Nō te rere moana Aotearoa
MARITIME NEW ZEALAND

QUICK GUIDE

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Guidance for electric-propelled vessels

This quick guide provides a general overview of actions that surveyors, designers, and operators can do to minimise risks arising from vessels propelled by a Lithium-ion (Li-ion) battery system. For technical design advice and standards, you will need to base the design on rules from a recognised classification society and Maritime Rules Parts 40A-40G.

It reflects the health and safety duties and responsibilities that operators, designers and surveyors have under the Health and Safety at Work Act 2015 (HSWA), and under the Maritime Rules (the Rules) Parts 40A-40G,Part 44 and Part 19.

What the maritime rules say

A vessel propulsion installation must comply with the relevant Parts of the Rules and the applicable standards. Currently the Rules do not include specific requirements to provide fire safety measures, electronic control systems and emergency power where Li-ion type electrical energy systems (EES) are used to propel vessels.. However, the Rules do include a general requirement that a vessel and its equipment must be fit for its intended use.

For the electrical system that powers the propulsion, the Rules will vary depending on the size of the vessel. In the case for vessels less than 24 metres long the electrical system must comply with requirements of the AS/NZS 3004.2 Electrical installations-Marinas and Boats or the relevant rules of a classification society. If the vessel is greater than 24 metres in length then the electric systems must comply with either the relevant rules of a classification society or the applicable parts of IEC 60092 series of standards-Electrical installations in ships.

Good health and safety practice

All parties involved with designing, building and operating a vessel, in this case one propelled by Li-ion EES or hybrid systems, have duties under HSWA. Under HSWA, these parties hold duties as a PCBU – a person conducting a business or an undertaking.

In this quick guide, depending on the involvement with the vessel, ‘you’ refers to the PCBU as the operator of the vessel, or as the upstream PCBU who designed, built and surveyed the vessel.

All PCBUs have a duty to eliminate risks to health and safety, so far as is reasonably practicable and if it is not reasonably practicable to eliminate risks, to minimise those risks so far as is reasonably practicable. When deciding what is reasonably practicable you need to consider the following:

- what is known about the risk, including how likely it is to occur and the severity of the consequences
- what control measures can be used. Consider industry standards where applicable
- what is known about the ways to eliminate the risk if possible
- if elimination is not possible, how the risk could be minimised
- how suitable are the control measures for managing the risks
- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, consider the cost associated with the suitable control measures, including whether the cost is grossly disproportionate to the risk. Cost can only be used as a reason to not do something when it is grossly disproportionate to the risk.

Key Definitions

Term	Definition
Battery Management System (BMS)	A BMS is designed to protect the battery and its cells by managing the current. It may include other monitoring and safety features like temperature sensors or be able to force the disconnection of unsafe voltage.
Battery space	The space where the battery system is installed. In smaller vessels, this includes enclosures or cabinets that are not built into the structure of the vessel.
Battery system. Also Electrical Energy System (EES).	The whole battery installation including battery modules, retaining frames, electrical interconnections, BMS and other safety features.
Lithium-ion (Li-ion) battery	A battery which is rechargeable and utilises the transfer of lithium-ions between the electrodes. Lithium-ion batteries do not contain metallic (elemental) lithium.
Thermal runaway	The condition where the rate of heat generation within a battery component exceeds its heat dissipation capacity. Once thermal runaway occurs it is very difficult to stop it.

Risks of using Li-ion batteries for propulsion

Vessels propelled by Li-ion battery systems present different risks than conventional diesel or petrol vessels. You must understand how these risks will impact on crew and passenger safety, the vessel and the environment. When identifying risks you must engage with your workers and their representatives, so far as is reasonably practicable. You must also have practices that provide reasonable opportunities for workers who carry out work for the business or undertaking to participate effectively in improving work health and safety in the business or undertaking on an ongoing basis

The risks associated with the use of Li-ion batteries and systems depend on the vessel and its operating limits. Some of the risks common to Li-ion batteries and battery systems are outlined below.

- **Temperature increases:** This can lead to a fire or possible explosion that can cause propulsion loss, loss of power for essential services or harm to human life. One of the biggest risks of temperature increases in Li-ion battery systems is thermal runaway. During thermal runaway, it is likely there will be damage to the adjacent cells and equipment within the battery compartment. Uncontrolled thermal runaway is dangerous and can lead to a total loss of the vessel through fire or explosion.
- **Physical damage to Li-ion batteries:** These batteries are prone to damage caused by puncturing, crushing or mechanical shock, particularly in rough seas. This damage can cause toxic gas leaks, electrolyte leakages or localised short circuits, which can cause harm to human life and the vessel.
- **Over-charging and over-discharging of Li-ion batteries:** The BMS should monitor these conditions however in some cases it may fail. This system failure can lead to loss or reduced performance of the battery, failure of the system that maintains the battery and of the safety system. This can result in harm to human life and danger to the vessel.
- **Condition of batteries:** The performance of Li-ion batteries can be reduced depending on the battery age, the number of charge/discharge cycles it has had and the temperature range of the battery. Battery life and performance can be affected if the batteries are operated outside the range recommended by the manufacturer. This can lead to loss of propulsion or disruption to safety systems.

What operators should consider

As a PCBU, maritime operators have the primary duty of care to make sure, so far as is reasonably practicable, that the health and safety of workers, passengers and other people involved is not put at risk from their work. To do this you must have in place systems and processes that are designed and adequately resourced to respond to risks, for example appropriate fire-fighting equipment.

In particular, you should:

- have systems and processes in place to allow the vessel to continue to the closest port to safely discharge passengers in case of Li-ion EES failure
- be able to continue providing essential services in case of Li-ion EES failure or fault.

Part 19 of the Rules states that you need a Maritime Transport Operator Plan (MTOP), which is a written description of your safety system, that is specific to the health and safety risks of vessels propelled by Lithium-ion EES (see Table 1).

Table 1: Specific topics around Li-ion batteries and battery systems that should be included in your MTOP
The parameters for the safe operation of the Li-ion battery.
BMS control systems in place, and what happens at each stage in the BMS controls
Evacuation procedures in the event of a fire due to Li-ion battery failure.
The training the crew will receive to manage the risks of the Li-ion batteries, taking into account the environment the vessel is operating in and how the vessel uses the Li-ion battery system.
Inspection requirements, and the timing of each inspection. At a minimum, inspection should check: - for physical damage to the batteries - that the batteries are clean - that there is no sign of arcing anywhere in the batteries or battery system - any signs of water ingress, particularly in the vicinity of the terminals and other conductors - whether there are any spikes in the temperature recorded in the BMS - whether the BMS data log is showing a history of errors or warnings that need to be remedied - there is adequate ventilation where the battery is installed - that the BMS is operating correctly
The maintenance that is required for the batteries and the battery system
Battery monitoring requirements
What data records are needed to be kept-for examples records of charging and discharge levels help show battery performance
Description of the regular equipment testing procedures of: - sensors/detectors - the environmental conditions - effectiveness of the systems like emergency ventilation, fire detection and suppression systems and shutdown switches **(This list is not exhaustive. Each vessel will have different equipment testing requirements based on its specific design)**

Advice for naval architects, boat builders, design approver surveyors and in-construction surveyors

Classification Society Rules

Naval architects, boat builders, design approver surveyors and in-construction surveyors are all considered to have duties under the HSWA and the Rules. They are in a strong position to eliminate risks to health and safety and if it is not reasonably practicable to eliminate those risk, to minimise risks through designing, building or approving the designing and building of vessels that have the Li-ion battery system/s installed safely.

In general, when designing a system you need to ensure that:

- the design of the electric-propulsion system is based on recognised Classification Society Rules. For a list of recognised classification societies see **https://www.maritimenz.govt.nz/content/commercial/safety/safety-management-systems/ISM-code/documents/Authorised-classification-societies.pdf**
- the battery system/s is sourced from a reputable battery manufacturer and is appropriate for the purpose that the vessel is going to be used for.

Advice for naval architects or boat builders

If you are a naval architect or boat builder, you should work closely with an experienced electrical engineer and a Maritime NZ recognised Design Approver – Electrical (DA-Electrical). For a list of recognised design approvers see https://www.maritimenz.govt.nz/content/commercial/safety/safety-management-systems/recognised-surveyors/recognised-design-approvers.asp to address the following key items:

- the battery compartment should have fire rating divisions, for example fire rated bulkheads and decks. This fire rating needs to be appropriate to the vessel's purpose but as a minimum should provide 30 minutes fire protection
- a fire detection and alarm system that is designed to detect off-gases associated with Li-ion batteries
- the location of pipes, cables and other infrastructure that carry essential services. Ideally they should not go through the battery compartment, but if they do they should be encased in appropriate fire rated materials to achieve a 30 minute rating
- a fire suppression system installed within the battery compartment, which is appropriate for the size and type of fire that is expected from the battery system
- the ventilation and cooling systems for the Li-ion battery system is appropriate for the vessel and Li-ion batteries
- an appropriate Li-ion BMS is installed

Electrical Design Approval

As part of the approval process for an electric-propelled vessel, a recognised DA-Electrical should review, as a minimum:

- the outline of how the proposed battery system is to be used, including:
  - the arrangement of the battery system
  - whether the battery system is the sole source of power
  - how the vessel will be charged
  - how long the vessel will be at port for charging
  - the type of voyages the vessel undertakes
- the operations and maintenance manual for the battery system and the BMS
- an electrical load chart indicating various operational modes and the capacity of the battery system. Include what the power consumption is at the proposed operational speed and the minimum operational speed

- information about the batteries, for example:
  - cell and battery configuration
  - safety devices linked to the batteries
  - battery chemistry
  - test certificates
  - cell voltage
  - system voltage
  - number of battery banks
  - recommended charge/discharge rates
  - the operational limits of the batteries
  - manufacturers environmental requirements
- a risk assessment process which covers all of the potential hazards posed by the battery type used, the evaluation of risk factors and control measures
- a block diagram which includes how the batteries are linked to the emergency equipment, and the control, monitoring and alarm systems
- the description of the BMS and the other related systems that are used
- copies of the test program, which includes tests on the alarm system, safety system and control systems
- any plans for systems which are designed to mitigate the effects of gas leakages or fire and explosions. These plans need to include the structural fire protection plans, ventilation systems and the emergency plans for when the vessel is charging.

More information

To understand your role as a PCBU or upstream PCBU, see:

WorkSafe New Zealand: Introduction to the Health and Safety at Work Act 2015 – special guide

https://www.worksafe.govt.nz/managing-health-and-safety/getting-started/introduction-hswa-special-guide/

To understand what is reasonably practicable see Worksafe New Zealand Reasonably practicable fact sheet

https://www.worksafe.govt.nz/assets/dmsassets/zero/848WKS-6-HSWA-reasonably-practicable.pdf

To understand some of the technical specifications to use, see:

MGN 550 Design, installation, operation of lithium-ion batteries

https://www.gov.uk/government/publications/mgn-550-mf-guidance-for-safe-design-installation-and-operation-of-lithium-ion-batteries

To see the full wording of the relevant Maritime Rules, see:

Maritime New Zealand: Maritime Rules

Parts 40A to 49

https://www.maritimenz.govt.nz/rules/

Part 19

https://www.maritimenz.govt.nz/content/rules/part-19/default.asp