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To : All Surveyors and whom it may concern

Subject	**9.103 Notice for Establishment to the KR Technical Rules (Guidance for Large Battery Systems on Board of Ships)**
Application	**16 August 2017 (Date of which contracts for construction are signed or of which application for Classification survey is submitted)**

1. Please be informed that the "Guidance for large battery systems on board of ships" has been established as attachments to reflect a Request for Establishment/Revision of Classification Technical Rules, and you are kindly requested to apply the Guidance on the relevant works.

2. Furthermore, please be informed that the establishment will be included in 2018 edition on KR Technical Rules which will be published in the first half of 2018.

---------- Below ----------

1) To apply for ships that a large battery system with a capacity of 50 kWh or more using lithium secondary battery is used as the additional source of electrical power.
2) To reflect the requirements for type approval, test and inspection of cell, module, battery system, etc.
3) To reflect the requirements for battery system design, electric power converters, fire protection and fire extinction, cooling, monitoring and safety systems, risk assessment.

Attachments: Guidance for Large Battery Systems on Board of Ships --- 1 copy. (The End)

Kim Chang-wook

Executive Vice President, Technical Division

CONTENTS

CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This requirements in this Chapter apply to the ships intended to be registered as ships provided with large battery systems(hereinafter referred to as "battery systems").
2. Items not specified in this Guidance are to be in accordance with each relevant requirement of **Rules for the Classification of Steel Ships** except for the requirements inapplicable to large battery systems on board of ships.
3. Items not included in this Guidance may comply with ISO, IEC, KS or equivalent recognized standards by the appropriate consideration of the Society.
4. Since the battery system has different characteristics depending on the classification of the battery being constructed, this Guidance applies when a large battery system with a capacity of 50 kWh or more using lithium secondary battery is used as the additional source of electrical power.
5. Even though the design of the battery systems deviates from those specified in this Guidance, it may be approved after inspection if it complies with the Rules and Guidance of the Society.

102. Definitions

The definitions of terms are to follow **Rules for the Classification of Steel Ships**, unless otherwise specified in this Guidance.

1. "**Additional source of electrical power**" means a source of electrical power used in addition to the main source of electrical power of the ship. However, even if no additional source of electrical power is used, the main source of electrical power shall comply with **Pt 6, Ch 1, 202.** of **Rules for the Classification of Steel Ships**.
2. "**Battery management system**" means a device for monitoring the charge/discharge status to that the battery can be efficiently managed by measuring the values of current, voltage, temperature, etc. and for safely controlling the function of the battery such as operating the safety device in case of abnormal operation.
3. "**Energy management system**" means the upper management system of the battery system including a monitoring and control system for energy capacity. When the function of the energy management system is included in the power management system, the power management system is regarded as an energy management system.
4. "**Electric power converter**" a device capable of both of the function of suppling power to the power system by converting the designated DC power from the battery to AC or suppling power directly to the AC load and the function to charge the battery by converting AC power from the power system to DC.
5. "**Lithium Secondary Battery**" means a secondary battery that stores electric energy obtained by an oxidation/reduction reaction of lithium ions between an anode and a cathode.
6. "**Cell**" means a component of the smallest unit that constitutes a battery.
7. "**Module**" means a component of a unit in which one or more cells are connected in series or in parallel. And a module-based battery management system may be included.
8. "**Battery pack**" means an energy storage device which is comprised of one or more cells or modules electrically connected.
9. "**Battery system**" means an independently operable device connected to the battery control device and an assembly in which one or more modules or battery packs are connected in series or in parallel. And battery system may include a power converter for charging/discharging the battery.
10. "**Battery room**" means the enclosed area where the battery is installed.
11. "**Rated capacity**" means capacity value of a cell or battery (Ah) determined under specified conditions and declared by the manufacturer.

12. "**SOC (state-of-charge)**" means the available capacity expressed as a percentage of rated capacity.

13. "**SOH (state-of-health)**" reflects the general condition of a battery and its ability to delibver the specified performance compared with a new battery.

14. "**Overcharge**" means charging exceeding the rated capacity.

15. "**Failure mode and effect analysis (FMEA)**" means a failure analysis methodology used during design to postulate every failure mode and the corresponding effect or consequences.

103. Class notations

Ships having large battery systems which complies with requirements of this Guidance may be assigned with the class notation Battery

104. Equivalency

Special equipment, which is not appropriate to apply the requirements of this Guidance or not specified in this Guidance, may be accepted by the Society provided that the Society is satisfied that such equipment is equivalent to or above those complying with the requirements of this Guidance.

105. Modification of requirements

Since commercial battery technology will be under constant development, the requirements of this Guidance may need to be supported by additional information and requirements, on a case by case basis. Designs that are not in compliance with this Guidance may be approved after evaluation by the Society, provided that it can be demonstrated that the design represents an equal or better level of safety.

Section 2 Drawings and Data

201. General

For a ship in which battery systems are installed, drawings and data, specified below para. **202** and **203**, are to be submitted before the work is commenced. And, the Society, where considered necessary, may require further drawings and data other than those specified below.

202. Drawings and data for approval

1. Arrangement drawings

(1) Arrangement for battery systems
(2) Drawings indicating dangerous spaces (if applicable)

2. Battery system

(1) Specifications
  (A) Dimension, material, operation temperature and weight
  (B) Description and application criteria of the components of the battery system including cell
  (C) Voltage and capacity per unit
(2) Electrical circuit diagram
(3) Alarm and monitoring items
(4) List of safety devices (Emergency stop condition)

3. Energy management system

(1) Drawings and data for control and monitoring system
(2) Drawings and data for system configuration algorithm
(3) Drawings and data for computer based systems

4. Electrical equipment

(1) Investigation table of electrical load analysis
(2) Wiring diagram for power systems
(3) Calculation sheets of short-circuit current in the circuits

5. Fire protection and fire extinction

(1) Arrangement and specification of fire extinguishing systems
(2) Arrangement of fire detection systems
(3) Arrangement of fire integrity
(4) Arrangement of ventilation ducts
(5) Gas detection systems (if applicable)

6. Risk assessment result

7. A test program (may be included in programme for sea trials or on-board test)

203. Drawings and data for reference

1. Detailed instruction on fire extinguishing system (detailed description of fire fighting, fire monitoring, ventilation system)

2. Maintenance plan (module replacement, etc.)

3. Operation manual for battery management system (classification of upper and lower battery management system and description of interface, charging/discharging condition at rapid/slow speed) ⚓

CHAPTER 2 CLASSIFICATION SURVEYS

Section 1 General

101. General

The classification surveys of large battery systems on board of ships, except where specially required in this chapter, are to comply with the requirements specified in **Pt 1** of the **Rules for the Classification of Steel Ships**.

Section 2 Periodical Surveys

201. Annual Survey

Annual survey of ships fitted with large battery system on board on ships shall include the followings.

1. Visual inspection and functional test

(1) Inspection for battery room including exposed battery system and their openings, battery system installation area skylights, ventilator openings and their closing appliances.

2. Functional test of measuring devices

3. Safety devices test (including at least the followings)

(1) Fire detector and gas detector (if applicable)
(2) Check the safety function related to ventilation in the battery system installation area
(3) fire extinction test

4. Operating instructions, name plates and lists

(1) Check operating instructions for battery system operation and maintenance
(2) Check the name plates and the list of name plates required for battery system

5. Performance test of battery system

(1) Performance test of electric power converter
(2) Performance test of battery (charge/discharge test)

6. Energy management system tests

(1) Functional test
(2) Check the interface between battery system and energy management system
(3) Check the interface between power management system and energy management system (if applicable)

202. Special Survey

In addition to the annual survey items, the special survey shall include the followings.

1. Emergency stop device test

2. Overcharge and overvoltage protection devices test

Section 3 Tests and Inspections

301. General

1. Manufacturing, testing, inspection and data shall conform to the specifications and recognized standards required by this Guidance.

2. Manufacturing, testing and inspection of equipment related to battery system not covered by this Guidance shall be in accordance with the relevant requirements of **Pt 6** of the **Rules for the**

Classification of Steel Ships.

3. The battery system and related control systems shall be type approved prior to use and the type approval test shall be in accordance with the test standards approved by the Society. However, operating conditions in the marine environment shall be considered.

4. The battery system shall be subjected to the type approval or test and inspection listed in **Table 3** below before installation on board. However, some test items may be added or changed at the request of the Society.

302. Test and Inspection

The battery system shall be subjected to the test and inspection in accordance with the following tables.

Table 1 Battery cell

No.	Tests	Test Standard	Test Subject	Classification
1	Temperature Cycling Test(1)	IEC 62281 / UN38.3 T-2	Cell	Type Approval
2	External Short Circuit Test(1)	IEC 62619 7.2.1(3)	Cell	Type Approval
3	Collision Test	IEC 62619 7.2.2(3)	Cell	Type Approval
4	Overcharge Test	IEC 62619 7.2.5(3)	Cell	Type Approval
5	Forced Discharge Test	IEC 62619 7.2.6(3)	Cell	Type Approval
6	Heating Test	IEC 62619 7.2.4(3)	Cell	Type Approval
7	Internal Short Circuit Test(2)	IEC 62619 7.3	Cell	Type Approval

(Notes)
(1) The test 1 and 2 are sequentially tested with the same battery.
(2) If deemed necessary by the Society, a propagation test (IEC 62619 7.3.3) for the battery system may be additionally required.
(3) Alternatively, relevant tests of IEC 62281 or UN38.3 may be accepted.

Table 2 Battery module

No.	Test	Test Standard	Subject	Classification
1	Capacity Checking Test	Specifications / IEC 62620 6.4.1	Module	Type Approval
2	Vibration Test	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(3)	Module	Type Approval
3	High Temperature and Drying Test	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(4)	Module	Type Approval
4	Temperature and Humidity Test	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(4)	Module	Type Approval
5	Low Temperature Test(1)	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(4)	Module	Type Approval
6	Salt water spray test(1)	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(4)	Module	Type Approval
7	Flame-Resistance Test(2)	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.(4)	Module	Type Approval
8	Test for degree of Protection	IEC 60529	Module	Type Approval

(Notes)
(1) Applied only when installed on open deck
(2) Applied only when using flammable materials
(3) References : IACS UR E10 / IEC 60092-504 / UN38.3 / IEC 62281
(4) References : IACS UR E10 / IEC 60092-504

Table 3 Battery system

No.	Test	Test Standard	Type Approval	Testing and Inspection
1	Overcharge Voltage Control Test	IEC 62619 8.2.2, IEC 62133-2	○	
2	Overcharge Current Control Test	IEC 62619 8.2.3, IEC 62133-2	○	
3	Overheating Control Test	IEC 62619 8.2.4, IEC 62133-2	○	
4	Cell Balancing Test	Specifications	○	
5	SOC Test	Specifications	○	
6	High Voltage Test	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.	○	○
7	Insulation Resistance Test	Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.	○	○
8	Safety Function Test(1)	Specifications	○	○
9	Sensor Failure Test	Failure Mode and Effect Analysis (FMEA)	○	
10	Maximum C-rate Checking Test	Specifications	○	○
11	Electromagnetic Compatibility Test	Refer to Table 6	○	
12	Pre-Installation Integration Test	Refer to Table 7	○	○

(Notes)
Some functions may be replaced by type approval tests in consultation.
(1) The safety function test shall include the followings.
- An emergency stop function
- An alarm and Shutdown function
- HVIL(High Voltage Interlock Loop)
- BMS function (temperature, overvoltage, low voltage protection etc.)
- Failure of communication signals
- Other tests related to safety functions

Table 4 Power conversion system for power supply

No.	Test	Test Standard	Type Approval	Testing and Inspection
1	Visual inspection(1)	-	○	○
2	Functional test	Refer to Table 6	○	○
3	Electrical power supply failure test	Refer to Table 6	○	
4	Input voltage/frequency variation test	IEC 62040-3/6.4.1	○	
5	Temperature rise test(2)	IEC 60146-1-1/7.4.2	○	
6	High voltage test	IEC 61800-5-1/5.2.3.2 IEC 60146-1-1/7.2	○	○
7	Insulation resistance test	IEC 60146-1-1/7.2.3.1	○	○
8	Capacitor discharge test	IEC 61800-5-1/5.2.3.7	○	
9	Rated current / Full load test	IEC 60204-3/6.4.3	○	
10	Short circuit current test	IEC 60204-3/6.4.2.10	○	
11	Charge and recharge energy test(3)	IEC 60204-3/6.4.4	○	
12	Cooling failure test(4)	IEC 61800-5-1/5.2.4.5	○	○
13	Cooling pipe/hose water pressure test(4)(5)	Refer to Table 6		○
14	Environmental test	Refer to Table 6	○	
15	Electromagnetic compatibility test	Refer to Table 6	○	
16	Voltage variation Test	IEC 61000-4-11	○	○

(Notes)
(1) Checking for degree of protection, clearance and creepage distance, items(name plate, etc.) shown on specifications
(2) Additional temperature rise due to harmonics shall be considered.
(3) Applicable only for battery charging
(4) Applicable only for forced type
(5) Applicable only for water-cooling type

Table 5 Power conversion system for frequency conversion (for propulsion)

No.	Test	Test Specification	Type Approval	Testing and Inspection
1	Visual inspection	IEC 91800-5-1/5.2.1	○	○
2	Functional test	Refer to Table 6	○	○
3	Electrical power supply failure test	Refer to Table 6	○	
4	Temperature rise test(1)	IEC 61800-5-1/5.2.3.8	○	
5	High voltage test	IEC 61800-5-1/5.2.3.2	○	
6	Insulation resistance test	IEC 60146-1-1/7.2.3.1	○	○
7	Capacitor discharge test	IEC 61800-5-1/5.2.3.7	○	○
8	Rated current / Full load Test	IEC 60146-1-1/7.3.2	○	
9	Light load and Functional test	IEC 60146-1-1/7.3.1	○	○
10	Impulse voltage test	IEC 61800-5-1/5.2.3.1	○	
11	Component failure test	IEC 61800-5-1/5.2.3.6.4	○	
12	Cooling failure test(2)	IEC 61800-5-1/5.2.4.5	○	○
13	Cooling pipe/hose water pressure test(2)(3)	Refer to Table 6		○
14	Environmental test	Refer to Table 6	○	
15	Electromagnetic compatibility test	Refer to Table 6	○	

(Notes)
(1) Additional temperature rise due to harmonics shall be considered.
(2) Applicable only for forced type
(3) Applicable only for water-cooling type

Table 6 Test criteria of power conversion System

No.	Test	Description
1	Functional test	a) The functions of the power conversion system specified in the specifications shall be basically checked. b) Emergency stop and restart function of power conversion system shall be checked. c) Other functions required by the Society shall be checked.
2	Electrical power supply failure test	a) Check the operating condition of the EUT when source of power is cut 3 times for 30 seconds once for 5 minutes. b) It may exceed 5 minutes if longer time is required to start the EUT (boot sequence). However, one additional power shutdown shall be performed. c) Acceptance criterion: According to specification of EUT at power failure or power recovery
3	Cooling pipe/hose water pressure test	a) The hydraulic test shall be carried out for a minimum of 1 hour at a pressure of at least 2.5 times the rated pressure of the pipe/hose. b) Acceptance criterion: No leakage or damage to joints shall occur.
4	Environmental test	a) The following environmental tests shall be carried out and the relevant test report shall be submitted after the test. For detailed test methods and standards, refer to Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc. - High temperature drying test - Temperature and humidity test - Vibration test - Inclining experiments - Low temperature test - Salt water spray test - Test for degree of protection (IP) b) The worst case scenario conditions that may occur during the vibration test shall be considered. c) The test for degree of protection is to comply with the relevant requirements of Pt 6, Ch 1, 201. 2 (5) of Rules for the Classification of Steel Ships.
5	Electromagnetic compatibility test	a) The following electromagnetic compatibility test shall be carried out and the relevant test report shall be submitted after the test. For detailed test methods and standards, refer to Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc. ·Electromagnetic interference Test - Conducted emission test - Radiated emission test ·Electromagnetic immunity test - Electrostatic discharge immunity test - Radiated radio frequency immunity test - Conducted low frequency immunity test - Conducted high frequency immunity test - Burst immunity test - Surge immunity test
6	Electrical power supply variation test	Refer to Ch 3, Sec 23 of Guidance for Approval of Manufacturing Process and Type Approval, Etc.

Section 4 Tests after installation

401. General

1. Tests after installation shall be performed under all load conditions.

2. The test procedure shall be submitted to the Society.

3. Visual inspection shall be carried out on the components.

4. Tests after installation of ships fitted with a battery systems shall include the following test items in addition to the test requirements carried out basically on ships. However, when it is deemed necessary by the Society, test items and requirements may be added or changed.

Table 7 Items of test after installation

No.	Test	Description
1	Interface checking Test	Check the interface between electric power converter and battery
		Check the interface between battery system and energy management system
		Check the interface between power management system and energy management system (if applicable)
2	Operation test of alarm and safety device	Check alarm device and automatic stopping device such as overcharge, voltage abnormality, temperature abnormality of the charging/discharging system and flammable gas detector
3	Check the function of important equipment	Check the functions of all important equipment related to batter system, including batteries, battery management systems, power converters, energy management systems, etc.
4	Check the function of fire extinguishing/ventilation equipment	Check the functions of ventilation, cooling facility, gas detector, fire detector, alarm device, etc.
5	Synchronization test	Measure and check the phase angle and frequency conversion rate of both power sources when the generator and battery power are synchronized.
6	Check interlock operation	Check the interlock operation for various possible combination of power generation.

CHAPTER 3 CONSTRUCTION AND EQUIPMENT

Section 1 General

101. General

1. Electrical equipment not specified in this chapter is to comply with the requirements in **Pt 1** of the **Rules for the Classification of Steel Ships**.
2. The battery system is generally configured as shown below and can be changed according to the manufacturer's design.

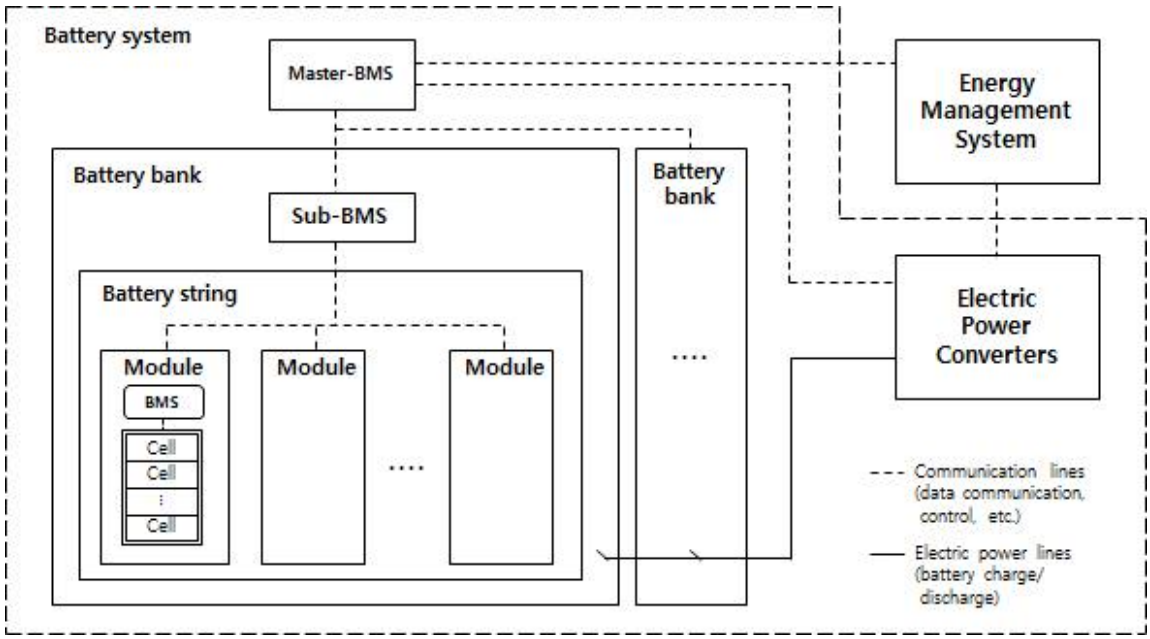

Fig 1 Block diagram of battery system

102. Materials

1. Rubber or plastic materials used in battery systems must have sufficient heat resistance and use low-smoke zero halogen (LSZH) materials.
2. Materials shall be of a material or coating that is corrosion-resistant to corrosion at the place of installation and at the environmental conditions of use.
3. Electrical insulating material and insulation shall be sufficiently heat-resistant to contact or ambient temperature conditions and shall be of a material that is not hygroscopic.
4. The conductive material shall be copper, copper alloy, stainless steel or equivalent, with sufficient electrical, thermal and mechanical safety.

103. Construction

1. All components shall be of a secure construction that is resistant to distortion, relaxation and other damage.
2. Resolvable panels, covers, etc. shall be constructed in such a way that it is not possible to replace them in other locations.
3. Parts that are likely to come into contact with people and those that require periodic maintenance and inspection shall be constructed in a structure free of sharp protrusions or corners.

4. Connection parts between live parts or connection parts between live parts and non-live parts are to be of a structure which does not cause relaxation under the use environment conditions.
5. Parts that can replace or disassemble parts of the main body shall be easy to replace or disassemble and be of a safe construction.
6. A dual-rated device with the ability to convert the rated input voltage or frequency shall be able to easily identify the converted voltage and frequency. However, except for devices with automatic conversion.
7. Electrical components and accessories shall be applied with a maximum voltage or maximum power.

104. Arrangement and location of area

1. The battery room shall be permanently fixed to the hull by welding or the like, and the hull substructure shall be adequately reinforced.
2. Safe access to the battery room shall be provided.

105. Power supply

When essential services are powered from the battery system, they must be configured so that power supply to essential services can be maintained or recovered immediately if any component of the battery system fails.

106. Protective devices

Electrical equipment shall be adequately protected against all overcurrents, including short circuits.

Section 2 System Design

201. General

1. Lithium secondary batteries are to be adequate to national standards, recognized international standards or equivalent standards.
2. A single failure in the battery system shall not affect other systems in the ship.
3. The battery system shall be able to block abnormal current flow, and effective protection shall be provided.

202. Construction and design

1. Battery system design

(1) The lithium secondary battery shall not overflow the electrolytes under the normal operational environment conditions of the ship, such as vibration and inclination of the ship.
(2) The electrolytes shall be injected into the integrated cell and not exposed to the outside.
(3) The battery module shall be designed so as to relieve the rise of internal pressure.
(4) The battery system shall be configured with appropriate protective devices and protective coordination against fault currents.
(5) The battery shall be protected against excessive temperature rise, and the protection function shall be fail safe. In addition, the protective device for this shall be separated from temperature indication, alarm and control functions.
(6) The battery system shall set the limits for the followings so that the temperature is maintained within a certain range.
  (A) Maximum charge and discharge current rate (C-rate)
  (B) Maximum and minimum battery voltage (overcharge and over-discharge protection)
(7) The battery system shall be equipped with short-circuit and over-current protection in the minimum unit forming the system voltage.
(8) The overcurrent protection device shall be installed as close as possible to the battery output terminal. Both the anode and cathode shall be operated simultaneously to prevent overcurrent.
(9) A device that limits the energy flow between the battery and the charging voltage source is to be installed to prevent damage to the battery.
(10) The fault current of the battery system shall be designed taking into account the manufacturer's instructions or the rated capacity (Ah) of the battery pack.
(11) Means of disconnection
  (A) A disconnecting device is to be installed outside the battery system for maintenance.
  (B) The battery disconnecting device shall be capable of simultaneously disconnecting and isolating anode and cathode.
  (C) The automatic disconnector shall be manually reset and operator shall not be exposed to high voltage and arc when resetting.
  (D) For the operation of a manual disconnecting device, tools or excessive force shall not be required by the operator.
  (E) The battery disconnecting device shall be applied considering the designed current and voltage and short-circuit fault current.

2. Degree of protection (IP)

(1) Batteries and related systems shall have a degree of protection suitable for the installation site.
(2) When water-based fire extinguishing system is used in the battery room, the degree of protection of the battery is to be at least IP 44.

3. Battery capacity

(1) Batteries shall have adequate capacity, taking account of aging deterioration and capacity required for ships.
(2) Where the battery is to be used as an additional source of electrical power, the battery capacity shall be sufficient for the intended operation of the ship and data on the basis and calculation of the design capacity shall be submitted.
(3) In the event of an excessive temperature rise in the battery system, a audible and visual alarm signal for manual load reduction shall be transmitted to the bridge or the load reduction shall be performed automatically.

4. Installation

(1) The battery shall be installed in an enclosed space consisting of hull bulkheads or in separate dedicated compartments.
(2) The battery room shall not contain other systems related to the essential services of the ship, and cables, pipes, etc. for supplying to systems other than the battery system shall not penetrate.

5. Operation and maintenance

(1) A detailed operating manual shall be provided on board for emergency situations and shall include the followings:
  (A) Measures to be taken in case of a fire accident due to internal or external factors
  (B) In case of an emergency, the local operation procedure of the battery (charge, stop procedure, etc.)
(2) A plan for functional test and maintenance shall be provided on board and shall include the followings:
  (A) Detailed test plan and maintenance method
  (B) Verification method for state-of-charge (SOC) and state-of-health (SOH)

203. Battery management systems

1. General

(1) The battery management system should be supplied from a separate power source other than its own battery, and should be configured as a system compatible with the communication system so that it can be monitored or controlled with other systems such as a power management system or an energy management system.
(2) The battery management system shall include important alarm and stop functions.
(3) The Master-BMS shall be able to detect major faults in the Sub-BMS and disconnect the associated module or battery pack.
(4) Communication between the Master-BMS and the power management system shall be communicated clearly in normal operation and in the event of an accident.
(5) Electric power converter shall be able to communicate with the battery management system and be designed to be sufficient for the capacity of the battery system.

2. Design

The battery management system shall have the following functions.
(1) The Master-BMS shall monitor all the states of the Sub-BMS and forward the information to the power converter or host controller.
(2) The battery management system shall control charge/discharge according to information transmitted from a power converter or an energy management system which is a host controller, and the power converter shall supply power to meet the charging/discharging conditions.
(3) It shall be able to monitor the status of battery voltage, current, temperature, etc. in real time to maintain the optimal state.
(4) BMS shall prevent overcharge, overdischarge, and overheating of the battery cell and monitor the battery to operate stably.
(5) The Master-BMS shall detect major failure of the Sub-BMS and forward it to the power converter so that it can immediately shut down the related battery system.
(6) Communication between the battery management system and the power converter or upper controller shall be redundant to increase the safety of the system.

204. Energy management systems

1. When applying an energy management system, the energy management system shall be installed as an upper controller of the battery system.

2. The energy management system shall always monitor the followings:
(1) The available energy or power of the battery system.
(2) State-of-charge (SOC)
(3) State-of-health (SOH)

3. The energy management system shall be designed so that the battery system operates within the specified limits and shall always monitor the followings in the engine control room.
(1) Maximum charge current and discharge current (C-rates)

(2) Maximum and minimum voltage of battery (prevention of overcharge and overdischarge)

Section 3 Electric Power Converters

301. Design

1. All power converters shall use approved products from the Society and comply with the following requirements.

(1) Designed and tested in accordance with the Rules of the Society and the recognized standards by the Society.

(2) Designed in accordance with the marine environmental conditions of the installation site.

(3) Designed considering the electrical characteristics of the equipment to be connected.

(4) It shall be designed in consideration of equipment and life safety.

(A) The enclosure shall be designed to protect personal injury due to sharp edges and excessive temperature rise.

(B) For the safety of life, a lock that can be used during maintenance and inspection shall be provided.

(C) When the operating voltage exceeds 50V, safety earth is to be carried out using earth wire.

(5) Power converters shall be equipped with separate control and monitoring systems.

(6) The power converter shall comply with the requirements in **Pt 6, Ch 1, 201. 8** of the **Rules for the Classification of Steel Ships**.

(7) The power conversion device shall be equipped with an emergency stop function and shall be composed of independent wiring.

(8) The components of the power inverter shall be easy to repair and replace.

(9) The capacity of the power converter shall be selected considering the electrical specifications of the connected load.

(10) The power converter shall meet the following performance requirements.

(A) Charge/discharge shall be controlled in accordance with the instruction of the upper controller responsible for the power control of the ship.

(B) In case of failure of the power converter, the power converter shall be immediately disconnected from the system so that the effect of the failure does not spread to the power system.

2. Installation

(1) Power converter shall be installed in a dry place as far as possible from steam pipes, water pipes, oil pipes, etc.

(2) Emergency stop devices for emergency isolation shall be provided for power converters of 50 kVA or more.

(3) Power converter shall be installed in a space where the proper temperature can be maintained in consideration of the charge/discharge characteristics.

(4) It shall be installed in a place where workers can access easily.

(5) It shall be installed away from heat sources such as engine exhaust manifolds.

(6) It shall have space for operation and maintenance.

(7) It shall be installed in a place where it can be firmly fixed to withstand vibration and so on.

(8) In the case of air-cooled type, it shall be installed in a place where the inlet air temperature does not exceed the limit of the manufacturing specification.

(9) The power converter shall not be installed on the battery.

3. Degree of protection (IP)

(1) Power converters shall have a degree of protection suitable for the installation site.

4. Power converters for battery charging and power supply shall meet the following requirements.

(1) Protection against overcharging and overvoltage shall be provided, and a indicator for the state-of-charge shall be provided.

(2) A protection system against reverse flow of charge current shall be installed.

(3) It shall be designed to charge the battery at the current and voltage appropriate for the specifications of the battery system.

(4) In the event of a power converter failure, a visual and audible alarm shall be issued to the bridge or engine control room.

5. Electric power converter

(1) Temperature monitoring of power semiconductor devices or other heat sources of power converters shall be performed.

(2) If the power converter is required to have an emergency stop function, it must be independent of the signals of other control systems.
(3) The internal capacitor shall be discharged to less than 60 V within 5 seconds of power removal. However, except when the residual charge amount is 50 μC or less, if this is not possible, the warning shall be displayed in a position easily visible to the operator so that it can wait for a certain time before opening the enclosure.

302. Protection system

1. The power converter shall be protected from damage due to transient overvoltage, such as surge voltage due to circuit opening and closing, and voltage rise due to regenerative braking.

2. Under normal operating conditions, the semiconductor device shall be controlled so as not to exceed the allowable current.

3. The system to which the power converter is connected shall be provided with an overcurrent limiting device.

Section 4 Fire Protection and Fire Extinction

401. General

1. The requirements in this Section apply in addition to **Pt 8** of the **Rules for the Classification of Steel Ships**.
2. Battery rooms may generally be considered as an "Other machinery spaces" for fire protection purposes.
3. The battery room shall be enclosed by an A-0 class bulkheads and the boundary between the following compartments shall be A-60 class.
   (1) Machinery spaces of category A specified by SOLAS Reg.II-2/3
   (2) Cargo area for the transportation of dangerous goods
4. Where a water injection system is applied for the arrangement of fire extinguishing systems in the battery room and for the cooling of batteries or other components, the necessity and safety shall be approved by the Society.

402. Fire detection system

1. Smoke detectors shall be used for fire detection. However, for areas where malfunction of the smoke detector may occur, a heat detector may be used.
2. The fire detection system shall be provided in accordance with the FSS code.
3. When a fire is detected in the battery room, the operation of the battery shall be stopped automatically. Functions are to be designed to fail-safe.

403. Ventilation

If there is a possibility of generating flammable gas in the battery room through a risk assessment, the ventilation system shall comply with the following requirements.

1. The ventilation fan shall be of a non-sparking type.
2. The ventilation system of the battery room shall be operated independently of other HVAC systems.
3. The power supplied to the ventilation system shall be supplied from outside the battery room.
4. The air of exhaust outlets shall be monitored at all times and an alarm shall be issued when 30% of the lower explosion limit is reached. In addition, the gas detection system shall be interlocked with the relevant equipment to automatically shut down the battery. When 60% of the lower explosion limit is reached, all electrical circuits in the battery compartment must be deactivated and the function of the trip condition is to be designed to fail-safe.

404. Fire protection

1. The battery room shall not contain the essential services related systems and heat sources which are highly likely to cause fire explosion.
2. The door of battery room shall be kept closed at all times and an alarm signal shall be issued upon opening or a self-closing door shall be installed.

405. Fire extinction and Cooling

1. The fire extinguishing system for the battery system shall be provided in accordance with the FSS code.
2. Because battery system has different materials according to battery type, the type and amount of fire shall be selected considering the method of fire extinguishing according to the material of the battery used. The type and amount of such fire extinguishing media shall be selected according to the risk assessment and additional fire fighting equipment or cooling means may be required (e.g. whether it is fixed or portable depending on capacity).
3. The battery system area shall be equipped with automatic fire extinguishing system. The operation

signal of the fire extinguishing system shall be operated as a separate redundant signal and also be operated manually.

4. Two portable dry powder fire extinguishers or two CO_2 fire extinguishers of at least 5 kg capacity shall be provided near the battery room and a portable fire extinguisher may be required depending on the capacity of the battery system.

Section 5 Cooling

501. General

1. The single failure of the cooling system shall not affect the operation of the battery system.

2. In order to prevent overheating in the event of a cooling system failure, the current shall be automatically reduced and then limited operation shall be performed.

3. In case of forced cooling type, a means of monitoring the condition of the cooling system shall be provided and a visual and audible alarm shall be issued to the engine control room in the event of a failure.

4. In the case of air-cooled type, it shall be designed so that it does not cause trouble due to salt air or moisture.

502. Water-cooled type

1. Forced water-cooled type

(1) In case of forced water cooling, the state of cooling water shall be monitored at all times.
(2) In relation to **501. 2** above, where limited operation of the power converter is not possible, an additional cooling pump is to be provided.
(3) Leak detection device shall be installed and a visual and audible alarm shall be issued to the engine control room when leaked.
(4) In the event of leakage, the leaked liquid shall be collected in one place and leakage shall not cause failure of the power converter and nearby equipment.
(5) Cooling water is not to be in contact with the conductive part.

503. Air-cooled type

1. Forced air-cooled type

(1) For forced air cooled type, the failure of the cooling fan shall be monitored at all times.
(2) In relation to **501. 2** above, where limited operation of the power converter is not possible, an additional cooling fan is to be provided.

Section 6 Monitoring and Safety Systems

601. General

1. Measurement and automation including computer-based control and monitoring are to comply with the requirements specified in **Pt 6, Ch 2** of the **Rules for the Classification of Steel Ships** in addition to the relevant requirements of this section.
2. The battery system shall be provided with means for emergency stop at the following locations and the emergency stop circuit shall be configured independently of the control, monitoring and alarm system.
   (1) Navigation bridge
   (2) Engine control room
   (3) Near the battery room
3. The battery system shall be equipped with a device capable of monitoring the alarm and status information of **602.**

602. Alarm and status information

1. If the following situation occurs in the battery system, a visual and audible alarm shall be issued to the engine control room. However, in case of (2), a visual and audible alarm shall be issued to the bridge.
   (1) Battery breaker trip
   (2) Gas detection (if applicable), fire detection
   (3) Overcurrent, overvoltage, undervoltage, overdischarge
   (4) Voltage unbalance between battery cells
   (5) Charging/discharging failure
   (6) Temperature rise of the cell
   (7) Failure of ventilation system
   (8) Failure of cooling system
   (9) Failure of energy management system, power converter and battery management system
   (10) Input of incorrect setting value
2. The battery system shall ensure that the following items are transmitted to the engine control room and continuously monitored.
   (1) Battery
      (A) Cell voltage, temperature
      (B) Battery pack current
      (C) Output of battery
      (D) Available energy of battery
      (E) Battery operating time
   (2) Power converters
      (A) Voltage, current
      (B) Cooling medium temperature
      (C) Internal temperature of the power converter
   (3) Battery room
      (A) Battery room temperature
      (B) Operating condition of the ventilation system in the battery room
      (C) Operating condition of the cooling system in the battery room
3. The battery voltage and temperature shall be monitored at the lowest cell-level voltage of the battery and always monitored during charging and discharging.

Section 7 Risk Assessment

701. General

1. A risk assessment shall be carried out with an emphasis on ship and life safety. And, causes and effect analysis for all possible accident scenarios and remedies for high risk potential shall be presented.
   (1) Risks due to reasonably foreseeable failure with regard to installation, operation and maintenance shall be considered.
   (2) Risks shall be analyzed using recognized analytical techniques and at least the loss of function, damage to components, fire, explosion, possible generation and ignition of flammable gases, and electrical shock shall be considered.
   (3) Risk analysis shall ensure that risks are eliminated wherever possible, and risks that can not be eliminated shall be mitigated as necessary.
   (4) Details of the risks and means to mitigate the risks shall be included in the operating manual.
2. In the event of any revision or supplementation of the risk assessment result, it shall be revalidated by the Society.

702. Considerations for risk assessment

1. Various methods can be used for risk assessment and at least an analysis of the following risk factors shall be included.
   (1) Risk of toxic, flammable, corrosive gas leaks
   (2) Fire and Explosion Hazards
   (3) Risk of electric shock
   (4) Suitability of monitoring, alarm and ventilation systems according to the risk
   (5) Protection measures against the risk factors (fire, flooding, vibration, etc.) surrounding the battery installation area
   (6) Protection and prevention measures against battery failure
   (7) Risk of electrical accidents (overdischarge, overcharge, electromagnetic compatibility, electrical shock, short circuit due to external factors, short circuit due to internal factors, overheating, etc.)
   (8) Suitability of fire extinguishing systems and fire extinguishing equipment
2. Fire and explosion within the area containing the battery system shall not cause damage or failure as follows.
   (1) Damage to any area other than the place where fire and explosion occurred
   (2) Interference with proper functioning of other areas
   (3) Ship damage in the form of flooding under the main deck or gradual flooding
   (4) Damage to service areas or accommodation spaces in the form of injury to persons in service areas or accommodation spaces under normal operating conditions
   (5) Obstruction of the proper functioning of control room and switchboard room for essential power supply
   (6) Damage to life-saving equipment or related facilities
   (7) disruption of the proper functioning of fire extinguishing facilities located outside the area damaged by fire and explosion
   (8) Affecting other areas of the ship in the form of a chain reaction involving cargo, gas and fuel oil
3. If it is deemed necessary by the Society, additional risk considerations may be required depending on the type of lithium secondary battery. ⚓