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CIMAC and Maritime Battery Forum Whitepaper

Environment for the use of batteries in deep-sea shipping

Regulations, Safety and Impact on Crew

Content

1 Introduction and motivation

After analyzing the use cases and application areas for batteries in the joint whitepaper by CIMAC and the Maritime Battery Forum entitled “Environment for the Use of Batteries in Deep-Sea Shipping”, published in 2024, the next step was to identify current challenges prohibiting the adoption of battery systems in deep-sea shipping related to regulations and safety.

The current regulatory landscape for maritime batteries has been thoroughly analyzed and it was concluded that current regulations provide sufficient support for batteries design, installation and testing for application in deep-sea shipping. However, a lack in crew training regulations has been identified. Therefore, impact on crew and the requirements for crew training for battery powered ships is investigated and analyzed to develop an overview and recommendations for crew training requirements for ship owners, operators, flag states and maritime authorities.

2 Regulatory analysis

This chapter discusses the current regulatory landscape governing the use of maritime batteries, outlining the scope of different regulations and regulatory bodies, and examining their implications for the deployment of batteries onboard deep-sea cargo ships.

2.1 Current regulatory landscape for maritime batteries

There is a large variety of regulations related to installing battery systems on board ships, created by the different types of regulatory bodies. The main types of organizations setting rules, regulations or guidelines for maritime battery systems include:

- Class societies
- Flag states
- Industry standards organizations

Table 1 until 3 show 13 regulations from 9 different Class Societies, 4 from Flag States, and 2 industry standards. These have been compared based on ship type and operational area to determine their relevance to ocean-going cargo ships. Besides their applicability, the chapter also compares what each regulation covers, to find out which topics are addressed by each organization, and which areas may need more focus in future developments of rules and regulations for battery-powered ships. See Section 6 for the full reference list of documents used for the regulatory analysis.

2.2 Applicability of different regulations

The different regulations were evaluated on their applicability based on specific ship types and their operational area. The specific ship types for which maritime battery regulations are applicable vary widely per regulatory body. Most Class Societies list several ship types, and all include ocean-going cargo ships. For smaller ships there can be a need for a review of the rules and their applicability, but this is outside the scope of work covered here.

Flag states typically focus and apply their rules and regulations to any ship that is flagged with them and without listing specific types. Other maritime and industry standards do not mention or specify ship types but mainly states a minimum installed battery capacity.

Some rules and regulations require a minimum battery capacity between 5 kWh and 50 kWh. It is assumed that for ocean-going cargo ships the installed battery system capacity will be above the 50 kWh capacity and therefore these rules will always apply.

None of the rules and regulations reviewed mention specific operating areas.

2.3 Scope of different regulations

Each of the regulations is compared on their scope regarding if the regulations are considering the following key aspects of maritime battery systems on board ships:

- Battery system design
- Battery system installation and integration
- Testing
- Operations (including crew training)

Table 1 – Overview of regulatory analysis for battery powered ships – Class Societies

	Class Societies												
Regulatory Body	DNV	DNV_2	ABS	ABS_2	ABS_3	LR	LR_2	BV	IRS	NK	RINA	CCS	KR
Design	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Installation	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Testing	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Operations	yes	no	yes	yes	yes	no	no	no	yes	no	no	yes	yes

Table 2 - Overview of regulatory analysis for battery powered ships - Flag States

	Flag States			
Regulatory body	EMSA (EU)	NMA (Norway)	DMA (Denmark)	STA (Sweden)
Design	yes	yes	yes	yes
Installation	yes	yes	yes	yes
Testing	yes	yes	no	no
Operations	yes	yes	no	no

Table 3 - Overview of regulatory analysis for battery powered ships - Industry Standards

	Industry Standards	
Regulatory body	IEC	NEK
Design	yes	yes
Installation	no	no
Testing	yes	yes
Operations	no	no

All evaluated rules and regulations include Battery System Design within their scope. Installation requirements are also included within all Class Society rules and regulations, as well as within the evaluated guidelines and regulations from Flag States. The industry standards evaluated either don’t include installation requirements or only cover them partly.

Testing requirements are also within the scope of most of the evaluated rules and regulations, specifically for Class Societies and maritime and industry standards. Not all flag states have testing requirements within the scope of their regulations.

Operations, including crew training is outside the scope of most of the evaluated rules, regulations and guidelines. Just a few of the Class Societies have operations and crew training requirements included within the scope of their maritime battery regulations. Nonetheless, in some of those cases the information or requirements are limited. Of the evaluated flag states, only the Norwegian Maritime Authority (NMA) has operations and crew training requirements for maritime battery powered ships. The European Maritime Safety Agency (EMSA) has operations and crew training included in their guideline as well. Within the maritime and industry standards operations and crew training are not included. A more in-depth evaluation of operational and crew training requirements is discussed in Chapter 3.

2.4 Impact on deep-sea shipping

The current regulatory landscape provides a solid foundation supporting the development of battery powered deep-sea cargo ships when it comes to the design, installation, and testing of maritime battery systems. Many of these analysed rules, regulations and guidelines do not include clear guidance on how to operate these battery systems once they are installed on board.

Most of the battery powered ships today sail on inland, intracoastal, or near-shore routes. In case of an incident with the batteries on board, the vicinity to shore adds an additional layer of safety. Deep-sea ships do not have that advantage; therefore, the crew needs and should be properly trained and required to have a high level of understanding on how to safely operate, maintain, and manage battery systems efficiently.

3 Impact on Crew

This chapter takes a closer look at the impact on the crew of battery powered ships, specifically relevant to the safe operation, maintenance, and efficient management of battery systems along with required operational and training requirements as specified by different regulatory bodies.

3.1 Current status of crew training requirements

Only two relevant guidelines for crew training requirements on board battery powered ships have been found:

- European Maritime Safety Agency (EMSA): Guidance on the Safety of BESS on board ships – Version 1.0 November 2023, Annex B – Guidance for officer's qualification.
- Sjøfartsdirektoratet (Norwegian Maritime Authority): Circular Series V – Guidelines on requirements for training in chemical energy storage (maritime battery systems) on board Norwegian ships.

See Section 5 for the complete overview of the above crew training requirements by EMSA and the Norwegian Maritime Authority.

Additionally, a relevant requirement in the Red Ensign Group Yacht Code: Annex A -Battery systems guidance for installation, stowage and operation-, paragraph A7 – July 2024, has been found. Here it is stated: "Crew training – it is recommended that at no time shall there be less than two persons on the vessel who are adequately trained and experienced in all battery equipment and procedures. In addition, all crew shall have an awareness of the vessel's emergency procedures regarding the battery."

The IMO does not have specific guidelines or resolutions about Li-ion batteries training for crew. The IMO publications that include training requirements applicable also to Li-ion batteries are:

- ISM Code 6.3 – mandates ship managers to establish procedures for personnel in safety and environmental roles, to ensure proper familiarization with their duties.
- ISM Code 6.5 – highlights the importance of identifying and providing necessary training to support safety management systems.
- STCW Convention Regulation I/14-5 – recalls the need for companies to familiarize seafarers with their duties, ship arrangements, equipment, and relevant aspects.

At the IMO Human Element, Training and Watchkeeping (HTW 11) meeting on 10-14 February 2025 it has been agreed to begin the development of interim guidelines for training seafarers on ships using alternative fuels and new technologies, including battery powered ships.

3.2 Analysis of crew training requirements

The regulations and guidance from EMSA and the NMA have been compared, and an overview is created to include all the aspects related to crew training requirements for maritime battery systems.

Two different types of training can be considered based on the role or function of the person related to the battery system.

- General battery training (theoretical)
- System specific training (practical)

The General battery training is a theoretical training for everyone involved with maritime battery systems in all different roles. This training can be facilitated by any capable and knowledgeable person or organization.

The System specific training is practical and applicable to crew that must perform work related to the battery systems on board. This training should be facilitated in cooperation with the battery supplier and/or integrator. The integrator in this case is the party responsible for all aspects of integrating the battery system on board the ship (electrical, control, monitoring, thermal management, off-gassing, firefighting, etc.), including battery room safety systems. Ideally this training takes place on board the ship, to include all aspects of the battery system including battery room, auxiliary systems and safety procedures.

The main topics that should be included in both the general battery training and system specific training are listed below. For the General battery training an overview of the different considerations or types of batteries/systems should be provided. For the System specific training each topic should be discussed in more detail related to the installed battery system and auxiliary systems on board.

- Battery technology
  - Distinct types of battery chemistries
  - Types of battery cells and how they work
  - Main characteristics of types of batteries
  - Battery aging
- Battery system components
  - Main components of a battery system
  - Diverse types of maritime battery systems
  - Performance and characteristics on system level
- Battery system design considerations
  - Battery sizing
  - Charging/Discharging
  - Efficiency
  - Lifetime
  - Performance
  - Redundancy
  - Resiliency
  - Operational use cases

- Battery Management System
    - Functions
    - Alarms
- Auxiliary systems
    - AC/DC coupled systems
    - Thermal management
    - Firefighting
    - Ventilation
    - Detection/monitoring
- Safety hazards and risks
    - Internal risks from batteries
    - External risks to the batteries
    - Battery space safety
- Safety procedures
    - Basic understanding of how to contain battery incidents
    - Detecting incidents
    - Cooling
    - Ventilation
- Maintenance and inspections
    - Checklists
    - Handling of batteries
    - Decommissioning

3.3 Responsibility for crew training

In many regulations, battery suppliers are made responsible for crew training. However, not all safety equipment and procedures on battery-powered ships are designed or installed by the battery suppliers. The responsibility can be with either system integrators or the shipyard as well. During the operational life of the vessel, the crew training responsibilities shift more towards the ship owners, operators, and regulators.

Consequently, the responsibility for educating and properly training the crew with regards to safety, operation, and maintenance of battery systems shall be shared between all respective parties involved in the design, installation and operation of the battery system.

Design

Equipment suppliers, battery system providers, ship designers, etc., have the responsibility to design equipment and ships with the aim to make them as user friendly as possible. New technologies increase the complexity of modern ships, but also have the potential to reduce the complexity in how to operate them. The supplied equipment shall be provided with clear and structured manuals for installation and operation.

Installation

Integrators and shipyards have the responsibility to make everything on board work well together. There shall be clear instructions on how to operate and maintain the onboard systems as safe and efficient as possible, as well as a trouble-shooting guideline.

Operation

Ship owners/operators and regulators have the responsibility to provide the access to the required knowledge and skills for crew members and a clear program for certification, re-certification, and how to deal with changing crews over time. Additionally, maritime schools and educational institutes should provide students with the required knowledge to operate ships with modern technologies on board.

4 Conclusions and recommendations

4.1 Conclusions

The analysis of current maritime battery regulations demonstrates that the regulatory framework for battery system design, installation, and testing in deep-sea shipping is largely mature and comprehensive. Class societies, flag states, and international standards organizations have all developed rules and guidelines that sufficiently address the technical and safety requirements for implementing battery systems on ocean-going vessels.

However, the research also reveals a significant regulatory gap concerning operational requirements and crew training. While battery systems are now technologically and regulatorily feasible for deep-sea applications, their safe and efficient operation heavily depends on human competence — an aspect not adequately covered in most existing regulations.

Only a limited number of authorities, specifically the European Maritime Safety Agency (EMSA) and the Norwegian Maritime Authority (NMA), currently include structured guidance on crew training related to battery operations. The International Maritime Organization (IMO) has not yet formalized specific training standards for battery-powered ships, although early steps are being taken to develop interim guidelines for alternative fuels and new technologies.

The study further concludes that responsibility for crew training is distributed across multiple stakeholders — including equipment suppliers, system integrators, shipyards, shipowners, educators, and regulatory authorities. However, this distributed responsibility requires clearer definition and coordination to ensure that all crew members, from operational to managerial levels, receive appropriate and consistent training.

In summary, the transition to battery-powered deep-sea vessels is no longer constrained primarily by technical or regulatory limitations, but rather by the human and organizational readiness to operate, maintain, and manage these new energy systems safely and effectively.

4.2 Recommendations

Regulators and policy makers

- Develop harmonized international training standards under the IMO framework that address the competencies required for crew working on ships equipped with large-scale battery systems.
- Incorporate operational and training requirements explicitly into existing regulatory instruments and class rules to ensure uniform implementation across all jurisdictions.
- Encourage collaboration between flag states, class societies, and industry bodies to align national guidelines with international standards and promote mutual recognition of certification.

Ship owners and operators

- Establish structured training programs combining both general theoretical education on battery technologies and system-specific practical training, ideally delivered in cooperation with equipment suppliers and battery system integrators.
- Implement continuous learning and re-certification schemes to ensure that crews remain proficient as technologies and safety protocols evolve.

- Promote a safety culture that includes regular drills, scenario-based exercises, and familiarization with emergency procedures related to battery hazards such as fire, gas release, and thermal runaway.

Equipment suppliers, integrators and shipyards

- Provide comprehensive operational manuals and training packages tailored to the specific system configuration and integrated ship design.
- Collaborate with shipowners and educational institutions to ensure that training materials are consistent, standardized, and meet both regulatory and operational needs.
- Design user-friendly systems with clear human-machine interfaces and intuitive monitoring tools to reduce operational complexity and minimize the potential for human error.

Maritime education and training institutions

- Update curricula to include knowledge areas related to maritime energy storage systems, battery management, and related safety procedures.
- Engage with industry stakeholders to ensure that training programs reflect current technologies and operational realities.
- Develop certification pathways in alignment with forthcoming IMO guidelines and national regulations to prepare seafarers for the energy transition in deep-sea shipping.

4.3 Outlook

The findings of this paper highlight that establishing clear and harmonized training frameworks is the next crucial step toward enabling the widespread adoption of battery technology in deep-sea shipping, as well as other sectors in the maritime industry. With coordinated efforts between regulatory authorities, industry, and educational institutions, the maritime sector can ensure that technological advances in energy storage are matched by the necessary human expertise — thereby securing both safety and sustainability in the evolving maritime energy landscape.

5 Annex – Overview of crew training requirements

The two most relevant guidelines for training requirements for crews on board battery powered ships have been evaluated and below is an overview of the included requirements per guideline.

European Maritime Safety Agency (EMSA): Guidance on the Safety of BESS on board ships – Version 1.0 November 2023, Annex B – Guidance for officer's qualification. Training should be facilitated at the battery manufacturer premises, shipyard or facilities licensed by the battery manufacturer.

Training should provide knowledge in the following areas:

- Types of long duration batteries
- Different battery chemistry characteristics
- Safety hazards to consider
- Components in a Battery Energy Storage System (BESS)
- Different battery system functions on board
- Battery system use cases on board ships
- AC/DC coupled systems
- End of life options for batteries

Training should foresee:

- Battery chemistry
  - Characteristics
  - Charge rates
    - Max charge
    - Discharge
  - Chemistries and potential failure mechanisms
- Lithium-ion BESS
  - Principles
  - BESS safety
- Notions about other battery technologies
  - Redux
  - Plating
  - Organic and others
- Design considerations
  - Common characteristics (sizing and roundtrip efficiency)
  - Projected life
  - Performance

- Safety
    - Battery scorecards
    - Relevant BESS Standards such as:
        - NEC 855 Standard for the installation of Stationary Energy Storage Systems (relevant chapters)
        - UL9540 and 9540A Energy Storage Systems and Equipment
        - IEC relevant standards as specific in this guidance
    - Fire protection and ventilation systems
    - Relevant safety standards
- Major components in a BESS
    - Batteries
    - Fire suppression
    - Inverters
    - Step-up Transformers
    - Secondary containment
    - Controllers
    - Housing
    - Battery Management System
    - Energy Management Systems
    - Substation
    - Other auxiliary systems (HVAC, BMTS)
- Operations & Maintenance

System resiliency

- Redundancy
- Backup Power/UPS

AC/DC coupled systems

- DC systems
- DC coupled to generation
- DC coupled to DC loads
- High voltage DC principles, design, operations and maintenance

Design considerations

- Li-ion batteries

Operational risks, inspections and maintenance

- Service agreements
- O&M agreement challenges

Decommissioning

- Recycling
  - The process
  - Li-ion decommissioning
  - Planning for disposal
- Environmental considerations
  - Recyclability
  - Regulatory framework
  - Decommissioning

Sjøfartsdirektoratet (Norwegian Maritime Authority): Circular Series V – Guidelines on requirements for training in chemical energy storage (maritime battery systems) on board Norwegian ships.

Persons who operate maritime battery systems or perform inspection or maintenance of such systems must have:

- Training adapted to function or tasks (to manage or perform)
- Required practical training in addition to theoretical training
- Regular maintenance of competence

Goal

The training in maritime battery systems must include:

- Potential risks and hazards related to the use of maritime battery systems
- Adapted safety training, procedures, plans and instructions, including any checklists to check the technical condition and suitability of the marine battery system before use;
- Equipment-specific training (provided by the battery supplier)

The company must ensure that training, practice and instruction are adapted to:

- The individual's function (manage or perform)
- The individual's tasks
- Relevant issues regarding the maritime electrical installation in question

The training:

- May be undertaken on board, at other suitable locations, through relevant tasks or at practical courses
- Must include relevant results from risk assessment

Training objectives

After completing the training, the person who manages or performs tasks related to operation, inspection or maintenance of maritime battery systems needs to:

- Be familiar with battery chemistry and the diverse types of battery cells
- Be familiar with a frequency converter
- Be familiar with important technical concepts for the battery system
- Be able to account for the dangers of the battery system from a safety point of view
- Be able to account for the dangers related to different hazards (temperature, poisoning and ignition)
- Be able to account for the auxiliary system
- Be able to account for the important and critical alarms related to the battery system, both regarding probable causes and consequences of the alarms
- Be able to account for the handling of hazards and incidents that could occur in maritime battery systems
- Be able to assess the risks associated with the battery system, both individually and in cooperation with others

Training plan

The training plan shall be adapted to the crew's function (manage or performance) and category (operation, inspection and maintenance) and consist of at least the following elements:

- Basic introduction to battery technology, including chemistry, risks and safety systems
- System understanding.
  - Basic knowledge of how a frequency converter works with a battery system
  - Battery Management System (BMS) – State of Charge (SOC) – State of Health (SOH)
  - Energy Management System (EMS)
  - Control system, including understanding and interpretation of alarms and associated alarm management
  - Automatic manual operations
  - Auxiliary system
- Safety and security
  - Gas (poisonous, corrosive and explosive)
  - Cooling and airing (ventilation)
  - Fire-extinguishing
  - Risk and safety assessments
  - Hazards related to Thermal Runaway (TR), fire, explosions
  - Understanding of consequences of loss or disconnection of auxiliary systems (such as ventilation, cooling, fire detection, EMS, BMS)
  - Key indicators of a potential unwanted event (temperature, cell temperature, cooling system, gas detection, fire detection)
  - Management of hazards and incidents

    - Handling of battery modules
    - Cooperation with land-based fire and rescue in connection with an unwanted event;
        - Situational awareness
        - Information flow between crew/company and shore-based fire and rescue service
        - Strategy for the removal of hazardous gas (toxic, corrosive and explosive)

Personnel who work on board shall also be provided with:

- Maritime battery system training adapted to manufacturers/system integrators
- Practical training with simulation learning related to the maritime battery system

6 References

Regulatory Body	Document Name	Publication Year
DNV	RU-SHIP Pt.6 Ch.2 Sec.1 Electric Energy Storage	2024
DNV_2	CG-0660 Safety philosophies Sec.3 Electric Energy Storage Systems	2023
ABS	Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries	2024
ABS_2	Requirements for Hybrid and All-Electric Power Systems for Marine and Offshore Applications	2024
ABS_3	ABS Requirements for Power Service for Marine and Offshore Applications	2022
LR	LR-RU-001 Pt.6 Ch.2 Sec. 12 Batteries	2024
LR_2	LR-RU-001 Pt.6 Ch.2 Sec. 24 Hybrid electrical power systems	2024
BV	BV NR467 Pt. F Ch.14 Sec.1 Electric Hybrid	2025
IRS	Guideline on Battery Powered Vessel	2024
NK	Rules Pt.H Ch.2 Annex 2.11.1-2 Accumulator Battery Systems	2024
RINA	REP 6 Pt.C Ch.2 App.2 Battery Powered Ships	2025
CCS	CCS Rules for Ships Applying Battery as a Power	2023
KR	Guidance for Battery Systems on Board Ships	2024
EMSA (EU)	Guidance on the Safety of BESS on board ships.	2023
NMA (Norway)	Regulations on ships using battery systems with lithium-ion cells with a total capacity of 20 kWh or more - 2025/22435-1	2025
DMA (Denmark)	Guideline for approval of Lithium-ion type battery installations	2022
Swedish Transport Agency (Sweden)	Transportstyrelsens riktlinjer för elektrifiering av fartyg	2023
IEC	IEC 63462-1 Maritime battery system – Part 1: Secondary lithium cells and batteries – Safety requirements	Planned
NEK	NEK NSPEK 411 Maritime battery systems - Safety requirements for secondary lithium cells and batteries	2022

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