
3.8	Wires and cables	X	—	—	—	—	X	X	

Legend:

(1) C - Product certificate; E - Equivalency document; W - Manufacturer’s document.

(2) DA - Design approval; TA - Type approval; WA - Works approval; PA - Plan approval.

(3) X - Applicable; O - Optional; - Not applicable.

(4) If there is no "C/E" requirement, the manufacturer shall provide a copy of the corresponding approval certificate along with the manufacturer certificate (original) when supplying the product.

7 Selection of typical samples

7.1 During type approval, a complete set of devices including fire suppression medium storage container, drive unit, container valve, control valve, connecting

pipeline fittings, nozzle, fire alarm detector, controller, etc. shall be tested. In addition, each component shall be selected and subject to the component functional test in 8.2.

7.2 During type approval, type test shall be carried out for each type of fire prevention and control device. If there are different specifications of fire suppression medium containers, pipeline, zone forms, and nozzles, each model shall be tested, and samples shall be randomly selected on site.

8 Type test

8.1 Test items for fire prevention and control device systems

No.	Test items		Test requirements	Test method	Remarks
1	Appearance and structure inspection		GD019-2024 2.1	GD019-2024 2.1	
2	Functional test		8.9	8.9	
3	Fire prevention and control test	Initial thermal runaway suppression test	5.11.1	8.4.1	
4		Basic functional test	5.11.2	8.4.2	
5		Initial physical fire suppression test	5.11.3	8.4.3	

8.2 Fire prevention and control device component test items

No.	Test items	Test objects	Test requirements	Test method	Remarks
1	Appearance inspection	①~⑨	GD019-2024 2.1	GD019-2024 2.1	Note 1: ①Fire suppression medium container ②Drive unit ③Container valve, control valve
2	Insulation resistance measurement	⑥~⑧	GD019-2024 2.3	GD019-2024 2.3	
3	Power supply variation test	⑥~⑧	GD019-2024 2.4	GD019-2024 2.4	
4	Power supply failure test	⑥~⑧	GD019-2024 2.5	GD019-2024 2.5	

5	Vibration test	⑥~⑧	GD019-2024 2.7	GD019-2024 2.7	④Pipeline fittings ⑤Nozzle ⑥Fire detector ⑦Audible and visual alarm ⑧Controller ⑨Wire and cable Note 2: ③ in test objects 6~12 is only applicable to container valve and control valve with electrical components.
6	Dry heat test	③, ⑥~⑧	GD019-2024 2.8	GD019-2024 2.8	
7	Low temperature test	③, ⑥~⑧	GD019-2024 2.9	GD019-2024 2.9	
8	Damp heat test-cyclic	③, ⑥~⑧	GD019-2024 2.10	GD019-2024 2.10	
9	Salt mist test	③, ⑥~⑧	GD019-2024 2.12	GD019-2024 2.12	
10	High voltage test	③, ⑥~⑧	GD019-2024 2.14	GD019-2024 2.14	
11	Enclosure test	③, ⑥~⑧	GD019-2024 2.15	GD019-2024 2.15	
12	Electromagnetic compatibility test	③, ⑥~⑧	GD019-2024 3	GD019-2024 3	
13	Filling density test	①	8.5	8.5	
14	Tightness test	①, ③, ④	8.6	8.6	
15	Strength test	①~⑤	8.7	8.7	
16	Flow test	②, ④, ⑤	8.8	8.8	
17	CO detection and alarm test	⑥	5.8.6	GB 15322.1-2019 5.3,5.5,5.7 or IEC 60079-29-1,5.4.4.5,5.4.5, 5.4.15	
18	H_2 detection alarm test	⑥	5.8.6	GB 15322.1-2019 5.3,5.5,5.7 or IEC 60079-29-1,5.4.4.5,5.4.5, 5.4.15	

19	Temperature detection and alarm test	⑥	5.8.6	GB 30122-2013 5.7，5.8	
20	Smoke detection and alarm test	⑥	5.8.6	GB 20517-2006 5.10，5.11，5.12	

8.3 General requirements for fire prevention and control test

8.3.1 The results of the fire prevention and control test shall correspond to the key conditions such as the type of lithium battery, battery specification, and battery pack composition structure. When the above key conditions change, the fire prevention and control test shall be carried out again.

The battery cell model and battery pack model selected for the fire prevention and control test (8.3.4 and 8.3.5) shall generally be tested with a typical marine battery model of larger size. The fire prevention and control device passing the type approval shall be evaluated for its suitability for other specifications of marine lithium iron phosphate battery pack in actual application. Generally, it is evaluated by the rated capacity (Ah) of the single unit and the total power (kWh) of the battery pack. If the above specification parameters of the marine battery pack are not greater than the test model, it can be considered to be applicable.

8.3.2 The fire prevention and control test is divided into: initial thermal runaway suppression test, basic functional test, and initial physical fire suppression test.

8.3.3 Test equipment

The test equipment shall meet the following requirements:

(1) The temperature measuring equipment shall be SMD type K thermocouple, and the diameter of the thermocouple shall not be greater than 1 mm;

(2) The data acquisition equipment shall be able to continuously monitor and record the parameters of the test process, and the sampling period shall not be greater than 1 second;

(3) The range of the time measuring equipment shall not be less than 60 minutes, and the division value shall not be greater than 1 second;

(4) See the table below for power selection of battery heating unit.

Triggered object energy E (Wh)	Maximum power of heating unit (W)
E＜100	30～300
100≤E＜400	300～1000
400≤E＜800	300～2000
E > 800	＞600

8.3.4 Battery cell model

The battery cell model is a square lithium iron phosphate lithium-ion battery, which consists of several modules of battery cells. The battery cells and the replacement models shall be placed inside the battery pack according to the actual use. The test battery cells and the adjacent battery cells shall be solid battery cells, and the number of solid battery cells shall not be less than 7.

8.3.5 Lithium iron phosphate battery pack model

Select a standard lithium-ion battery pack, the size of the battery pack shall comply with the provisions of GB/T 34013-2017, and a typical marine battery pack model can also be used. The top and side of the battery pack are provided with observation ports, which are sealed with high-temperature and high-strength glass. The side of the battery pack is provided with threading holes, fire suppression medium pipeline mounting ports, etc.

The initial thermal runaway suppression and basic functional test model is a closed battery pack. The initial physical fire suppression test battery pack is opened at the top, and the opening area is 5% of the area of the box cover. The opening is along the long side of the battery pack. For the layout form, refer to Fig. 1 and Fig. 3.

8.3.6 Test triggering mode

The test uses heating trigger to make the lithium battery thermal runaway. When conducting the initial thermal runaway prevention and control test, basic functional test and initial physical fire suppression test, heat the battery cell as shown in Fig. 1, and the SOC of the battery cell is 100%.

8.4 Fire prevention and control test method

8.4.1 Initial thermal runaway suppression test

Arrange the battery inside the battery pack model and install the heating device at the battery cell shown in Fig. 1, and make the heating device in close contact with the battery. Multiple temperature measuring devices are arranged around the test battery (as shown in Fig. 1 and Fig. 2) to monitor the temperature of the battery at adjacent locations, and the battery pack is provided with necessary safety pressure relief measures. Close the top cover of the battery pack, start the heating unit to heat the battery cell until the battery thermal runaway, turn off the power supply of the heating unit, continue for 3 min or until the temperature on the back of the heated battery exceeds 130°C (whichever comes first), and manually start the fire prevention and control device. Ignite the battery pack with an electric ignition device every 3 minutes to observe whether there is deflagration on the battery pack. Record the temperature data of each temperature measuring point of the battery pack 30 minutes after the start of spraying.

8.4.2 Basic functional test

Arrange the battery inside the battery pack as shown in Fig. 1, and install the heating unit at the battery cell shown in Fig. 1, and make the heating equipment in close contact with the battery. The composite fire detector, audible and visual alarm, nozzle and other components of the fire prevention and control device shall be set according to the manufacturer's design, and multiple temperature measuring devices shall be arranged around the test battery (as shown in Fig. 1 and Fig. 2). Close the top cover of the battery pack, start the heating unit to heat the battery, and observe the warning conditions, automatic and manual start conditions, and suppression medium spraying conditions of the composite fire detector, audible and visual alarm, and fire prevention and control device when the conditions for fire suppression medium spraying are met. Record the data of each temperature measuring device at the same time.

8.4.3 Initial physical fire suppression test

Arrange the battery inside the battery pack as shown in Fig. 3, and install the heating equipment at the battery cell shown in Fig. 3, and make the heating unit in close contact with the battery. Arrange several temperature measuring devices around the test battery (as shown in Fig. 2 and Fig. 3) to monitor the temperature of the battery

adjacent to it. Close the top cover of the battery pack, start the heating device to heat the battery cell until the battery thermal runaway, turn off the power supply of the heating unit, ignite with an open flame, and manually start the fire prevention and control device after the fire continues to burn for 3 minutes or the temperature on the back of the heated battery exceeds 150°C (whichever comes first). Ignite the battery pack every 3 minutes and observe whether there is deflagration on the battery pack. Record the fire extinguishing time and the temperature data of each temperature measuring point of the battery pack 30 minutes after the fire is extinguished. The test shall be carried out for 3 times, and if 2 tests are successful, it will be judged that the requirements are met.

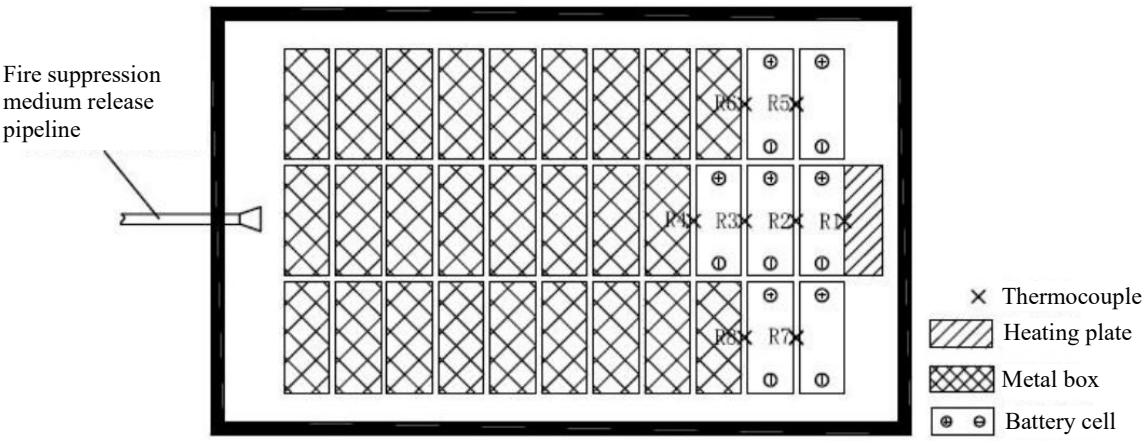

Fig. 1 Initial Thermal Runaway Prevention and Control Test Layout

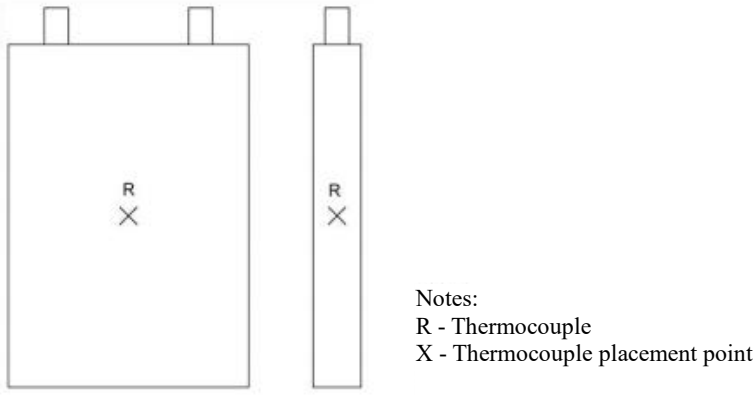

Fig. 2 Position of Battery Cell Temperature Measuring Points

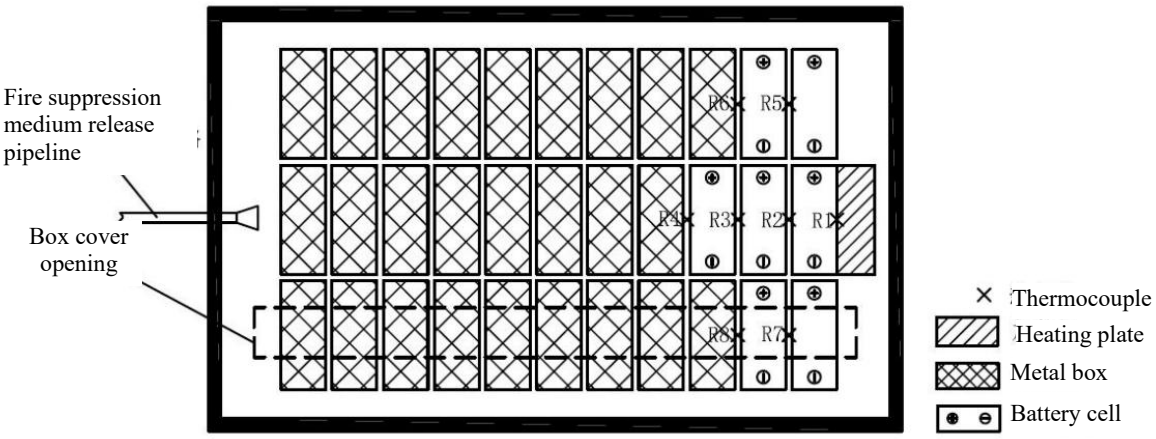

Fig. 3 Arrangement for Initial Physical Fire Suppression Test

8.5 Filling density test

The test shall be carried out according to Clause 5.2.3 of GB 25972-2010 Gas Fire Extinguishing Systems and Components and relevant requirements of ISO 14520-5-2024. The filling density of the storage device for fire suppression medium shall not be greater than the design value of the cylinder group.

8.6 Tightness test

When carrying out the tightness test to check the leakage, the pressure shall be gradually and slowly increased to the test pressure, which shall not be lower than the maximum working pressure, and the duration shall be 5 minutes. There shall be no leakage or deformation.

8.7 Strength test

The test pressure of the strength test shall not be less than 1.5 times of the design maximum working pressure, and the pressure holding time shall be 5 minutes. There shall be no leakage, deformation or damage. The strength test can also be carried out in conjunction with the tightness test.

8.8 Flow test

After the drive unit, pipeline and nozzle are connected, check the flow of the pump according to the design conditions (calibrated speed and calibrated pressure) of the pump, which shall meet the requirements of the design conditions.

The battery pack nozzle and pressure gauge are installed on a supply pipeline to

measure the nozzle flow at a pressure interval of approximately 10% from the minimum operating pressure to the rated operating pressure, which shall be within ± 5% of the design value.

8.9 System functional test

After the installation of the fire prevention and control device is completed, the system shall be externally inspected to check whether the integrity, layout and structure of each component of the system and the capacity of the fire suppression medium meet the requirements of the approved drawings and calculations. Check the manufacturing and installation quality of each component and its fixing.

Carry out the automatic and manual spraying start effect test (without releasing the fire suppression medium) to verify the alarm device and action time, zone release, remote control and communication functions.

9 Single piece/single batch inspection

9.1 The raw materials and components of the fire prevention and control device shall be licensed in accordance with the requirements of Clause 6.

9.2 The first set of fire prevention and control device of the same specification shall be subject to type test according to the requirements of Clause 8 of the Guidelines. On the basis of the self-inspection test completed in the factory, the inspection of subsequent products shall be carried out according to the single piece/single batch inspection test items.

9.3 Before single piece/single batch inspection, the manufacturer shall submit the Technical Appraisal Certificate of Fire Products, typical battery pack model physical fire test inspection report, fire monitoring and alarm device inspection report, and cylinder group pipeline hydraulic test factory inspection report for the same model for the surveyor to review.

9.4 In principle, single piece/single batch inspection shall be carried out piece by piece, and the inspection test items shall at least include:

(1) Appearance and structure inspection;

(2) Insulation resistance measurement test;

(3) Filling density test (8.2.13);

(4) Tightness test (8.2.14);

(5) Strength test (8.2.15);

(6) Flow test (8.2.16);

(7) System functional test (8.9).