Requirements for

# Use of Lithium-ion Batteries in the Marine and Offshore Industries

ABS

April 2024

REQUIREMENTS FOR

# USE OF LITHIUM-ION BATTERIES IN THE MARINE AND OFFSHORE INDUSTRIES
# APRIL 2024

**American Bureau of Shipping**
**Incorporated by Act of Legislature of**
**the State of New York 1862**


**ABS Plaza**
**1701 City Plaza Drive**
**Spring, TX 77389 USA**

# Foreword *(1 April 2024)*

ABS recognizes the increasing use and benefits of batteries in the marine and offshore industries. Lithium-ion batteries, as the dominant rechargeable battery, exhibit favorable characteristics such as high energy density, lightweight, fast charging, low self-discharging rate, and low memory effect. The use of lithium-ion batteries for large energy applications is still relatively new, especially in the marine and offshore industries. ABS has produced this document to provide requirements and reference standards to facilitate effective installation and operation of lithium-ion battery systems.

The document establishes safety guidelines for owners, operators, shipyards, designers, and manufacturers for marine systems. This document does not address Lithium-ion batteries used in small portable electronic devices such as power tools, laptops, tablets, smartphones, and radios. This document covers lithium-ion battery types currently used in the industry (for example, lithium-ion cobalt oxide, lithium-ion manganese oxide, lithium-ion nickel manganese cobalt oxide, lithium-ion nickel cobalt aluminum oxide, lithium-ion iron phosphate, and lithium-ion titanate). For requirements applicable to conventional battery types (for example lead-acid, alkaline), refer to the requirements found in Part 4 of the ABS *Rules for Building and Classing Marine Vessels*. For requirements applicable to batteries used in underwater vehicles, refer to 10/11 of the ABS *Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities*.

Battery technology is continuously evolving with respect to battery chemistries and designs. Alternative arrangements or battery technologies may be considered by ABS provided it can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety standards of this document and the ABS Rules.

The February 2020 edition clarified and expanded the requirements when the battery space is adjacent to a machinery space of category A.

The January 2022 edition included changes to the title of this document to replace "Lithium Battery" with "Lithium-ion Battery", and to update the requirements for emergency source of power, battery space, fire safety, hazardous areas, risk assessment approach and other editorial changes.

The July 2022 version changed the document type from “Guide” to “Requirements”. “Requirements” documents contain mandatory criteria for Classification and issuance of Class Certificates, while Guides contain only requirements for optional Notations (see 1-1-4/1.5 of the ABS *Rules for Conditions of Classification (Part 1)*). The title is changed from "*Guide for Use of Lithium-ion Batteries in the Marine and Offshore Industries*" to "*Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries*". Accordingly, editorial changes are made throughout this document.

The April 2024 edition includes an update to the battery system’s energy, which has been reduced from 25 kWh to 20 kWh. This edition adds new requirements for the Lithium-ion battery system components, ventilation system, environment control, and gas detection. It also introduces goal-based standards and functional requirements to prescriptive criteria and includes updates to the requirements for the main and emergency sources of power, battery spaces, fire safety, hazardous areas, risk assessment approach, and maintenance manuals.

This document becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version is the most current.

*We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.*

REQUIREMENTS FOR

# USE OF LITHIUM-ION BATTERIES IN THE MARINE AND OFFSHORE INDUSTRIES

## CONTENTS

# SECTION 1
# General

## 1 Introduction *(1 April 2024)*

ABS recognizes the increasing use of batteries in the marine and offshore industries and their benefits. This document has been developed to facilitate the effective installation and operation of lithium-ion (Li-ion) batteries. This document is to be used in conjunction with and as a supplement to Part 4 of the ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)* and the ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*, and the ABS *Requirements for Hybrid and All-Electric Power Systems for Marine and Offshore Applications* as applicable. The basic safety principles contained in the ABS Rules are to be followed in general (such as providing sufficient power generation/storage capacity, having adequate standby and emergency power sources, arrangements for continuity of supply in the event of a fault, general electrical safety such as proper cable sizing, appropriate insulation, and suitable equipment enclosure ratings). These specific requirements are not repeated in this document.

## 2 Objective *(1 April 2024)*

### 2.1 Goal

Lithium-Ion battery systems addressed in this section are to be designed, constructed, operated, and maintained to:

| *Goal No.* | *Goal* |
|---|---|
| POW 1 | Provide safe and reliable storage and supply of fuel/energy/power. |
| POW 2 | Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel. |
| POW 6 | Have fail-safe features that prevent progressive failure in the event of failure of any single component. |
| POW 8 | Maintain Continuity of Power Supply. |
| PROP SG 9 | Maintain the vessel/unit on station in the open waters |
| FIR 1 | Prevent the occurrence of fire and explosion |
| FIR 2 | Reduce the risk to life caused by fire. |
| FIR 3 | Reduce the risk of damage caused by fire to the ship, its cargo and the environment. |
| SAFE 1-1 | Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems. |
| SAFE 2 | Provide suitable and readily available illumination. |
| AUTO 1 | Perform its functions as intended and in a safe manner |

| Goal No. | Goal |
|---|---|
| AUTO 2 | Indicate the system operational status and alert operators of any essential machinery/systems deviate from its defined design/operating conditions or intended performance |
| AUTO 3 | Have an alternative means to enable safe operation in the event of an emergency or failure of remote control. |
| AUTO 5 | Be provided with a safety system that automatically leads machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/ equipment or environment. |
| MGMT 5-1 | Facilitate safe access, ease of inspection, survey, and maintenance of vessel, machinery, and electrical systems |

The goals in the cross-referenced Rules and Guides are also to be met.

## 2.2 Functional Requirements

To achieve the above stated goals, the design, construction, installation and maintenance of Lithium-Ion Battery Systems are to be in accordance with the following functional requirements:

| Functional Requirement No. | Functional Requirement |
|---|---|
| **Power Generation and Distribution (POW)** | |
| POW-FR1 | Provide sufficient power capacity and quantity to achieve continuity of power with at least one source of power in standby. |
| POW-FR2 | Means to be provided to protect the main source of power from sustained overload. |
| POW-FR3 | Provide arrangement and location provisions for emergency power such that a casualty of the space containing the main source of power will not affect the emergency power. |
| POW-FR4 | Provide transitional power to supply essential safety systems that are not to be interrupted upon loss of either the main or emergency source of power. |
| POW-FR5 | Maintain the integrity of emergency power and associated electrical distribution equipment. |
| POW-FR6 | Provide cables with sufficient current carrying capacity to support connected loads and within the ratings of overload protection. |
| POW-FR7 | Primary essential services and secondary essential services necessary for safety are to be provided with arrangement to automatically restart upon loss of main source of power. |
| POW-FR8 | Provide system/equipment redundancy such that a single failure will not disable the essential and emergency services. |
| POW-FR10 | Auxiliary equipment is to be arranged such that failure to one power distribution section does not prevent power supply to equipment necessary for propulsion. |
| POW-FR11 | Provide protection against overload, short circuit, earth-fault and overvoltage conditions and other hazards to prevent damage to equipment and maintain continuity of power to remaining circuits. |
| POW-FR12 | Provide means to distribute loads such that blackouts are avoided, and power is always maintained to essential services and propulsion loads. |
| POW-FR14 | Circuit disconnecting devices are to be constructed to withstand vibration or shock encountered during normal marine environmental conditions and avoid deterioration. |
| POW-FR15 | Circuit disconnecting devices used for battery system are to be designed to operate at full load conditions and are to be constructed to prevent flammability due to any damage. |
| **Fire Safety (FIR)** | |

| *Functional Requirement No.* | *Functional Requirement* |
|---|---|
| FIR-FR1 | The location of the switchboard, distribution equipment and main source of power is to be arranged such that the integrity of main electrical power may be affected only by a fire, flooding or similar casualty in one space. |
| FIR-FR2 | Provide fire-extinguishing systems for effective containment and extinction of fire within space of origin with due regard to fire growth potential. |
| FIR-FR3 | Provide means to shutdown the power ventilation system covering high fire risk areas in the event of a fire. The shutdown means are to be in a location outside the affected space and in location not likely to be cut off in the event of fire and in centralized firefighting stations |
| **Safety of Personnel (SAFE)** | |
| SAFE-FR1 | Provide conditions for the safe use of hull return and earthing systems. |
| SAFE-FR2 | Provide segregation of accommodation, cargo, and machinery space ventilation circuits such that shutdown of one system will not affect the other. |
| SAFE-FR3 | Provide protection to prevent accidental contact with live parts of the assembly. |
| SAFE-FR4 | Provide an external insulation enclosure for switchgear and control gear assemblies for protection of the equipment from electric hazards. |
| SAFE-FR5 | Provide enclosure with suitable degree of protection against ingress of foreign objects and liquids based on location and personnel accessibility of installation. |
| SAFE-FR6 | Provide safety measures and alarms to detect and to protect from the earth leakage in AC and DC systems. |
| SAFE-FR7 | Provide enclosed ventilation or other means of protection for battery system to prevent personal injury or entrance of foreign matter. |
| SAFE-FR8 | Provide safety design for water-air cooler to prevent the water leakage. |
| **Automation: Control, Monitoring and Safety Systems (AUTO)** | |
| AUTO-FR1 | Provide overload protection to the battery system when arranged for feedback operation |
| AUTO-FR2 | Provide safety measures and alarms to protect the battery system |
| AUTO-FR3 | Provide protection against overload, undervoltage and short circuit conditions to prevent damage to equipment and maintain continuity of power to remaining circuits. |
| AUTO-FR4 | The circuit protection devices are to be able to withstand the prospective short circuit current values at the point of installation. |
| AUTO-FR5 | Provide coordination for all protective devices to allow the system to open the protective device closest to the fault first to protect the healthy portion of the system. |
| AUTO-FR6 | Provide safety measures and alarms to protect the electrical distribution system from harmonics |
| AUTO-FR7 | Provide means to initiate disconnect of equipment and be designed such that a single failure will not result in the loss of duplicated essential equipment |
| AUTO-FR8 | Provide means to monitor the emergency disconnect circuits to alert the crew of any failures. |
| **Communications (COMM)** | |
| COMM-FR1 | Provide means of communication from the navigation bridge to essential interior locations. |
| COMM-FR2 | Provide means of visual indication of the orders and responses in the bridge and machinery space control stations. |

| *Functional Requirement No.* | *Functional Requirement* |
|---|---|
| COMM-FR3 | Provide a general alarm that is audible throughout all accommodation and normal crew working areas for summoning passengers and crew to muster stations. |
| COMM-FR4 | Provide means to initiate alarm from the centralized propulsion machinery control stations to alert the engineers not on duty. |
| COMM-FR5 | Provide means to initiate alarm from the refrigerated space and elevator such that the normally manned control station is alerted of an emergency. |
| COMM-FR6 | Provide a broadcast system that is audible in all spaces where passengers and personnel are normally present to notify them of an emergency and actions to be taken. |
| **Safety Management (MGMT)** | |
| MGMT-FR1 | Provide accessibility to all the parts of the equipment requiring inspection or adjustment or replacement. |
| MGMT-FR2 | Provide means of disconnecting the electrical equipment from power source for maintenance. |
| MGMT-FR3 | Cables are to be constructed to withstand marine environment , support connected loads and their overload protection. |
| MGMT-FR4 | To determine the authorizations required for each operation or task involving high voltage equipment and for access to the equipment location. |
| MGMT-FR5 | Electrical equipment installations are to be well supported and provided with adequate clearance for ease of operation and maintenance. |
| MGMT-FR6 | Provide suitable marking for high voltage cables, equipment and spaces containing them for warning. |

The functional requirements covered in the cross-referenced Rules and Guides are also to be met.

### 2.3 Compliance

A system is considered to comply with the goals and functional requirements when the prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2 of the ABS *Marine Vessel Rules*.

## 3 Application *(1 April 2024)*

This document is applicable to marine and offshore assets designed, constructed, or retrofitted with a lithium-ion battery system used as a source of electrical power with an energy of 20 kWh or greater. An optional notation (**ESS-LiBATTERY**) may be granted to those assets once the battery installation has complied with the requirements of this document. Where batteries are being used as the main source of power, the additional requirements set forth in Section 4 are to be met. Where batteries are being used as the emergency source of power, the additional requirements set forth in 2/1.17 are to be met.

The requirements contained in this document are mandatory, even if the optional notation is not selected.

Battery systems having a rated energy of less than 20 kWh are not required to comply with the provisions of this document unless specified otherwise. However, they are to be designed, constructed and equipped in accordance with good commercial and marine practices. Acceptance of such batteries will be based on a manufacturer's affidavit, verification of battery nameplate data, and is subject to satisfactory type and performance tests before installation. Surveyor attendance is not required for those tests, but the test certificates are to be made available when requested by the Surveyor. Refer to 3/2 Table 1.

Certain criteria of this document may be applicable to marine and offshore assets designed, constructed, or retrofitted with a lithium-ion battery system used as a source of electrical power with an energy capacity less than 20 kWh. Refer to 2/1.

Where Type Approval of a lithium-ion battery system is requested, applicants should contact ABS for the approval process. For ABS Type Approval Program requirements, refer to 1A-1-4/7.7, Appendix 1A-1-A3, and Appendix 1A-1-A4 of the ABS *Rules for Conditions of Classification (Part 1)*. See 2/1.1 TABLE 1 for certification details. Alternative certification schemes are also available as documented in 1-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1)*.

This document was primarily written for vessels that comply with Marine Vessel Rules or units that comply with MOU Rules. It may be applied to other vessel types (HSC, Yachts, FPI, etc). In this case, the equivalent requirements from the Rule set applicable to the vessel or unit are to be applied. Refer to Appendix 2 for special considerations related to vessels that are not required to comply with the International Convention for the Safety of Life at Sea (SOLAS) regulations.

In addition, containerized battery systems are addressed in the Appendix 3.

## 5 Scope *(1 April 2024)*

Lithium-ion battery types covered by this document include the following battery types:

- lithium-ion cobalt oxide
- lithium-ion manganese oxide
- lithium-ion nickel manganese cobalt oxide
- lithium-ion nickel cobalt aluminum oxide
- lithium-ion iron phosphate
- lithium-ion titanate.

For requirements related to conventional battery types, refer to 4-8-3/5.9 of the *Marine Vessel Rules* or 4-3-3/3.7 of the *MOU Rules*.

For requirements related to the use of batteries in underwater vehicles, refer to Subsection 10/11 of the ABS *Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities*.

Battery chemistries and designs are continously evolving. Alternative battery technologies and arrangements may be considered provided it can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety standards of this document and the ABS Rules. Refer to ABS *Rules for Alternative Arrangements, Novel Concepts and New Technologies, Part 1D*.

## 7 Terminology *(1 April 2024)*

*Abnormal Conditions*. Conditions that deviate from the normal operation of the battery system and that can lead to safety hazard such as gas release

*Battery Management System*. Electronic system associated with a battery module/pack that has functions to cut off in case of overcharge, overcurrent, over-discharge, and overheating. It monitors and/or manages the battery's state, calculates secondary data, reports that data, and/or controls its environment to influence the battery’s safety, performance, and/or service life. [*IEC 62619*]

*Battery Cell*. The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, and terminals that creates electrical energy by insertion/extraction reactions of lithium ions or oxidation/reduction reactions of lithium between a negative electrode and a positive electrode. It is ready for use only after it has been fitted with its final housing, terminal arrangement, and electronic control device(s). [*UL 1642*]

*Battery Module*. A group of cells connected together in a series and/or parallel configuration with or without protective devices and monitoring circuitry. [*IEC 62620*]

*Battery Pack*. Energy storage device that is comprised of one or more cells or modules electrically connected. It has a monitoring circuitry that provides information to a battery system. [*IEC 62620*]

*Battery System (Array)*. System comprised of one or more cells, modules, or battery packs. It has a battery management system to cut off in case of overcharge, overcurrent, over-discharge, and overheating.

*Battery Space (Compartment)*. The space in which the battery system is physically located. A typical battery space (compartment) is illustrated in Appendix 1/7 Figures 1 and 2.

*Battery String*. A number of battery cells or modules are connected in series to produce the same voltage level of the battery system.

*Cell Balancing.* The technique of balancing and equalizing the voltages of the battery cells within a battery module to have identical voltages so as to improve the available capacity of a battery pack with multiple cells and increase each cell's longevity. Cell balancing is achieved by means of a balancing circuit, which is usually part of the Battery Management System. Without cell balancing, cells may become under- or overcharged, either of which can lead to a failure of the battery module.

*Control Station.* A location where controllers or actuators are fitted, with monitoring devices, as appropriate, for purposes of effecting desired operation of specific machinery. Refer to 4-1-1/1.9.1 of the *Marine Vessel Rules* and 4-1-1/3.1 of the *MOU* Rules.

*Electrical Load Profile*. The type and demand of electrical load versus time for the intended application.

*Emergency Disconnect System*. A control system used for emergency electrical isolation of battery system.

*Emergency Source of Electrical Power*. A source of electrical power, intended to supply the emergency switchboard in the event of a failure of the supply from the main source of electrical power.

*Emergency Switchboard*. A switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or the transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

*Fixed Containerized Battery.* A battery system integrated into a shipping container or similar sized structure which is permanently affixed to the vessel or offshore unit and only to be replaced or upgraded at the end of life of the battery system.

*Gas Tight Door*. A solid, close-fitting door designed to resist the passage of gas under normal atmospheric conditions.

*Lower Explosive Limit (LEL)*. LEL is to be taken as the same as the Lower Flammable Limit (LFL) and which is 4.0% vol. fraction for hydrogen.

*Main Source of Electrical Power*. A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship/unit in normal operational and habitable conditions.

*Main Switchboard*. A switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ship’s/unit’s services.

*Off-gas*. Toxic and flammable gases released during abnormal conditions and thermal runaway events.

*Portable Containerized Battery.* A battery system integrated into a shipping container or similar sizedstructure which can be removed, swapped, or replaced when required.

*Power Management System (PMS)*. A complete switchboard and generator control system controls power generation and distribution including multiple switchboards and ring bus systems. The PMS on board a vessel is responsible for functions such as load sharing among different power sources, load shedding when generated power is insufficient, etc.

*Primary Cell/Battery*. A cell or battery that can only be discharged once. It is not designed to be rechargeable and is usually protected from a charging current.

*Rated Capacity*. The capacity value of a cell or battery under specified conditions, determined and declared by the manufacturer. [*IEC 62620*] Capacity is usually measured in Ampere-hours (Ah).

*Safety System*. A system comprising several components that work together to prevent damage to the battery and immediate surroundings. The components that make up the safety system for the battery system and space are Battery Management System (BMS), Thermal Management System (TMS), Electrical Protection System (EPS), Gas Detection System, Fire Detection and Suppression System, Ventilation System, Environmental Control System and Emergency Disconnect System.

*Secondary Cell/Battery*. A cell or battery that is intended to be subjected to numerous charge and discharge cycles in accordance with manufacturer's recommendations.

*SOLAS Vessels*. Vessels that are required to comply with the International Convention for the Safety of Life at Sea (SOLAS) regulations

*State of Charge (SOC)*. Available capacity in a battery expressed as a percentage of rated capacity. [*IEC 62660-1*]

*State of Health (SOH)*. An indication of the general condition of a battery compared to its ideal conditions (i.e., a new battery). The unit of SOH are percent points (100% = the battery's conditions match the battery's specifications).

*Thermal Runaway*. A condition where the rate of heat generation within a battery component exceeds its heat dissipation capacity. Thermal runaway can have many causes, such as overcharging, and high ambient operating temperatures, and can lead to a catastrophic failure of the battery cell, including fire and explosion.

*Transitional Source of Emergency Electrical Power*: A battery suitably located for use in an emergency which can operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and so arranged as to supply power automatically for a specified period of time in the event of failure of either the main or emergency source of electrical power.

## 9 Data and Plans to be Submitted *(1 April 2024)*

### 9.1 General *(2022)*

The following plans, data, and specifications covering the battery system are to be submitted for review as applicable. These submittal items are in addition to those provided in each section.

The following symbols are used in this section for the type of review of the documents:

- R: Documents to be reviewed
- I: Documentation for information and verification for consistency with related review

- OB: Documentation required to be kept onboard

*i)* Test reports, in accordance with 4-9-9/15.7 Tables 1 and 2 of the *Marine Vessel Rules* and Subsection 3/2 of this document **(R)**

*ii)* Battery Management System (BMS) functional description, power supply arrangement, list of controlled and monitored parameters, and test reports, as per Subsection 2/5 **(R)**

*iii)* Battery system technical specifications such as nominal voltage and operational limits (e.g., voltage, current, and temperature), safety devices such as Positive Thermal Coefficient (PTC) switch. Current Interrupt Device (CID), cell/module batteries configuration, battery chemistry (Refer to 1/5 for the chemistries within the scope of this document), method of activation and de-energizing, discharge and recharge rates for the batteries **(R)**

*iv)* Cell and module thermal runaway isolation analysis, off-gas analysis, and cell module pressure relief venting system **(R)**

*v)* Battery cooling system **(R)**

*vi)* Battery System sizing, capacity calculation, and electrical load profiles for intended application **(R)**

*vii)* Battery System electrical schematic drawing (block diagram with system interface including switchgear and control gear) **(R)**

*viii)* Material specifications and design for exhaust duct vent system, piping, valves, and associated components related to the integrated off gas vent, if applicable **(R)**

*ix)* Material specifications and design for piping, valves of the draining system and the cooling system, if applicable **(R)**

*x)* Emergency disconnect system (EDS) arrangement **(R)**

*xi)* Battery system location and arrangement plan

  *i)* Details of the off-gas vent system indicating the vent duct sizes and height of the openings above the main deck **(R)**

  *ii)* Arrangement and location of the permanently installed gas detector system for battery space and specifications of gas detectors, including alarm devices **(R)**

  *iii)* Details of the safety valves of the draining system and the cooling system and relevant calculations of their relieving capacity **(R)**

*xii)* Battery system Risk Analysis document (e.g. HAZID, Failure Modes and Effects Analysis (FMEA)) and the associated commissioning/sea-trial functional safety testing {Periodic Safety Test Procedures (PSTP)} **(R)**

*xiii)* Battery system installation and sea-trial/commissioning procedures **(I)**

*xiv)* Off-gas Vent arrangement of battery space including fire dampers, emergency disconnect system (EDS) from outside space and integrated off-gas vent system, if applicable **(R)**

*xv)* Environmental control arrangement (temperature sensors, filter, and air conditioning unit) **(I)**

*xvi)* Plans, calculations and data for heat exchangers and heaters, if applicable **(R)**

*xvii)* Fixed fire extinguishing system (FFES) arrangements, details, and validation of suitability for the battery chemistry involved **(R)**

*xviii)* Active fire extinguishing system integrated into the battery system, if applicable **(R)**

*xix)* Smoke, heat detection and fire detection and alarm system arrangement **(R)**

*xx)* Detailed stage by stage Fire Fighting Procedure **(R, OB)**

*xxi)* Concept of Operations CONOPS **(R, OB)** *xxii)* Battery installation/mounting arrangement and associated drawings and calculation. This is to include battery weights, weight of the battery cabinets and connection details between battery cabinets and deck and/or bulkhead structure **(R)**

*xxiii)* List/booklet of intended electrical equipment in the indicated hazardous areas including a description of the equipment, applicable degree of protection, and ratings **(R)**

*xxiv)* Operations and Maintenance manual for battery system and BMS including battery system maintenance Schedule. Refer to 1/9.2 **(I, OB)**

*xxv)* Structural fire protection details, joiner work details, and insulation arrangements, approved structural fire protection materials and equipment **(R)**

*xxvi)* Details of containerized battery system including general arrangement and supporting calculation as per Appendix 3 for the design, installation, and handling of the system, if applicable **(R)**

## 9.2 Opertation and Maintenance Manuals (I, OB)

The Battery System Operations and Maintenance manual is to be submitted and is to address normal and emergency operating procedures and maintenance procedures for the use of the battery system.

Recommendations on maintenance/servicing records are to be part of the maintenance manual.

Where methods for the verification of proper operation are provided (for example, SOH of battery system and software testing programs), the use of such methods are to be detailed.

The manual is to contain clearly defined, legible and complete instructions for the following, at a minimum:

*i)* Instructions for disconnection, de-energizing and firefighting of the battery system depicting illustrations and locations of all relevant components.

*ii)* The maintenance procedure for the calibration of the BMS.

*iii)* Procedure for checking the SOH of the battery system as per 4/3.9.

*iv)* Specifications for the frequency of air filter change or cleaning and the dimensional size and type of filter for replacements. These instructions are to provide directions for removal and replacement of filters and pictorially illustrate and denote all components supplied by the manufacturer referred to in the instructions for removal and replacement of filters.

*v)* Instructions for examining the battery system installation to confirm

- Any intake or exhaust openings are clear and free of obstructions.
- There are no obvious signs of physical deterioration of the battery system or its support (i.e., casing, frame, or rack).

*vi)* Periodic examination of the vent system, gas detection system, fire dampers, and related functional parts.

*vii)* Calibration of gas detectors .

The procedures and information are to include maintenance of electrical equipment installed in explosive hazardous areas. The inspection and maintenance of electrical installations in explosive hazardous spaces are to be performed in accordance with a recognized standard.

The inspection and maintenance covered by this document is to be carried out only by trained or experienced personnel. Documentation verifying compliance with this requirement are to be made available to the Surveyor upon request.

A Battery System maintenance schedule is to be provided for review and maintained on board. Refer to 4-8-4/5.1.5 of the *Marine Vessel Rules* or 4-3-3/3.7.5 of the *MOU Rules* for requirements related to the maintenance schedule.

### 9.3 Test Plans

#### 9.3.1 Commisioning Test Plan (R)

A Test Plan is to be submitted to ABS at the start of the plan review process. The test plan is to identify all equipment and systems, listing performance tests or trials. Additionally, the control, monitoring and safety system are to be tested and verified according to Section 3, Table 1, as applicable.

#### 9.3.2 Inspection/Survey Plan (R, OB)

An inspection/survey plan for the battery system is to be submitted for review and is to be approved by ABS. The inspection/survey plan is to identify components/systems to be examined and/or validated during surveys throughout the battery system's life and, in particular, any necessary in-service inspections, maintenance and testing that was considered when selecting the battery chemistry system design parameters.

## 11 Abbreviations and Acronyms *(1 April 2024)*

The following abbreviations and acronyms are applied to the terms used in this document:

*ABS: American Bureau of Shipping*

*BMS*: Battery Management System

*CID*: Current Interrupt Device

*CONOPS*: Concept of Operations

*DPS*: Dynamic Positioning System

*EDS :* Emergency Disconnect System

*EPS*: Electrical Protection System

*FMEA:* Failure Modes and Effects Analysis

*FFES*: Fixed Fire Extinguishing System

*IEC*: International Electrotechnical Commission

*MOU: ABS Rules for Building and Classing Mobile Offshore Units*

*MVR: ABS Rules for Building and Classing Marine Vessels*

*NAVSEA*: Naval Sea Systems Command

*PMS*: Power Management System

*PSTP*: Periodic Safety Test Procedure

*PTC:* Positive Thermal Coefficient

*SOC*: State of Charge

*SOH*: State of Health

*SOLAS*: Safety of Life at Sea

*UL*: Underwriters Laboratories

# 13 References

## 13.1 ABS *(1 April 2024)*

ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*

ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*

ABS *Rules for Building and Classing Facilities on Offshore Installation (Facilities Rules)*

ABS *Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities*

ABS *Guide for Dynamic Positioning Systems*

ABS *Guidance Notes on Alternative Design and Arrangements for Fire Safety*

ABS *Guidance Notes on Risk Assessment Application for the Marine and Offshore Industries*

ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification*

ABS *Advisory on Hybrid Electric Power Systems*

ABS *Requirements for Hybrid and All-Electric Power Systems for Marine and Offshore Applications*

ABS *Rules for Certification of Cargo Containers*

ABS *Guide for Certification of Offshore Containers*

## 13.3 IEC References *(1 April 2024)*

IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 62619: *Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Secondary Lithium Cells and Batteries, For Use in Industrial Applications*

IEC 62620: *Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Secondary Lithium Cells and Batteries for Use in Industrial Applications*

IEC 62660 Series: *Secondary lithium-ion cells for the propulsion of electric road vehicles*

IEC 62281: *Safety of primary and secondary lithium cells and batteries during transport*

IEC 60529: *Specification for classification of degrees of protection provided by enclosures*

IEC 61508: *Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements*

IEC 60092-101*: Electrical installations in ships-Definitions and general requirements*

IEC 60695-11-10: *Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods*

IEC 60695-11-20: *Fire hazard testing - Part 11-20: Test flames - 500 W flame test method*

## 13.5 Other References *(1 April 2024)*

UL 1642: *Standard for Safety of Lithium Batteries*

UL 1973: *Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail*

UL 9540A: *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage*

UL 2054: *Standard for Household and Commercial Batteries*

UL 94: *Test for Flammability of Plastic Materials for Parts in Devices and Appliances*

NAVSEA TM-S9310-AW-SAF-010: *US Navy Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures*

NAVSEA SG270-BV-SAF-010: *High-Energy Storage System Safety Manual*

SOLAS: *International Convention for the Safety of Life at Sea*

IMO: *International Maritime Dangerous Goods (IMDG), Dangerous Goods List, Substance Details – UN 3481, Lithium Ion Batteries Contained in Equipment (including lithium ion polymer batteries), 1/2/2013*

*USCG 46 CFR Subchapter J, Electrical Engineering*

ASTM F3353-19: *Standard Guide for Shipboard Use of Lithium-ion (Li-ion) Batteries*

IMO MODU Code: *Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009*

ISO 3864-2: International Organization for Standardization ISO Safety Colors and Safety Signs Part 2: Design principles for product safety labels

ISO 668: Series 1 freight containers Classification, dimensions and ratings

MGN 550 (M+F) Electrical Installations: *Guidance for Safe Design, Installation and Operation of Lithium-ion Batteries*

## 13.7 Alternative Standards *(1 April 2024)*

Battery systems for which there are specific requirements in this document, may comply with the requirements of an alternative standard, in lieu of the requirements in this document, if the standard is determined by ABS as being not less effective than the requirements provided in this document. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative standard to meet the intent of this document. In all cases, the battery system is subject to design review, survey during construction, tests, and trials, as applicable, by ABS for purposes of verification of its compliance with the alternative standard.

SECTION **2**

**Battery System Design and Construction**

# 1 Battery System Design and Construction *(1 April 2024)*

The provisions of this Section apply to vessel battery energy storage systems. These systems are intended to complement the electric propulsion, the main electrical power sources, and the emergency power sources.

The provisions of this Section address battery systems fulfilling functions such as:

- Operation of all-electric vessels (defined by ABS *Requirement for Hybrid and All-Electric Power Systems for Marine and Offshore Applications*) for which the battery energy storage system is the source of power
- Hybrid powering (peak shaving, backup/reserve, loads optimization) for which the battery system is an energy source
- Emergency and transitional powering (for example, primary and secondary essential services, as well as habitability services as per 4-8-1/7.3.3 of the *Marine Vessel Rules*)
- Electrical services and other ancillary services for non-essential services

Battery systems having a rated energy of less than 20 kWh are to be provided with arrangements for appropriate fire detection and suppression. Additional requirements found in 2/2.3, 2/2.5, 2/3 and 2/5 are to be complied with for these systems, as applicable.

## 1.1 Objective

The goals and functional requirements for this section are covered in Subsection 1/2.

## 1.2 Certification Details

**TABLE 1**
**Certification Details – Battery System Components**

| *Battery System Components* | *ABS Type Approval Tier* | *Requirements Reference* |
|---|---|---|
| 1. Cells and Modules | 4/5 | 2/2.3, 3/2 |
| 2. Pipe, Valves and Fitting | See 4-1-1/Table 6 MVR,<br>6-1-7/Table 1 MOU | 4-6-1 MVR*, 4-1-1/Table 6 MVR<br>4-2-2 MOU**, 6-1-7/Table 1 MOU<br>2/2.4 |
| 3. Cooling System | 4/5 | 2/2.4 |

| *Battery System Components* | *ABS Type Approval Tier* | *Requirements Reference* |
|---|---|---|
| 4. Electrical Equipment | See 4-1-1/Table 3 MVR, 6-1-7/Table 1 MOU | 4-8-3 MVR, 4-1-1/Table 3 MVR as applicable<br>4-3-2 MOU, 6-1-7/Table 1 MOU as applicable<br>2/2.10,2/2.11 |
| 5. Battery Chargers | 4/5 | 2/3, 3/2 |
| 6. Battery Management Systems | 4/5 | 2/5, 3/2 |
| 7. Battery Control and Monitoring System | 4/5 | 2/2.13, 3.2 |

***Note:***

* MVR: ABS Rules for Building and Classing Marine Vessels

** MOU: ABS Rules for Building and Classing Mobile Offshore Units

### 1.3 Environmental Conditions

The battery systems are to be suitable for proper operations under the inclination and environmental conditions as shown in 4-1-1/Table 7 and 4-1-1/Table 8 of the *Marine Vessel Rules*, 4-1-1/7 Tables 1 and 2 of the *MOU Rules* and the IEC 60092-101.

The requirements of Sections 4-9-1 and 4-9-2, as appropriate, of the *Marine Vessel Rules*, are also applicable to all vessels with equipment for control, monitoring and safety systems associated with the battery systems. For vessels requesting special notations (such as **ACC**, **ACCU**, and **ABCU** in *Marine Vessel Rules*), the equipment is to be designed to withstand the test conditions stipulated in 4-9-9/Table 1 of the *Marine Vessel Rules*, as applicable.

## 2 Battery System Design

### 2.1 General *(1 April 2024)*

*i)* The battery system enclosures installed in a battery space are to have a degree of protection not lower than IP44. For battery system enclosures installed on an open deck an IP67 rating is required.

*ii)* Accessible parts of the battery system are to have no sharp edges, sharp angles or rough surfaces likely to cause injury.

*iii)* The exposed parts of battery system are to be designed and constructed to prevent slipping, tripping, or falling hazards.

*iv)* The battery systems are to be designed, constructed and/or equipped to mitigate risks due to the release of gases, liquids, combustion products or vapors during abnormal conditions, electrical shock or maintenance. Refer to requirements in 2/2.2 to 2/2.16 and 3/5 and 3/7.

*v)* The battery system and components are to be designed and constructed with sufficient stability that under operating conditions, they are not at risk of overturning or tipping. Refer to the requirement 2/1.3. Appropriate means of anchorage are to be incorporated and indicated in the installation manual. Refer also to 3/7.1

*vi)* All parts are to be securely mounted or attached and rigidly supported.

*vii)* The battery system is to be fitted with an emergency disconnect mechanism adjacent to, but outside of the battery space. If the battery system is used to provide power for propulsion of the asset, there should be an additional emergency disconnect arrangement on the navigation bridge and the centralized control station (CCS) or enclosed operating station (EOS). All emergency disconnect circuits are to be hardwired and independent of any control, monitoring, and alarm system circuits.

*viii)* If the battery system is to be used as part of the emergency source of electrical power, it is not to be installed in the same space as the emergency switchboard. If the battery bank is used in conjunction with an emergency power source (e.g., emergency diesel generator), it should not be located in same space as the emergency power source. Both spaces are to be readily accessible and as near as practical.

*ix)* All outgoing circuits of the battery system are to be protected against overload and short-circuit, excluding the emergency batteries used for engine starting.

## 2.2 Materials *(1 April 2024)*

*i)* Materials in general are to comply with the requirements of the ABS *Rules for Materials and Welding (Part 2).*

*ii)* The exposed battery casing (for cells and modules) is to be constructed of durable, non-combustible, moisture resistant materials, which are not subject to deterioration in the marine environment.

*iii)* The materials used within the battery space such as the battery casing, rack or frame and piping system are to be suitable for the intended application.

*iv)* The use of combustible materials inside the battery space is to be minimized. However, the use of combustible materials may be acceptable for sealing purposes subject to ABS review and approval.

*v)* The battery system and associated cables as applicable are to be made of a flame-retardant material and tested in accordance with 4-8-4A1/7 of the *Marine Vessel Rules* or IEC Publications 60092-101. Other recognized standards such as IEC 60695-11-10/20 and UL93 may be accepted. Refer to the requirements for type test in 4-9-9/15.7 Table 1 of the *Marine Vessel Rules*.

## 2.3 Battery Cell and Module *(1 April 2024)*

*i)* The battery cell and module are to be designed, type tested, and/or routine tested, and certified by a competent independent testing laboratory for compliance with IEC 62619 and 62620 or other recognized standards accepted by ABS. Refer to 3/2 Table 1. In addition, the module is to comply with appropriate requirements for installation in marine environment as documented in 2/1.3.

*ii)* Battery cells of different physical characteristics, chemistries, and electrical parameters are not to be used in the same electrical circuit.

*iii)* Cell swelling within a module is not to result in insulation breakdown or any other hazard.

*iv)* The casing of a cell, module, battery pack, and battery systems are to be provided with a pressure-relief mechanism/arrangement to prevent rupture or explosion. The individual modules are also to have arrangements to prevent release of electrolyte.

*v)* As applicable, battery and/or module terminals are to be easily accessible, clearly marked and protected against mechanical damage and accidental contact for earthing, short-circuit.

*vi)* The module design is to prevent propagation of a thermal runaway from one cell to another cell. Alternatively, as a minimum, the system is to be designed such that a thermal runaway in one cell can spread within that module but will not propagate to another module. The type and level of insulation in the module to prevent thermal runway propagation is to be based on the heat released per cell and the total number of cells per module and is to be verified through type test as per 3/2 Table1. The manufacturer's simulation model may be used where it has been validated through a previous type test on similar model.

*vii)* The battery modules are to be equipped with an independent overcurrent protection other than the BMS and the switchgear. The requirement for independent overcurrent protection is not applicable for battery systems with cells provided with Current Interrupt Devices (CID) or similar safety devices.

### 2.4 Piping Systems *(1 April 2024)*

*i)* Piping systems, cooling systems and auxiliaries are to be designed, constructed, installed, inspected, tested and surveyed in accordance with the requirements for piping systems provided in Chapters 3 and 4 of the ABS *Rules for Materials and Welding (Part 2),* Part 4, Chapter 6 of the *Marine Vessel Rules* and the ABS *Rules for Survey After Construction (Part 7),* except as modified below.

*ii)* The minimum thickness of pipes and tubes is to comply with Part 4, Chapter 6 of the *Marine Vessel Rules* or recognized standard.

*iii)* For pipes made of materials other than steel, the allowable stress will be specially considered by ABS provided that a recognized standard has been used.

*iv)* Pipes other than those serving the battery system are not to pass through or enter the battery space. Exception to this requirement for existing vessels or retrofit installations may be considered on a case-by-case basis

*v)* The drainage system is to have a capacity at least equal to that of the water-based fire extinguishing system. Where the water is discharged by means of a pump operating directly from a bilge well or dedicated tank, the capacity of the bilge pump is to be at least 125% of the combined capacity of the water-spraying system pumps.

*vi)* Battery systems arranged with liquid cooling systems for cooling of the battery cells and/or modules are to comply with the following requirements:

- Where water cooling is used, the cooling system is to be arranged to avoid water ingress into the battery cell or module due to internal or external leakage from the cooling system.
- For liquid cooled battery systems, the cooling system piping is to be hydrostatically tested to 1.5 times the design pressure for a period of 30 minutes after fabrication.
- After installation, the cooling system is to be subjected to a tightness test at the design pressure. No leakage will be allowed.
- The closed-loop cooling system is to be equipped with an appropriate tank featuring high and low liquid detection. Additionally, an alarm is to be provided to monitor the tank's liquid level.
- The liquid cooling system is to be protected by over pressure protection.
- The battery system is to be arranged with cooling fluid leakage detection. Any detection of cooling fluid leakage is to result in an alarm with closing of the cooling supply.
- Cooling pipes are to be arranged to minimize the number of joints.
- An appropriate detection system is to be provided to continuously monitor the operation of the liquid cooling system and alarm in case of a coolant leak.

### 2.5 Enviornmental Control System *(1 April 2024)*

*i)* The battery space is to be arranged to meet the environmental conditions as specified by the manufacturer of the battery system with respect to ambient temperature and humidity. Also, refer to 4-8-3/1.17 of the *Marine Vessel Rules* and 4-3-1/17 of the *MOU Rules*.

*ii)* A filter is to be provided to limit the ingress of dust, water, and salt mist into the battery space. The maintenance manual is to include clearly defined instructions for the frequency of filter changes or cleaning and the dimensional size and type of filter for replacements. These instructions are to provide directions for the removal and replacement of filters and pictorially illustrate and denote all components supplied by the manufacturer referred to in the instructions for removal and replacement of filters. Refer to 1/9.2.

*iii)* The environmental control system is to be monitored and an alarm to the manned station is to be provided in case of failure of this system.

## 2.6 Heat Exchangers and Heaters *(1 April 2024)*

*i)* Plans, calculations and data for all heat exchangers and heaters are to be submitted for review and approval applicable to pressure vessels per Section 4-4-1 of the *Marine Vessel Rules* or recognized international standards. They are to be constructed, installed, inspected and tested to the satisfaction of the attending Surveyor in accordance with approved plans.

*ii)* The heater and cooling systems are to maintain the temperature of the battery system and other equipment installed within the battery space for which they were designed to operate.

## 2.7 Off-gas Vent System *(1 April 2024)*

### 2.7.1 Off-gas Vent System of the Battery Space

The off-gas vent system serving the battery space is to comply with the following requirements:

*i)* An effective vent system is to be provided for air circulation in the interior of the battery space. The mechanical exhaust vent system is to comprise at least two ventilation fans with 100% capacity each. Both fans are to be supplied from separate circuits and power sources.

*ii)* The required capacity of the vent plant is normally based on the gross volume of the room. The ventilation system is to be capable of providing at least six (6) air changes per hour. An increase in the required ventilation capacity may be necessary for rooms having a complex form such as L-shaped form supported by engineering calculations or analysis (for example: computational fluid dynamics CFD analysis).

*iii)* The design of the mechanical exhaust vent is to be determined by analysis considering the number of cells/modules releasing off-gas during thermal runaway in a battery system. This analysis is to be submitted for review and approval. Where exhaust systems are equipped with thermal runaway insulation for individual cells, the reduction of the exhaust vent capacity and scantling may be accepted as determined by the risk assessment.

*iv)* The design of vent fans serving the battery space during abnormal conditions is to be of the non-sparking type, and comply with 4-8-3/11 of the *Marine Vessel Rules*.

*v)* If the fan motor is installed inside the duct, it is to be suitable for zone 2 with minimum temperature class T2 and gas group IIC.

*vi)* Venting of the battery space is to be automatically activated upon:

*i)* gas detection in the battery space. See 2/2.9.

*ii)* high cell temperature detection (maximum setpoint controlled by the BMS). See 2/5

*vii)* Vent ducts and openings are to be arranged so that water ingress does not reach the battery system. When conducting the risk assessment, it is important to consider the possibility of a leak or condensation in the vent duct and its impact on the battery system.

*viii)* The outside vent openings are to be arranged to prevent rain/sea water from entering and at a height sufficient to comply with the International Load Line Convention without arranging any closing appliances.

*ix)* The vent duct(s) are to be of fully welded construction and duct materials are to be compatible with the gases produced in abnormal and thermal runaway conditions. Ducts serving battery spaces should not pass through accommodation spaces, service spaces, or control spaces.

*x)* The vent ducts are to be gastight and able to withstand the off-gas temperature and pressure build up associated with abnormal and thermal runaway conditions.

*xi)* The ventilation is to function at all temperatures and environmental conditions the vessel is expected to be operating in.

*xii)* Vent inlets for the battery space are to be taken from areas which, in the absence of the considered inlet, would be deemed non-hazardous. Vent inlets are to be taken from non-hazardous areas at least 1.5 meters away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct is to be gastight and have over-pressure relative to this space.

*xiii)* Protection screens of not more than 13 mm (0.5 in.) square mesh are to be fitted in the inlet and outlet of ventilation openings on the open deck to prevent the entrance of foreign objects into the fan casing.

*xiv)* Vent outlets are to be fitted with corrosion resistant flame-screens.

*xv)* Vent outlets are to vent to the open deck or semi- enclosed spaces on deck at least 1.5 meters away from passenger spaces, egress routes, muster stations, air intakes, or ignition sources.

*xvi)* Manual control of the vent system is to be arranged outside the battery space at a manned control station and locally at the entrance to the battery space.

*xvii)* Venting is to be such that with the battery room door open, air flow is from the other space into the Battery space. Loss of differential pressure is to be alarmed at a normally manned location.

#### 2.7.2 Off-gas Vent System Integrated to the Battery Space

For battery system with integrated off-gas vent ducts, the integrated vent system is to comply with the requirements of 2/2.7.1 iii to 2/2.7.1 xv and connected to an independent outlet vent duct directly to open air. This integrated outlet duct is to be arranged in addition to the battery space outlet duct.

### 2.8 Fire Dampers *(1 April 2024)*

*i)* Battery space vent inlet and outlet openings are to be provided with fail-safe automatic closing fire dampers which are to be operable from outside the battery space. All fire dampers are to be capable of manual operation.

*ii)* Before actuation of the gas-based fire-extinguishing system, if applicable, the fire dampers are to be closed.

*iii)* Installation of fire dampers is to be such that there is unobstructed access to the dampers for operation, maintenance, and inspection. Arrangements are to be provided to indicate whether the damper is open or closed. Where a fire damper is located within a ventilation coaming, such arrangements may include provision of an inspection port or opening at least 150 mm (6 in.) in diameter on the coaming to facilitate survey of the damper without disassembling the coaming or the ventilator. The closure provided for the inspection port or opening is to maintain the watertight integrity of the coaming and, if appropriate, the fire integrity of the coaming.

### 2.9 Gas Detection System *(1 April 2024)*

*i)* Gas detection required by this Section is to be continuous and without delay.

*ii)* The gas detection system is to have power supply from two separate supply circuits, one from the main source of power and one from the emergency source of power. An automatic changeover is to be arranged for the two supply circuits.

*iii)* At least two gas detectors are to be fitted in the battery space. The number of detectors in the battery space are to take into account the size, layout and ventilation of the space. The detection equipment is to be located where gas may accumulate and/or in the ventilation outlets based on the risk assessment. Gas dispersal analysis or a physical smoke test is to be used to identify the optimal arrangement.

*iv)* An audible and visible alarm is to be activated at a gas concentration of 30% of the lower explosion limit (LEL). The automated battery safety system is to be activated including the activation of battery space vent system and the emergency disconnect system at 30% of LEL of two detectors.

*v)* The integrated vent duct is to be fitted with gas detector. The integrated exhaust vent is to be automatically activated upon gas detection in the integrated ventilation duct at 20% of LEL. An alarm is to be activated.

*vi)* Failure of the power supply for the gas detection system is to initiate an alarm at the manned control station.

*vii)* The gas detection system is to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating gas, so that the alarms are heard and observed at the following locations as fitted:

- Navigating Bridge
- Central control station
- Fire control station
- Battery space

*viii)* In case of gas detection in the battery space or the integrated exhaust vent system, the safety system is to carry out an automatic disconnect and isolation of the battery system or the affected section of the battery system if detectable.

## 2.10 Electrical System *(1 April 2024)*

*i)* The electrical requirements in this Section supplement the requirements of Part D of SOLAS Chapter II-1 and Part 4, Chapter 8 of the *Marine Vessel Rules*. Where electrical equipment is installed in hazardous areas it is to be selected, installed and maintained in accordance with a standard acceptable to ABS (e.g., IEC 60079 series and IEC 60092-502, as applicable). Refer to 4-8-1/5.3.2(b) of the *Marine Vessel Rules* for the hazardous area equipment booklet.

*ii)* Means are to be provided to protect the battery system against short circuits and flow of reverse current.

*iii)* Means are to be provided to protect against overload, earth-fault and overvoltage conditions and other hazards to prevent damage to equipment and maintain continuity of power supply to remaining circuits.

*iv)* Switchgear providing means for safe isolation of the battery system is to be arranged. The switchgear is to disconnect both poles in order to completely isolate the battery system. This isolation mechanism is to be independent of the emergency disconnect arrangement.

*v)* Selective tripping of downstream circuit breakers and fuses is to be based on the short circuit current of the battery system according to the manufacturer's specification.

## 2.11 Transformers and Converters *(1 April 2024)*

*i)* Transformers are to be designed, constructed, and tested in accordance with 4-8-2/3.7, 4-8-3/7 and 4-8-5/3.3.3, 4-8-5/3.5 of the *Marine Vessel Rules* as applicable.

*ii)* Power Electronic Converters (PEC) are to be designed, constructed, and tested in accordance with 4-8-2/3.7, 4-8-3/5.9, 4-8-3/8 and 4-8-5/3.7.5 of the *Marine Vessel Rules* as applicable.

## 2.12 Emergency Disconnect System *(1 April 2024)*

*i)* The vessel is to be fitted with an Emergency Disconnect System (EDS) operable from both the manned control station and outside of the battery space. Refer to 2/2.1 vii. This is to allow a rapid and safe isolation of the battery system . Refer to 2/1.3 and 4-8-3/8.5.9 of the *Marine Vessel Rules*.

*ii)* A method to initiate an emergency disconnection is to be a separate control from the BMS (see 2/5), and have an independent means of actuation, (e.g. an emergency stop (E-stop) switch).

*iii)* The emergency stop is to have fail-to-safe functionality upon wire break or loss of power.

*iv)* Alarm in case of power loss is to be provided for normally de-energized emergency stop circuits.

## 2.13 Control, Monitoring, Alarm and Safety Systems *(1 April 2024)*

*i)* Control, monitoring, and safety systems are to have self-check facilities. In the event of failure to the systems or power supply, an alarm is to be activated. See Section 2, Table 1 for list of battery system monitoring requirements.

*ii)* In the event of failure to the safety system, any of its components or power supply, an alarm is to be activated.

*iii)* The safety system is to be designed so as to limit the consequence of failures. It is to be constructed on the fail-safe principle.

*iv)* Sensors for safety functions are to be independent from sensors used for other purposes (e.g., for alarm system).

*v)* The sensors are to be designed to withstand the local environment. The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located. Any malfunctioning in the sensors is to be detectable. See 2/7.8, Table 1 for list of battery system monitoring requirements.

*vi)* Loss of the required ventilation/exhaust ventilation (see requirements for vent system, 2/1.9) is to give an audible and visual alarm on the navigation bridge, in a manned central control station or fire control station, as well as locally.

*vii)* The following is to be monitored and give an alarm in case of abnormal conditions at a manned control station:

- ambient temperature in battery space
- indication of vent system running in the battery space
- indication of vent system running for the integrated off-gas vent duct as applicable

*viii)* A continuous insulation (earth fault) monitoring on both poles of the battery system is to be located inside the battery system on the battery side of any switchgear. The insulation monitoring is to remain in operation when the battery system is not connected. An alarm is to be provided in the event of detecting an earth fault at a manned control station.

*ix)* State of Charge (SOC) and State of Health (SOH) are to be monitored and available for the operator and visible at the manned control station.

### TABLE 2
### Monitoring of the Battery System *(1 April 2024)*

| *Parameter* | *Alarm and Display* | *Automatic Disconnect of the Battery System* | *Comments* |
|---|---|---|---|
| Failure of the cooling system | X | | See 2/2.4 |
| Liquid leak detection in cooling system | X | | See 2/2.4 |
| Low- and high-level cooling water tank | X | | See 2/2.4 |
| Failure of the environmental control system | X | | See 2/2.5 |
| High ambient temperature in the battery space | X | | See 2/2.13 and 3/3 |
| Failure of power supply | X | | See 2/2.12, 2/2.13, 2/5 |
| Failure of the safety system or its components | X | | See 2/2.13 |

| *Parameter* | *Alarm and Display* | *Automatic Disconnect of the Battery System* | *Comments* |
|---|---|---|---|
| Failure of the battery charger | X | | See 2/3 |
| Abnormal conditions provided by the BMS | X | X | See 2/5 |
| Gas detection 30% of LEL in the battery space | X | X | See 2/1.9 |
| Gas detection in the integrated vent duct 20% LEL | X | X | See 2/1.9 |
| Electrical insulation | X | | See 2/2.10 and 2/2.13 |
| Loss of vent in the battery space | X | | See 2/2.13 |
| Loss of integrated vent system | X | | See 2/2.13 |
| Open gas-tight door of the battery space | X | | See 3/3 |
| Fire detection in the battery space | X | X | See 3/3.1 |
| Heat and smoke detection | X | X | See 3/3.1 |
| Low level of freshwater of the FFES | X | | See 3/3.1 |
| Liquid leak detection in the battery space | X | | See 3/3.3 |
| SOC and SOH of the battery system | X | | See 2/2.13 and 4/3.9 |

## 2.14 Battery System Used as Main Source of Electrical Power *(2022)*

See Section 4 for detailed requirements.

## 2.15 Battery System Used as Emergency Source of Electrical Power *(1 April 2024)*

Batteries may be used as an emergency source of power provided that the following arrangements are met.

***i)*** Installations are to be designed for proper operations under the conditions as per 4-1-1/7.9 and 4-1-1/9 Table 7 of the *Marine Vessel Rules* and 4-1-1/7 Table 1 of the *MOU Rules* as applicable.

***ii)*** Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power.

***iii)*** Immediately supplying at least those services specified in 4-8-2/5.11 i) and ii) of the *Marine Vessel Rules* and 4-3-2/5.7.i) and ii) of the *MOU Rules* as applicable. The required capacity and SOC of this system are to be based on the required power and time for these services. The minimum remaining emergency time is to be documented in the electrical load analysis.

***iv)*** Attention is directed to the requirements of the governmental authority of the country whose flag the vessel flies for the emergency services and the lithium-ion batteries required in various types of vessels.

***v)*** Are to be installed directly adjacent to, but not in the same space as the emergency switchboard

***vi)*** See additional requirements as per 4/3.3, 4/3.7, 4/3.9, 4/3.11, 4/3.13 of this document; and 4-8-2/5 of the *Marine Vessel Rules* and 4-3-2/5 of the *MOU Rules*.

***vii)*** Vent system for the battery space is to be operable upon loss of main source of electrical power

## 2.16 Battery System used as Transitional Source of Electrical Power *(2022)*

Batteries may be used as a transitional source of power provided that the following arrangements are met.

***i)*** Attention is directed to the requirements of the governmental authority of the country whose flag the vessel flies.

*ii)* See additional requirements as per 4/3.3, 4/3.7, 4/3.9, 4/3.11, 4/3.13 of this document; and 4-8-2/5.11 of the *Marine Vessel Rules* and 4-3-2/5.7 of the *MOU Rules*.

## 3 Battery Chargers *(1 April 2024)*

*i)* Battery chargers used for main, emergency, and transitional sources of power are to meet the requirements specified in 4-8-3/5.9 of the *Marine Vessel Rules*, or constructed and tested according to recognized standard as applicable.

*ii)* Battery charger is to be kept away for any heat source or flammable materials and the battery is to be continuously monitored during charging. Refer to 2/5.

*iii)* The battery charger is to operate within the limits (i.e., charging and discharging) set in the BMS as specified by the battery cell manufacturer.

*iv)* The battery charger is to be designed to maintain charging within the voltage, current, and temperature limit for the battery as specified by the battery cell manufacturer.

*v)* The battery charger is to be interfaced with and controlled by the BMS.

*vi)* An alarm is to be provided to indicate a failure of the battery charger.

## 5 Battery Management System (BMS) *(1 April 2024)*

*i)* The battery system is to have a Battery Management System (BMS).

*ii)* The BMS is to be appropriately designed for the associated cells and modules. The BMS is to be designed by the same manufacturer as the batteries or to be certified by both the BMS manufacturer and the battery manufacturer for compatibility.

*iii)* The BMS is to monitor the battery cell voltage, cell temperature, and battery string current.

*iv)* The BMS is to be continuously powered and an alarm is to be given in the event of failure of the normal power supply.

*v)* The following conditions are to be tested as specified in 3/2 and to result in an individual or group audible and visual alarm to be displayed in a continuously manned location:

- Cell overvoltage
- Cell undervoltage
- Cell voltage unbalance
- Cell over-temperature
- Battery module/pack ground fault
- Tripping of mechanism that provides electrical isolation
- Failure of communication with asset's
- Recommendations as specified in the result of the risk assessment

*vi)* The BMS is to comply with the requirements in Section 4-9-3 of the *Marine Vessel Rules*. Appropriate computer-based system category for BMS is to be assigned in accordance with 4-9-3/7 of the *Marine Vessel Rules*. The BMS is to be considered as a computer-based system with system Category II or III. The exact category is dependent on the risk assessment for all operational scenarios (e.g., intended use for battery system, etc.). The relevant software design requirements and ABS Surveyor witness requirements for Category II or III systems are to be complied with.

*vii)* The safety system is to be activated automatically in the event of identified conditions that could lead to damage of the lithium-ion battery system. Activation of any automatic safety actions is to activate an alarm in a continuously manned location.

*viii)* A software-based feature/mechanism is to be installed to prevent the crew from over-riding or ignoring critical BMS system alarms and disconnect. Manual override of safety functions is not permitted.

*ix)* The BMS is to be capable of the following conditions:

- Measuring and communicating battery voltage, battery current, battery internal temperatures, battery balance, ground fault.
- Incoming and Outgoing communications with batteries.
- Calculating and communicating state of charge (SOC), state of health (SOH), and time remaining [1].
- Balancing the batteries as necessary.
- Isolating batteries using contol gear (e.g midpack contactor) in case of damage or incorrect operation.

*Note:*

1 Time remaining can also be calculated and communicated via the Energy Management System (EMS) or Power Management System (PMS). Refer to 4/3.

## 7 Marking and Designation *(2022)*

Marking and designation is to be in accordance with clause 5 of IEC 62620.

SECTION 3
# Battery System Installation

## 1 Objective *(1 April 2024)*

The goals and functional requirements for this section are provided in Subsection 1/2.

## 2 Battery System Testing Requirements *(15 July 2018)*

The Battery System is to undergo Type Test and Routine Tests carried out to the satisfaction of attending ABS Surveyors as per Table 1. Type tests are to be carried out on one prototype while the Routine tests are to be carried out on all battery systems, as per the test procedure in the respective standard/section given.

### TABLE 1
### Summary of Type and Routine Tests *(1 April 2024)*

| *No.* | *Test* | *Type Test* | *Routine Test* | *Reference*(1) |
|---|---|---|---|---|
| | **Cell Tests** | | | |
| 1 | External short-circuit test | x(2) | | IEC 62619 7.2.1 |
| 2 | Impact test | x(2) | | IEC 62619 7.2.2 |
| 3 | Drop test | x(2) | | IEC 62619 7.2.3 |
| 4 | Thermal abuse test | x(2) | | IEC 62619 7.2.4 |
| 5 | Overcharge test | x(2) | | IEC 62619 7.2.5 |
| 6 | Forced discharge test | x(2) | | IEC 62619 7.2.6 |
| 7 | Discharge performance | x(2) | | IEC 62620 6.3 |
| 8 | Charge (capacity) retention and recovery | x(2) | | IEC 62620 6.4 |
| 9 | Cell internal resistance | x(2) | | IEC 62620 6.5 |
| 10 | Endurance in cycle | x(2) | | IEC 62620 6.6 |
| 11 | Internal short-circuit test | x(2) | | IEC 62619 7.3.2 |
| | **Battery System Test**(4) | | | |
| 12 | Ingress Test | x(2) | | IEC 60529 |
| 13 | Flammability Test | x(2) | | IEC 60092-101 |
| 14 | Propagation Test | x | | IEC 62619 7.3.3(3) |
| 15 | Overcharge control of voltage | x | | IEC 62619 8.2.2 |

| No. | Test | Type Test | Routine Test | Reference(1) |
|---|---|---|---|---|
| 16 | Overcharge control of current | x | | IEC 62619 8.2.3 |
| 17 | Overheating control | x | | IEC 62619 8.2.4 |
| 18 | Over discharge Protection | x(2) | | UL 1973 19 |
| 19 | Imbalance Charging | x(2) | | UL 1973 21 |
| 20 | Static Force (Enclosure) | x(2) | | UL 1973 31 |
| 21 | Impact (Enclosure) | x(2) | | UL 1973 32 and 33 |
| 22 | Resistance to Moisture | x(2) | | UL 1973 39 |
| 23 | Salt Fog Exposure | x(2) | | UL 1973 40 |
| 24 | Insulation resistance | | x | MVR 4-8-3/5.11. 2 |
| 25 | Dielectric Strength | | x | MVR 4-8-3/5.11. 3 |
| 26 | Battery system/BMS safety function tests | | x | 2/5 |
| 27 | Type tests for control, monitoring and safety equipment | x | | 4-9-9/15.7 TABLE 1 of the *Marine Vessel Rules* |
| 28 | Unit Certification tests for control, monitoring and safety equipment. | | x | 4-9-9/15.7 TABLE 2 of the *Marine Vessel Rules* |
| 29 | Pressure test of cooling system(5) | x | x | 2/2.4 |

***Notes:***

**1** Battery systems may comply with requirements in an alternative standard provided it has been determined by ABS as being not less effective. Where applicable, requirements may be imposed by ABS in addition to those in the alternative standard so that the intent of the Rules is met.

**2** For type approved products and design approval (e.g., battery cells), the type tests as required in Table 1 above, are not to be repeated on units already tested, approved and certified by a National Recognized Testing Laboratory (NRTL), and test reports verified by ABS; therefore, Surveyor attendance is not required for those "type tests".

**3** The test should be conducted in worst-case location and in worst-case orientation with regard to propagation. The triggering method for thermal runaway is to be by overcharge or heating. Acceptance criteria is defined as only the cell or module which is directly caused to fail by testing show fire or off-gassing and that all other cells in module or other modules show no external signs of thermal runaway and still produce a measurable voltage within normal operating range. For liquid cooled modules the integrity of the liquid cooling system is to be intact.

**4** The static and dynamic inclination tests listed in 4-9-9/15.7 TABLE 1 of the *Marine Vessel Rules* are not required for battery system.

**5** Applicable for battery systems arranged with liquid cooling systems

**6** The required tests per IEC 62619 should be conducted for battery cells that are stored for not more than six months under conditions specified by the battery manufacturer.

## 3 Battery Space *(1 April 2024)*

The battery space is to meet the following requirements:

***i)*** Battery spaces are not to be located forward of the collision bulkhead of the vessel.

***ii)*** Boundaries of the battery space are not to be contiguous to the vessel's side shell and the bottom shell.

*iii)* When the battery space is located below the vessel's damaged waterline, or when it is located below the main deck on ships that are not subject to damage stability requirements, the boundaries of the battery space are to be watertight. A battery space that is not completely watertight may be accepted provided the battery systems have an IPX7 rating.

*iv)* Battery spaces are not to contain any equipment not related to the battery system and its associated safety components including heat sources or high fire risk objects external to that of the battery system.

*v)* Battery spaces are not to contain any equipment (including cables and pipes) supporting essential services as defined in 4-8-1/7.3.3 of the *Marine Vessel Rules* or 4-1-1/3.5 of the *MOU Rules*, so as to prevent loss of such essential services in the event of an incident such as thermal runaway.

***Note:***

This requirement does not apply to cables supplying power to and from the battery system itself.

*vi)* The rated capacity of the battery system is to be determined for the ambient temperature conditions in 4-1-1/9 TABLE 8 of the *Marine Vessel Rules* or 4-1-1/7.7 TABLE 2 of the *MOU Rules*. Where the expected ambient temperatures are different from those in the applicable table, the rating of the battery system is to be based on the actual ambient temperature.

*vii)* The battery system is installed in an environmentally controlled space, the applicable requirements in 4-8-3/1.17.2 of the *Marine Vessel Rules* or 4-3-1/17.3.1 of the *MOU Rules* are to be complied with. Refer to 2/2.5. The failure of the environmentally controlled system is to be alarmed at a manned location.

*viii)* High ambient temperature in the battery space is to be monitored and alarmed at a continuously manned location.

*ix)* The battery space is to be installed with appropriate means to vent gases, which may be generated during an abnormal situation, from the battery space to open deck.

*x)* The battery system location and arrangement plan should clearly show the battery pack with respect to the space it is being installed in as well as the clearance of distances between any other equipment in the room and the battery pack.

*xi)* Battery spaces are to be mechanically ventilated and the vent system is to comply with the requirement given in 2/2.7. The vent ducting for the battery space is to be separate from the HVAC systems used to ventilate other spaces on the vessel.

*xii)* The battery space is to be fitted with flammable and toxic gas detection, appropriate to the battery chemistry being used. Refer to 2/2.9. The gas detection is to give an alarm at a continuously manned location and automatically disconnect the battery system if the concentration of gas in the battery space reaches 30% LEL. Gas detection system is to be interlocked with the battery chargers to prevent battery charging.

*xiii)* In the case where batteries are used as main source of electrical power (i.e., ship service loads) and/or propulsion power, see 3/3.1.5 and 4/3.11 for structural fire protection requirements.

*xiv)* The ventilation duct is to be arranged with means to close the fire damper when the battery space is fitted with a combined fire extinguishing system according to 2/2.8.

*xv)* Access to the space is to be through normally closed gas-tight doors or hatches with alarm at a normally manned location or self-closing gas-tight doors or hatches with no holdback arrangement.

*xvi)* Means to disconnect the battery system in the event of a fire in the lithium-ion battery space are to be provided and located outside of the protected space.

*xvii)* Means of escape from the battery space, are to be in accordance with SOLAS Regulations for machinery spaces.

*xviii)* Warning signs are to be appropriately placed to identify access to the battery space, electrical hazards, and contents from drain valves. Symbols should be standardized and comply with ISO 3864-2.

## 3.1 Fire Safety

### 3.1.1 General *(1 April 2024)*

In general, the battery space is to meet the following requirements:

*i)* The battery space is to be considered a Machinery Space other than category A as defined in SOLAS Regulation II-2 and is subject to additional structural fire protection requirements listed therein. Battery spaces are considered as not normally manned. The fire rated insulation arrangements for the boundaries of the battery space should be designed to contain the fire within the space of origin. The fire loads associated with the Li-ion batteries should not exceed the endurance of the fire rated divisions.

*ii)* The battery space is to be fitted with a Fixed Fire Extinguishing System (FFES) that provides continuous cooling and appropriate to the battery chemistry used. A fixed system is to have provisions (i.e., selection of proper metallic material for nozzles, grounding methods) to prevent a buildup of static electricity at nozzle during release of extinguishing agent. The FFES is to comply with the provisions of Part 4, Chapter 7 of the *Marine Vessel Rules* or Part 5 of the *MOU Rules*, to the extent applicable, and is to adequately consider the potential fire loads involved (e.g., size of the batteries, battery chemistry used, specific materials involved, etc.). Technical validation of the system is to be carried out in accordance with the procedures outlined in the ABS *Guidance Notes on Alternative Design and Arrangements for Fire Safety* and sufficient documentation to verify the same is to be submitted along with arrangements and details of the system for review. Where the FFES requires closing of vent, fire damper, etc., provisions are to be made in the design to ensure that it does not lead to over pressurization or toxic gas buildup in the room as Li-ion battery fire is self-perpetuating.

*iii)* The fixed fire extinguishing system is to be designed to limit the heat dissipated into the load bearing structure during a specific period identified in the risk assessment to control the fire during a thermal runaway event.

*iv)* The following Fixed Fire Extinguishing Systems (FFESs) may be accepted subject to ABS approval:

- Fresh water-based system complying with the provisions of 4-7-3/7 of the *Marine Vessel Rules*. The fresh-water quality and quantity are to be provided based on the manufacturer's recommendation and addressed during the risk assessment. Additionally, an alarm is to be provided when the freshwater tank level is low and next stage of the firefighting procedure is to be initiated. See 3/3.1.1v. The stability of the vessel, when the battery space is completely flooded with water, is subject to intact stability requirements outlined in Part 3 chapter 3 of the *Marine Vessel Rules* and the Part 3 Chapter 3 of the *MOU Rules*.

- A combined system: The battery space is to be protected with both a freshwater based water spray system and a gas-based system complying with the provisions of the requirements of 4-7-3/3.1 and 4-7-3/3.3 or 4-7-3/3.5 of the *Marine Vessel Rules*. The two systems are to be separated, each with its own independent components.

*v)* Gas-based systems are not to be used as the main and only FFES due to their limited cooling capabilities and the risk of toxic gas generation.

*vi)* A non-automatic seawater-based firefighting system is to be installed for the battery space. It is to be used as a last resort system and after deploying all the recommended systems defined in 3/3.1.1 iv, and if the fire mitigation and temperature increase are not successful. The immediate evacuation of vessel is to be initiated.

*vii)* A fire hydrant is to be provided close to and outside the battery space.

*Note:*

It is not recommended to use seawater for extinguishing fires during thermal runaway because of its electrical conductivity. This poses several risks, including electrocution, asset damage, electrolysis, and the release of chlorine gas.

*viii)* In addition to the requirements of 3/3.1.1 iv, the following active fire extinguishing systems or agents to preventing fire spread and thermal runway propagation may be accepted subject to ABS approval:

- Condensed aerosol complying with the provisions of 4-7-3/3.9 of the *Marine Vessel Rules*.
- Foam based extinguishing systems in accordance with 4-7-3/5 of the *Marine Vessel Rules*.

*ix)* Portable fire extinguishers are to be provided as required in 4-7-2/1.7 of the *Marine Vessel Rules* or 5-2-4/1 of the *MOU Rules*. Portable fire extinguishers for the Class fires of the battery system are to be provided based on the battery manufacturer recommendation. The number and sizes of the portable fire extinguishers should be governed by the calculated fire load(s) in the battery space. Specific Personal Protective Equipment (PPE) and Safety equipment is to be included in the operation and maintenance manual.

*x)* Openings and penetrations in the boundaries of the battery space are to maintain the fire, gastight and watertight integrity of the space.

*xi)* Combined smoke and heat detectors or a combination of smoke and heat detectors are to be installed in the battery space and in the integrated vent duct as applicable. The arrangement is to comply with the International Code for Fire Safety Systems (FSS Code).

*xii)* Means are to be provided in the battery space to remove the flammable and toxic gases after incident without causing the risk of ignition. These procedures should be explicitly outlined in the post-incident protocol.

*xiii)* The battery room or space is to be provided with gas-tight door to prevent escape of combustible gasses. The battery room or space is to be provided with a deck drain. Refer 3/3.3 iv.

#### 3.1.2 Battery Space Adjacent to Accommodation Space, Control Station or Service Spaces *(2022)*

Where battery space is located adjacent to accommodation space, control station, or service spaces, the following additional requirement is to be met:

*i)* At a minimum, "A-60" class insulation is to be provided for battery space, subject to the results of the Risk study in Subsection 3/5.

#### 3.1.3 Battery Space Adjacent to or within Machinery Space of Category A *(2022)*

In addition to the requirements in 3/3.1.1, where battery space is located adjacent to or within machinery space of category A, the following additional requirements are to be met:

*i)* A-60 Fire integrity between the battery space and machinery space of category A. The fire rated insulation arrangements for the boundaries of the battery space and the adjacent machinery space(s) should contain the fire(s) within the space of origin. The protection provided by A-60 fire rated insulation should be appropriate for the cumulative fire loads within the battery space and the adjacent machinery space of category A. The fire load(s) associated with the battery room or adjacent the category A machinery space should not exceed the endurance of the A-60 fire rated divisions

*ii)* Ventilation duct(s) from the battery space are to be A-60 insulation.

*iii)* At least two separate escape routes are to be provided, situated as far apart as practicable, to allow ready means of escape to the open decks and/or embarkation stations. Exceptionally, one means of escape may be considered, taking into account the nature and location of the space.

### 3.1.4 Battery Space for Battery Systems Used as Emergency Source of Power *(1 April 2024)*

Where battery system is used as emergency source of power, the following additional requirement is to be met:

*i)* With regard to structural fire protection, the battery space is considered Machinery Space Category A (as defined in SOLAS Regulation II-2) and is subject to the structural fire protection requirements listed therein.

*ii)* At a minimum, "A-60" class insulation is to be provided for the battery space. However, the level of fire protection and blast resistance of the bulkheads and decks are to be properly considered through fire and explosion analysis.

***Note:***

Fire and explosion analysis may be required if it is determined by the required Risk Assessment in Subsection 3/5 of this document.

### 3.1.5 Battery Space Adjacent to Fuel Tanks or Spaces *(1 April 2024)*

*i)* Where battery space is located adjacent to Fuel Oil tank/space having a flash point of 60°C or above, the following additional requirements are to be met:

- Bulkheads and decks forming boundaries between Battery spaces and fuel oil tank/ spaces are to be insulated to "A-60" class standard and the insulation is to extend at least 450 mm (18 in.) outside the area of the joint bulkheads and decks.
- The top of the battery space is not to be in direct contact with the fuel tank's bottom. Alternatively, the top of the battery space is to be fitted with a cofferdam. The cofferdam is to be fitted with suitable drainage arrangements to prevent accumulation of oil in the event of oil leakage from the tank.

*ii)* Where battery space is located adjacent to low-flash point fuel tanks, the Li-ion battery space should be separated from space containing fuel containment system by a cofferdam of at least 900mm with structural fire insulation with A-60 Class. For type C tanks, the fuel storage hold space may be considered as a cofferdam in accordance with 5C-13-11/3.3 of the *Marine Vessels Rules*.

## 3.3 Hazardous Area Requirements *(1 April 2024)*

Flammable gases and toxic gases are released during abnormal conditions and thermal runway. For batteries of this type, the vent systems of the battery space and the integrated vent system (Refer to 2/1.7.1 and 2/1.7.2) are to be classified as a hazardous area Zone 2 and the following additional requirements are to be met:

*i)* The Operations and Maintenance Manual [1/9.2] is to list hazardous gases released.

*ii)* The equipment selection is to comply with applicable requirements in 4-8-4/27 of the *Marine Vessel Rules* or Section 4-3-6 of the *MOU Rules*.

*iii)* The related electrical equipment list for the battery space (e.g. electrical equipment located in the vent ducts, installed either within 0.4m of the ceiling or suspended from the ceiling, exposed to the off-gas release) is to be part of the overall hazardous area plan for the asset. Refer to 4-8-1/5.3.2(b) of the *Marine Vessel Rules* for the hazardous area equipment booklet.

*iv)* The battery space is to have an independent deck drain. The independent deck drain is to be drained to a closed dedicated drain tank or from a bilge well to a safe location. Refer to 2/2.4. The drain tank is to be provided with:

- A vent pipe to a safe location on the open deck
- Adequate capacity
- A high level alarm
- The material of the drainage piping systems, tanks, and other components which may come into contact with corrosive materials in the presence of liquid electrolyte solution is to be of a suitable grade of alloyed steel coated with appropriate anti-corrosion coating, non-combustible plastic, or other compatible material established to be suitable for the application. Non-alloyed steels, copper, copper containing alloys, and zinc-coated steels are not to be used for the drain tank or piping systems.

*v)* Areas on the open deck within 1.5 meters (5 ft) of the battery space intake(s) and exhaust ventilation outlet(s) are to be considered as hazardous areas.

*vi)* The areas on the open deck are to have the same area classification as the vent ducts.

### 3.5 Cable Installations *(2022)*

*i)* General

In general cable installations are to comply with 4-8-4/21 of the *Marine Vessel Rules* and 4-3-3/5 of the *MOU Rules* as appropriate.

*ii)* Services Necessary under a Fire Condition

Where battery systems are used in any of the services that are required to be operable under a fire condition as defined by 4-8-4/1.9 of the *Marine Vessel Rules* and 4-3-3/3.29 of the *MOU Rules*, their cable installation should be in accordance with 4-8-4/21.17.2 of the *Marine Vessel Rules* and 4-3-3/5.17.2 of the *MOU Rules*.

## 5 Battery System Risk Assessment *(1 April 2024)*

The primary objective of the risk assessment (e.g. HAZID) is to identify technical risks and uncertainties associated with the proposed battery system design and its incorporation on a vessel. The risk assessment is to demonstrate the vessel safety (e.g. HAZID) and the continuity of power supply in case of failure of the battery (e.g. FMEA). Considering the risk of fire and explosion, a fire and explosion analysis may be necessary. However, prior to performing the fire and explosion analysis, please consult ABS (see Note 5 below), and if applicable, the regulations, guidance notes, and circulars from the flag Administration to establish the basis for conducting the fire load and explosion assessment related to the installation of Li-ion batteries on marine vessels and offshore units.

A Failure Mode and Effects Analysis (FMEA) is typically used but alternatively other risk assessment techniques may also be considered acceptable. The use of other risk assessment techniques should be agreed upon with ABS prior to performing the risk assessment. The risk assessment is to be carried out in accordance with ABS *Guidance Notes on Risk Assessment Application for the Marine and Offshore Industries*, ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification* or other ABS-recognized industry standards (e.g., *IEC 60812*).

All foreseeable hazards, their causes, consequences (local and global effects), and associated risk control measures are to be documented. The Battery System Risk Analysis document submitted for review is to, at a minimum, address the following issues:

*i)* Power system redundancy and overall safety considerations

*ii)* Appropriate measures taken into account for internal hazards (i.e. internal short-circuit, cell swelling, and fire propagation inside a module)

*iii)* Thermal management of the battery space to prevent the possibility of thermal runaway of the battery modules, including the criticality of any cooling systems required to ensure reliable operation.

*iv)* Appropriate measures taken into account for external hazards (i.e., external short-circuit, fire, gas development, water ingress and flood, etc.)

*v)* Loss of communication with the asset's Power Management System (PMS), as applicable: Appropriate measure taken to isolate the battery pack in the event of a loss of communication with the PMS

*vi)* Inherently safer design(4) implemented (usually by the BMS) for the safe operation of the battery system, redundancies in place and communication protocols used

*vii)* Temperature and voltage measurement sensor failure

*viii)* Appropriate quality plan implemented by the vendor to identify manufacturing defects in individual cells

*ix)* Failure due to abuse conditions (such as overvoltage, over temperature, and mechanical stress)

*x)* A fire and explosion analysis of the battery due to rapid chemical fire and explosion. Prior to performing the fire and explosion analysis, ABS is to be consulted, and if applicable, the relevant regulations, guidance notes, and circulars from the Flag Administration are to be used to establish the basis for conducting the fire and explosion analysis related to the installation of Li-ion batteries on marine vessels and offshore units

*xi)* Risk of chemicals used and chemical fire are to be considered

*xii)* Arrangement of the vent ducts and gas detectors within the battery space

*xiii)* Fixed fire extinguishing system including the quality, duration, and quantity of the extinguishing agent

*xiv)* Post incident clean up procedure

*Notes:*

1 There may be two risk assessments carried out in some cases. One performed by the battery vendor/ manufacturer and the other by the shipyard/system integrator.

2 The shipyard/system integrator's risk assessment covers items *i)*, *ii)* and *iii)*.

3 The battery vendor/manufacturer's risk assessment covers items *iv)*, *v)*, *vi)* and *vii)*.

4 Inherently safer design exists in some specific equipment as a permanent and inseparable element. The safety mechanisms in place are "built in" by virtue of the design and not "added on". Traditionally, the approach to safer design considers preventive controls and/or mitigation measures as options to minimize hazardous events

5 Fire and explosion analysis may be required if it is determined by the required Risk Assessment in Subsection 3/5.

## 7 Installation and Commissioning *(1 April 2024)*

The Battery System installation and sea-trial/commissioning procedures submitted for review is to address the following:

*i)* The necessary information for the preliminary work of setting up the battery system, including the mechanical protection system such as the shock absorber, if applicable, and the fixation system such as anchorage or bolting.

*ii)* Correct interface between the battery system and the DC-bus or battery charger, as applicable.

*iii)* Testing of the following safety functions and associated alarms (Refer to 2/2.13 Table 1): cell balancing detection/protection, overvoltage detection/protection, undervoltage detection/ protection, emergency disconnect arrangement, ground fault detection, loss of communication detection/protection.

*iv)* Testing of the expected performance functions of the battery system on the particular asset. Refer to 2/2.13 Table 1.

*v)* Testing of protective functions in the battery space, as applicable to asset specific installation. Refer to 2/2.13 Table 1.

SECTION 4

# Battery System Used as Main Source of Electrical Power

## 1 General *(1 April 2024)*

This Section covers battery systems used as the main source of electrical (i.e., vessel service loads) and propulsion power. These requirements are to be in addition to those specified in Section 2 and Section 3 covering design, construction, and installation.

### 1.1 Objective *(1 April 2024)*

The goals and functional requirements for this section are covered in Subsection 1/2.

## 3 System Requirements *(15 July 2018)*

Battery systems used as the main source of electrical power must meet flag State and SOLAS requirements, as applicable.

In addition to the plans and data to be submitted in accordance with Subsection 1/13, as applicable, the following requirements are to be met.

### 3.1 Redundancy *(1 April 2024)*

***i)*** For all-electric vessels, two independent battery systems are to be provided and located in separate spaces.

***Note:***

Heightened fire risk associated with thermal runaway is the main reason for separate compartments.

The redundant source of energy is to provide the power needed for the period denoted in 4/3.3 for normal operation and after a single failure event. However, having regard to overall safety considerations, a partial reduction in propulsion capability from normal operation may be accepted.

***ii)*** Each battery system is to be connected to an independent switchboard.

***iii)*** The switchboards are to be placed as near as practicable to the battery systems.

***iv)*** The propulsion design is to incorporate at least two independent systems as defined in 4-8-5/5.3.1 of the *Marine Vessel Rules* or 4-3-5/3.3.1 of the *MOU Rules*.

### 3.3 Capacity *(1 April 2024)*

In addition to the capacity submittal of 1/9.1vi, design capacity based on the asset's intended operations is to be submitted.

***i)*** Remaining times are the duration available for normal operations and single failure event, which depend on the available capacity of the battery storage and the average power consumption. They are to be calculated and submitted to ABS for approval based on the electrical load profiles for the intended application and the design capacity of the system.

***ii)*** The remaining time that the vessel can operate from the battery storage during normal operation is to be calculated and displayed at the navigation bridge and at a manned control station.

***iii)*** The remaining time that the vessel can operate from battery storage under the single failure condition is to be calculated and displayed at the navigation bridge and at a manned control station.

***iv)*** An audible and visual alarm is to be announced at the navigation bridge and at a manned control station when the battery system capacity reaches minimum capacity as required for the intended operation or voyage. For instance, the alarm can be based on:

- The remaining time for normal operation after the single failure
- The energy required for supplying essential services

***Guidance note***

- ***Remaining time for normal operation (Top)***

$$Top = \frac{Ca}{Pavr}$$

Where

– Top = remaining time for normal operation [h].

– Ca = available capacity of the main battery system (main and redundant systems) [kWh] .

– Pavr = average power consumption of all electrical loads defined for relevant period [kW].

- ***Remaining time after single failure (Tsf)***

$$Tsf = \frac{Car}{Pavr + Paux - Pem}$$

Where

– Tsf = remaining time for operation after a single failure[h]

– Car = remaining capacity of the redundant battery system if available [kWh]

– Pem = available power generated from additional available power sources[kW]

– Pavr = average propulsion power consumption for relevant period [kW]

– Paux = average auxiliary power consumption for relevant period [kW].

***v)*** For SOLAS compliant all-electric vessels, when the main battery system is out of service, the remaining available capacity (Car) is to be sufficient to carry all the loads for vessel services during Tsf. Tsf time is to be adequate to return to port or start up additional power sources as indicated in the load profiles. The vessel services include essential services, normal services and for minimum comfortable conditions of habitability and the propulsion loads to provide for a speed of not less than 7 knots or one half of the design speed, whichever is the lesser.

## 3.5 Power Management System (PMS) *(1 April 2024)*

In addition to the requirements of Subsection 2/5 for a battery management system (BMS), a PMS is to be provided per 4-8-5/5.3.3 of the *Marine Vessel Rules* or 4-3-5/3.3.3 of the *MOU Rules*.

## 3.7 Protective Systems

***i)*** *Circuit Protection*. System protection requirements of 4-8-2/9 of the *Marine Vessel Rules* or 4-3-2/9 of the *MOU Rules* are applicable.

*ii)* Load Shedding Arrangements are to be in accordance with 4-8-2/9.9 of the *Marine Vessel Rules* or 4-3-2/9.3.3 of the *MOU Rules*.

### 3.9 Monitoring *(1 April 2024)*

*i)* *Battery Systems*. SOC and SOH are to be monitored and available for the operator and visible at the manned control station. The results of the SOH of the battery system are to be monitored and documented continuously by the operator and checked during the annual Survey. A verification procedure provided by the manufacturer for the SOH is to be included in the maintenance manual for the battery system.

***Commentary:***

The calculation of available capacity is to take into account the possible inaccuracy of the SOC and SOH given by the battery system. If there is a larger deviation than +/- 5% during the verification of SOH, a correction factor Kc is to be determined for the calculation of the available capacity Ca = Cd/Kc.

Where

Ca = available capacity of the battery system [kWh]

Kc = Correction factor. The determination of Kc can be performed by coulomb counting during a complete charge or discharge, or other method as documented in the maintenance manual

Cd = Design capacity provided by the manufacturer [kWh]

*ii)* *PMS*. The parameters below are to be monitored remotely at the navigation bridge.

- Available batteries' energy
- Available batteries' power
- Remaining range/time that batteries can supply energy for the planned operation/voyage and during a single failure event, see 4/3.3.

*iii)* In case of over-temperature in the battery system, an audible and visible alarm is to be provided for manual load reduction at the navigation bridge. Alternatively, an automatic load reduction is to be arranged.

### 3.11 Fire Protection *(2022)*

For battery spaces housing batteries in accordance with this Section, the Battery Space is considered Machinery Space Category A (as defined in SOLAS Regulation II-2) and is subject to the structural fire protection requirements listed therein.

The fire rated insulation arrangements for the boundaries of the battery space and the adjacent machinery space(s) should contain the fire(s) within the space of origin. The protection provided by A-60 fire rated insulation should be appropriate for the cumulative fire loads within the battery space and the adjacent spaces or tank. The fire loads associated with the battery room (Cat. A machinery space) or the adjacent space(s) should not exceed the endurance of the A-60 fire rated divisions.

See 3/3.1 of this document for battery space requirements for fire safety.

### 3.13 Trials

In addition to the requirements of Subsection 3/7, complete tests of the system are to be carried out during sea-trials in accordance with 4-8-5/5.19 of the *Marine Vessel Rules*.

SECTION 5

# Battery System Surveys

## 1 General *(15 July 2018)*

The provisions in this Section are requirements for obtaining and maintenance of classification of **ESS-LiBATTERY** notation. These requirements are in addition to the provisions noted in other ABS Rules and/or Guides, as applicable, to the asset. See the ABS *Rules for Survey After Construction (Part 7)* or Part 7 of the *MOU Rules* for further detailed requirements.

For the purposes of this Section, the commissioning date will be the date on which a Surveyor issues an Interim Class Certificate to the asset with the **ESS-LiBATTERY** notation.

## 3 Surveys During Construction *(1 April 2024)*

This Section pertains to surveys carried out on lithium-ion battery system(s) with **ESS-LiBATTERY** notation during construction, installation, and testing of the asset at the builder's yard/facility, including required onboard testing and trials. The documentation requirements for design review are given Sections 1, 2, 3, and 4.

All surveys and testing listed in 3/2 Table 1 are to be carried out to the satisfaction of the attending Surveyor. The lithium-ion battery system(s) are to be installed and tested in accordance with this document.

The following items are to be verified by the attending Surveyor:

***i)*** *Location and Arrangements*. Battery system(s) are to be installed in accordance with the location and arrangement plan.

***ii)*** *Testing*. Battery system(s) testing are to follow the approved sea trial/commissioning procedures and are to include at least the following items:

- Visual inspection
- Operational tests
- Tests of all the alarms and safety functions
- Emergency disconnect operation
- Fire protection systems
- Fire and Gas detection systems
- Simulation of communication failure with power management system
- Correct operation of ventilation, cooling, gas detection system, fire detection system, fire extinguishing system, etc., where provided.

*iii)* *Ventilation and Environmental Control*. Battery system(s) spaces follow the approved ventilation arrangement and environmental control arrangement plan, as applicable.

*iv)* *Maintenance and Replacement*. A maintenance schedule and procedures of batteries replacement are provided and maintained onboard.

*v)* *Installation of the Battery System*. The installation of the battery system and associated cabinets are effectively secured to the surrounding structure to the satisfaction of the attending Surveyor.

## 5 Testing Onboard and Commissioning *(1 April 2024)*

The commissioning, testing and trails are to be carried out as per approved plans as described in 1/9 listed below:

*i)* Commissioning Test Plan

*ii)* Inspection/ Survey Plan

### 5.1 General

Onboard testing is to verify that the specified functionality is achieved with all systems in operation.

*i)* Onboard testing is to verify that correct functionality has been achieved with all systems in operation. These systems include and not limited to:

- Piping system and cooling system if applicable
- Vent system
- Gas detection system
- Electrical installation
- Battery Management System
- Control system

*ii)* All systems in this document are to be examined and tested to the satisfaction of the attending Surveyor in accordance with the approved plans.

### 5.2 Onboard Testing

Each battery system is to be tested under nomral operating conditions after installation onboard to demonstrate satisfactory operation. All battery system components are to be tested and include :

*i)* the verification of the battery capacity is consistent with the SOH value calculated for all the battery systems. If there is a deviation larger than +/- 5%, the values in the battery system are to be adjusted. In case of large deviation and/or adjustment, test results are to be submitted for review and approval by the technical office.

*ii)* charging and discharging capacity test to verify maximum C-rates as specified for the intended operation of the vessel.

### 5.3 Trials

In addition to the requirements of Subsection 3/7, complete tests of the system are to be carried out during sea-trials in accordance with 4-8-5/5.19 of the *Marine Vessel Rules.*

## 7 Surveys After Construction *(1 March 2018)*

For requirements for surveys after construction, see Section 7-9-25 of the ABS *Rules for Survey After Construction (Part 7)*.

APPENDIX 1

# Commentary on Batteries

## 1 General

A battery is an electrochemical device designed to store and release energy by direct conversion of chemical energy to electricity. A battery may be either a single cell or multiple cells connected in series or parallel configurations. It can be used in any marine and offshore application.

Lithium batteries include lithium-ion, lithium-alloy, lithium metal, and lithium polymer types. This section provides an overview of the technology and focuses on the characteristics of Li-ion batteries common to the majority of available batteries. Additional information on Li-ion batteries is available in the ABS *Advisory on Hybrid Electric Power Systems*.

## 3 Battery Type

### 3.1 Battery Categories *(1 April 2024)*

International standards divide batteries into two broad categories:

***i)*** *Primary (Non-rechargeable) Batteries*. Primary batteries have a lower discharge rate and once fully drained these batteries cannot be recharged. These are the best alternative solutions for low cost, low drain applications such as watches, calculators and hearing aids.

***ii)*** *Secondary (Rechargeable) Batteries*. Secondary batteries can be charged/discharged many times over their life. These batteries are more cost efficient over the long term and are the best solution for high drain applications such as laptops, cars, motor drives, and power tools.

***Note:***

Terms "Primary" and "Secondary" are used in recognized international standards such as IEC to categorize batteries.

Secondary batteries are commonly used in the marine and offshore industries. The most common rechargeable batteries are Lead-acid, Nickel-cadmium (NiCd), Nickel Metal Hydride (NiMH) and Lithium-ion (Li-ion).

Of the above battery types, Lead-acid is the oldest rechargeable battery type, and Nickel-cadmium is mature and well understood, Nickel-metal-hydride serves as a replacement for NiCd and Li-ion is a technology that came to use in the 2010s. Recent advances in the development of Li-ion chemistry are facilitating their use for energy storage in applications that were previously the domain of more traditional battery chemistries and have opened the door to new applications.

### 3.3 Lithium-ion Battery Basis

The fundamental element of a lithium-ion battery system is the lithium-ion cell. It is within the cell that the electrochemical reaction takes place to absorb energy when charging and releases stored energy when discharging.

The four primary functional components of a practical lithium-ion cell are as follows,

- Anode (Negative Electrode)
- Cathode (Positive Electrode)
- Electrolyte
- Separator

There are more components such as current collectors, cell enclosures (cases and pouches), charge interrupt devices, positive temperature coefficient switches, battery pack protection electronics, and battery pack enclosures.

## 5 Battery Use *(1 April 2024)*

Li-ion batteries can be generally used for the following applications in marine and offshore industries:

- Main source of electrical power
- Emergency source of electrical power
- Transitional source of electrical power

Some examples of the benefits of batteries in different applications in marine and offshore industries are:

***i)*** Batteries may be used as the main source of power for the propulsion of the asset.

***ii)*** Using batteries, an asset can run an electrical motor in port or during transit or in zero emission areas and transition to a diesel engine or a gas turbine for medium or high speed for its voyage.

***iii)*** When used for load levelling/peak-shaving, batteries act as a buffer to supply/absorb energy allowing generator sets to be operated at a near constant load. Use of these batteries can reduce maintenance on engines due to optimal loading and reduced engine running hours. With optimal loading, a higher average load can be maintained resulting in a smoother and more stable operation of engines.

***iv)*** Batteries may be used in some instances as an additional power source in case of generator shutdown.

***v)*** Using batteries as a standby power source may reduce the number generators required to be in operation.

***vi)*** Batteries may be used for blackout prevention, fault ride though and blackout recovery in some instances.

***vii)*** Batteries may be used as an emergency source of power for essential and emergency services in some instances.

***viii)*** *Dynamic Positioning Vessels*. Batteries may be used to supply thrusters and act as a buffer in DP mode and/or standby power for fault ride through on DP-2/DP-3 vessels operating in closed bus. For DPS-2/DPS-3 redundancy criteria applies.

***ix)*** *Bollard Pull*. Vendors have proposed allowing a battery to be used in order to meet maximum bollard pull required power on AHTS vessels.

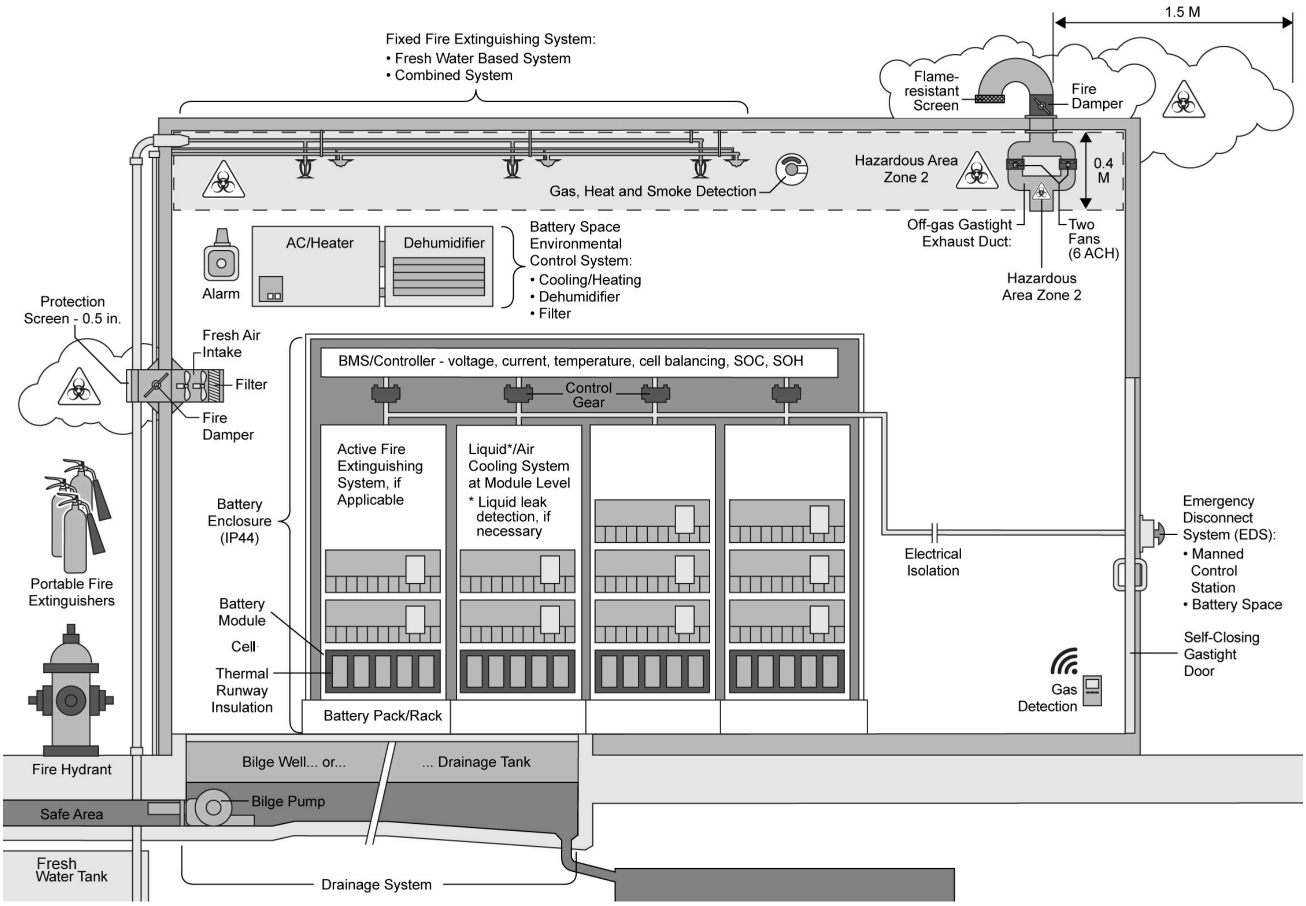
***x)*** *Heave Compensation*. On MODUs as a buffer for heave compensation equipment and to capture regenerative power from cranes.

*xi)* *Military/Naval Vessels*. As a buffer for pulse power weapons systems (electromagnetic rail guns, catapults, lasers, high power radar systems).

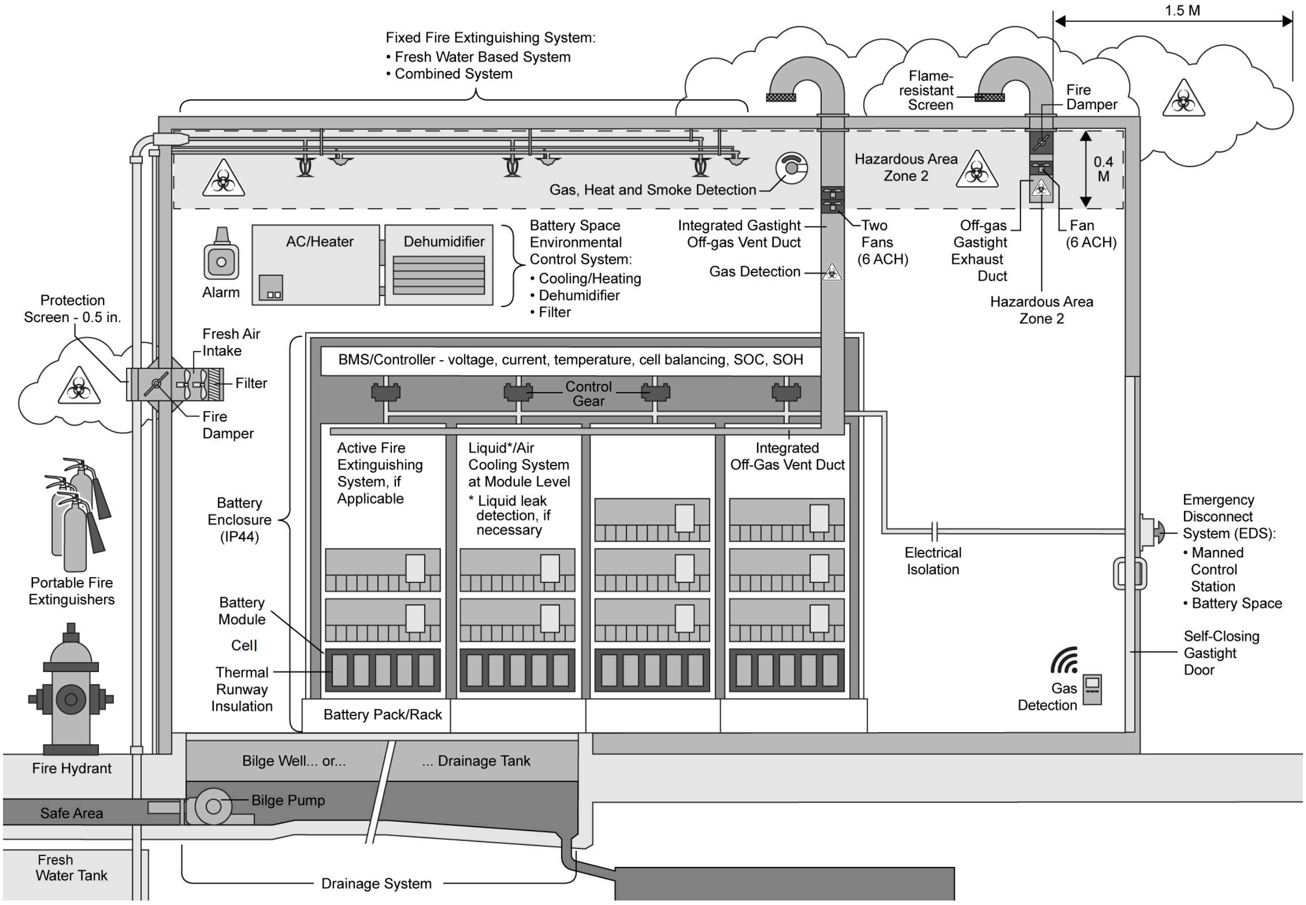
*xii)* *Renewable Energy/DC Grid*. As a storage device on vessels with cyclic renewable energy sources such as wind, solar, wave power.

# 7 Battery System (Compartment) Figures *(2022)*

## FIGURE 1
## Design 1 *(1 April 2024)*



## FIGURE 2
## Design 2 with Integrated Off-Gas Vent *(1 April 2024)*



APPENDIX **2**

# Battery Systems For Non-SOLAS Vessels *(1 April 2024)*

## 1 General

This Section covers battery systems used on board non-SOLAS Vessels operating in controlled and domestic waters. This section modifies the requirements contained elsewhere in this document.

## 2 System Requirements

Battery systems used as the main source of electrical power on board non-SOLAS vessels are to meet Flag State and/or Coastal State requirements , as applicable.

The plans and data to be submitted are to be in accordance with Subsection 1/9, as applicable. However, certain relaxation from those requirements can be considered as described below for these vessels.

### 2.1 Redundancy

Redundancy requirements in Subsection 4/3 need not to be met for the battery systems used as main power source if the risk assessment indicates sufficient mitigations are in place.

The redundancy and overall safety considerations are to be addressed during the risk assessment process depending upon the vessel's size and service. Refer to Subsection 3/5.

***Commentary:***

Mitigations may include vessels in the operational area assigned to provide assistance and /or available shoreside firefighting resources.

**End of Commentary**

### 2.2 Fire Protection

In general, freshwater is to be used for cooling purposes in case of thermal runaway event. The quantity of freshwater available on board may be limited and less than required as determined per 3/3.1.1 iv. where additional marine or shoreside firefighting resources are available for support. The vessel response procedure is to include emergency plans and procedures for transferring responsibility of firefighting to first responders.

Where the storage of freshwater is not practical due to limited space onboard, an alternative system combining a gas-based or condensate aerosol with an integrated foam-based extinguishing system may be accepted subject to design review, survey during construction, test and approval by ABS as applicable. In addition, a non-automatic seawater-based firefighting system is to be provided and to be used as last resort.

## 2.3 Battery System Used as Emergency Source of Electrical Power

### 2.3.1 Alternate Arrangement for Non-SOLAS Vessels and Mobile Offshore Units

Where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in other spaces and such that a fire, flooding or other casualty in any other of the spaces will not affect the power distribution from the others, or to the essential services, the requirements for self-contained emergency source of power may be considered satisfied without an additional emergency source of electrical power, subject to acceptance of the same by the vessel Flag State, provided that:

*i)* There are at least two battery systems meeting the environmental requirements of 2/1.3

*ii)* Each battery system is of sufficient capacity to meet the requirements of 2/2.16

*iii)* The battery systems are located in at least two separate spaces; and

*iv)* The arrangements required by this 2/2.16 in each such space are equivalent with Subsection 3/3 of this document, 4-8-2/5.13 of the *Marine Vessel Rules*, and 4-3-2/5.9 of *MOU Rules* so that a source of electrical power is available at all times for the services required by 2/2.16.

APPENDIX 3

# Containerized Battery Systems (*1 April 2024*)

## 1 General

This Section covers containerized battery systems used as source of electrical power and/or additional energy storage systems. These requirements are to be considered in addition to those specified in Sections 2, 3 and 4 covering design, construction, and installation. In addition, the containerized battery systems are to meet the flag State requirement.

The requirements of this Section are applicable for portable and fixed containerized battery systems.

Vessels used for housing containerized battery systems are to meet the applicable requirements of the ABS Rules *for Certification of Cargo Containers* or the ABS *Guide for Certification of Offshore Containers,* ISO 668 and *International Maritime Dangerous Goods Code*, IMDG Code based on the intended use. Containers that are designed and fabricated to other recognized industry standards that are not less effective than the Rules or Guides may be considered acceptable.

***i)*** The containerized battery system may be installed on the open deck. The container and associated equipment are to be located in a dedicated space

***ii)*** In general, the stacking of containerized battery systems is not permitted. However, alternative arrangements may be accepted, subject to a detailed design review and risk assessment.

***iii)*** The containerized battery systems are to be normally unmanned and may be entered occasionally for repairs, maintenance, or other purposes.

***iv)*** The safety system of the containerized battery is to be powered by the main battery in all operational modes (active and standby modes)

***v)*** Sufficient controls and displays are to be provided in the containerized battery systems to monitor and control the battery system operations.

***vi)*** Containers with wooden floors are not permitted for containerized battery systems.

***vii)*** The fire rated insulation arrangements for the boundaries of the container should be designed to contain the fire within the space of origin. The fire loads associated with the Li-ion batteries should not exceed the endurance of the fire rated structure subject to a risk analysis as per Subsection 3/5. Refer 3/3.1 and 4/3.11.

***viii)*** The container is to be provided with:two access gastight doors located at opposite ends. Exceptionally, one access door may be considered, taking into account the nature, location of the container and subject to the approval of the flag administration.

  ***a)*** An independent vent system designed in accordance with 2/2.7

  ***b)*** An independent gas detection system in accordance with 2/2.9

  ***c)*** An emergency disconnect System in accordance with 2/2.12

### 1.1 Objective

The goals and functional requirements for this section are covered in Subsection 1/2.

## 2 State of Charge of the Containerized Battery System

*i)* The SOC of the portable containerized battery system is to be continuously monitored. The maximum and minimum limits of the SOC during different operational modes (such as storage, on board, in port, at the warehouse, handling, during use, and maintenance) is to be provided by the battery manufacturer and carefully controlled.

*ii)* Means are provided to maintain the SOC of the containerized battery system in place to protect the batteries from any abnormal conditions such as over-discharging.

## 3 Interface Between Vessels/Offshore Facilities and Containerized Battery Systems

### 3.1 Installation of Containerized Battery Systems

*i)* Containerized battery systems are to be installed in non-hazardous areas on a vessel/offshore facility as defined per IEC 60079-10.

*ii)* The orientation of the portable containerized battery on the container, onboard the vessel and on the charging, station is to be marked clearly visible to the lifting and handling operator.

*iii)* Containerized battery systems are to be installed in spaces or locations that are adequately ventilated. Containerized battery systems are not to be installed in the vicinity of intakes and exhausts/ventilation outlets from machinery spaces and galleys.

*iv)* When a containerized battery system is located on an open deck or similar structures, special attention is to be given to providing protection (for example the IP rating) from the sea, icing or any damage which may result from other activities onboard the vessel/offshore facility.

*v)* To minimize deflections and to obtain satisfactory transfer of heavy loads through the deck foundations, containerized battery systems are to be installed in such a way that the underdeck supporting structure of the vessel/offshore facility is in-line with the deck foundations

### 3.2 Angle of Inclinations

The containerized battery systems installed on vessels/offshore facilities are to be designed for operation under the inclinations specified in 4-1-1/9 TABLE 7 of the *Marine Vessel Rules and* 4-1-1/7 of the *MOU Rules.* The equipment manufacturer is to submit details as shown in 4-1-1/7.9 of the *Marine Vessel Rules.*

### 3.3 Ambient Temperature

For containerized battery systems that are installed on ships or offshore facilities, the ambient temperatures specified in Table below are to be considered for the design and installation of battery systems. For containerized battery systems on special service vessels, the ambient temperatures appropriate for the intended service are to be considered.

| *Location* | *Temperature Range (°C)* |
|---|---|
| Enclosed Spaces | 0 to +55°C |
| Open Deck | -25 to +55°C |

***Note:*** For drilling units, refer to 4-1-1/7.7 TABLE 2 of the *MOU Rules*.

## 4 Support Systems for Containerized Battery Systems Installed on Vessels/Offshore Facilities

Support systems are those systems that are provided by the installation vessels/offshore facilities and are not an integrated part of a containerized battery system. These include:

- Electrical systems (charging station, etc.)
- Environmental control systems
- External fire extinguishing, fire detection and alarm systems
- Structural support (Means of fastening of the containerized battery systems to the hull structure, deck foundations, under-deck supporting structure, etc.)
- Lifting and handling systems

For containerized battery systems installed on ABS classed vessels/offshore facilities, these support systems are to be in accordance with Section 3-2-A7 of the *Marine Vessel Rules* and and 6-1-2/11 of the *MOU Rules*. Drawings, specifications, data and calculations are to be submitted to ABS for review and approval.