Sjøfartsdirektoratet
Norwegian Maritime Authority

Sjøfartsdirektoratet
Norwegian Maritime Authority

Circular - Series V

Circular recipients: (check box)

- ☐ Sdir : Norwegian Maritime Authority
- ☐ A: 16 specially authorized employment offices
- ☐ U: Selected Foreign Service stations
- ☐ P: Equipment manufacturers, any subgroups
- ☐ OFF: Offshore companies / platform managers /operators
- ☐ Hov: Main organizations
- ☐ Andre:

No.:	**RSV 09-2022**
Date:	04.05.2022
Journal No.:	2021/154280
Applicable until:	31 December 2027
Supersedes:	
Reference to:	The Ship Safety and Security Act section 9 and references in paragraph 5 of this circular.

Guideline for electrical energy storage systems (maritime EES systems) onboard Norwegian ships of less than 24 meters in length (L)

1. Purpose of the circular

1. This circular provides guidance on technical and operational matters which should be adhered to so that EES systems comply with the requirements in section 9 of act 16 February 2007 No. 9 relating to ship safety and security (the Ship Safety and Security act).
2. The guidance in this circular may be applied as an alternative to relevant rules for battery systems adopted and promulgated by a classification society recognised by the NMA.

2. Background

The maritime industry in Norway is currently at the forefront of the development and use of maritime EES systems. In cooperation with the industry, the NMA wishes to contribute to using this advantage and to further develop the technology in a safe manner.

Maritime EES systems can, depending on chemistry and design, generate significant volumes of flammable, corrosive and toxic gases with the risk of both explosion and fire. Internal faults in the battery cells may occur regardless of the EES system's safety systems.

Electrical energy storage systems are vulnerable to external influences, in particular; heat, sea water and mechanical damage and must therefore be sufficiently safeguarded and protected. Service and maintenance require highly skilled professionals, methods and equipment due to the high risk of electrical shock.

3. Application

1. The circular applies to Norwegian[1] ships of less than 24 meters in length (L) with maritime EES system based on Li-ion batteries or similar technology installed.
2. For EES system installations of less than 20 kWh, only the guidance in section 21 of this circular applies.

[1] Ref. Norwegian Maritime Code of 24 June 1994 No. 39 section 1

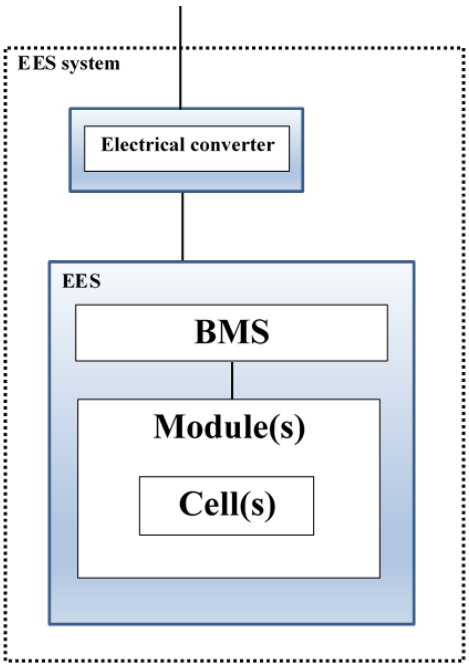
4. Definitions and abbreviations

1. Definitions and abbreviations set out in table 1 are used in this document.

Table 1

ACH	Air changes per hour, abbreviated ACPH or ACH, or air change rate is a measure of the air volume added to or removed from a space in one hour, divided by the volume of the space.
Battery cell	smallest building block in a battery, a chemical unit. *Note modified definition described in section 9.3.*
Battery module	assembly of cells including electronic control
BMS	Battery management system. System designed to protect EES from potentially damaging events such as overcharging, discharging, high temperatures, low temperatures, etc.
CID	Current interrupt device (CID) is a fuse-type device that cuts off the electrical circuit permanently when triggered by excessive cell pressure, high temperature, or high voltage, depending on design
Classification society recognised by the NMA	The following 6 classification societies are authorised to carry out surveys and inspections and issue statutory certificates – as applicable – on behalf of the Norwegian Maritime Authority: - American Bureau of Shipping – ABS - Bureau Veritas – BV - DNV - Lloyds Register of Shipping - LR - RINA S.p.A – RINA - Nippon Kaiji Kyokai – ClassNK
Complete EES system	EES system intended to be designed as a self-contained and standalone enclosure
EES	Electrical Energy Storage (including BMS)
EES converter	Equipment controlling charging/discharging of EES
EES system	The EES system includes electrical energy storage (incl. BMS) and electrical converter (controlling charging/discharging of EES)
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 source of electrical power can be - a generator driven by combustion engine, - an accumulator battery system, or - a maritime EES system.
EMS	Energy Management System
FAT	Factory Acceptance Test
Flammable liquids	Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (such as paints, varnishes, lacquers, etc., but not including substances which, on account of their other dangerous characteristics, have been included in other classes) which give off a flammable vapour at or below 60°C closed-cup test (corresponding to 65.6°C open-cup test), normally referred to as the "flashpoint". See IMDG Code for more information.
High fire risk objects	High fire risk objects are objects similar to those listed in SOLAS Reg. II – 2/3.31. Heat sources are sources with temperature higher than 220ºC as used in SOLAS Reg. II-2/4.2.2.6.1.
IAS	Integrated Alarm System
IEC	International Electrotechnical Commission
IP	IEC standard 60529 classifies and rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact, and water.
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 in normal operational and habitable conditions. Main source of electrical power can be - a shaft generator driven by main propulsion engine, - a maritime EES system, - a generator driven by combustion engine or a combination.
NMA	Norwegian Maritime Authority
PMS	Power Management System

SOH (state of health)	Indication of the condition of EES (or a cell, or a module), compared to its initial condition (100% = EES' initial condition).



5. References

1. The guidance provided in this circular should be applied in conjunction with requirements adopted in the following regulations under the purview of the NMA:

- Regulations of 19 December 2014 No. 1853 on the construction and supervision of small cargo ship
- Regulations of 1 July 2014 No. 1072 on the construction of ships
- Regulations of 22 December 2000 No. 1574 on additional requirements for the handling, controllability, equipment and operation of passenger high-speed craft less than 24 m in length which are engaged on domestic voyages
- Regulations of 22 November 2013 No. 1404 on fishing vessels of less than 15 meters in overall length
- Regulations of 13 June 2000 No. 660 on the construction, operation, equipment and surveys of fishing vessels of 15 m in overall length (LOA) and upwards
- Regulations of 1 July 2014 No. 1099 on fire protection on ships

6. Safety principle applied

1. This guidance is based on the principle that EES systems should be inherently safe by default and thus able to handle internal failures autonomously without endangering passengers, crew or vessel.
2. Acknowledging that on smaller ships it may not be possible to cater for physical separation and safety features like what can be done on larger ships, the aim is to minimize the inherent danger posed by the batteries by limiting the amount of heat and gas produced due to an internal cell failure.
3. Limiting cell size and propagation between cells minimizes the inherent danger. The EES system would however still need to be protected from an external event onboard which could have the potential for damaging the EES system leading to uncontrollable production of heat and gas release.

7. Supervision of ships with maritime EES systems

1. The supervision of passenger ships with EES systems onboard is carried out by the NMA.
2. The supervision of EES systems onboard cargo ships of less than 15 meters in overall length as well as fishing vessels of less than 15 meters in overall length, can only be performed by companies authorized by the NMA for this particular activity.

8. General

1. Any EES system to be installed onboard should have a valid type approval(s) issued by a classification society recognized by the NMA based on applicable and relevant rules and a type approval scheme for maritime EES systems. The type approval should also document compliance with section 9 and 10 of this circular, as applicable.
2. A design verification report in combination with tests required by a type approval scheme for maritime EES system witnessed and endorsed by a classification society recognized by the NMA may replace a valid type approval(s).
3. Any conditions listed in any type approval(s) of components included in the EES system should be fulfilled (e.g. arrangement, documentation, testing).
4. Documentation (including FAT, quay and sea trial test procedures) and test reports necessary for assessing whether the applicable EES system complies with the requirements should be made available.
5. Documentation and test reports should be submitted to the NMA or entities authorised to act on the behalf of the NMA, upon request.

Note:

*3rd party involvement (*e.g. by a classification society recognized by the NMA*) is not required by the NMA for vessels of less than 24 metres in length (L).*

9. Thermal runaway propagation

1. The design of the EES should ensure any thermal runaway is contained within the cell of origin and does not propagate to any other cell.
2. A cell should not produce a volume of off-gas larger than 300 litres (normalized to 25 ^{0}C and 1 atm).
3. A submodule of cells is accepted as a "cell" if it does not produce a volume of off-gas larger than 300 litres (normalized to 25 ^{0}C and 1 atm).
4. Verification should be performed at EES level (IEC 62619 section 7.3.3).
5. An EES should be tested according to requirements adopted in IEC 62619 (7.3.3 and Appendix B) with the following modifications implemented:

- The method for initiating the thermal runaway should be heating or overcharge as listed in IEC 62619 Appendix B B.3 (method 1 or method 2), or a combination of the two. The method chosen should be in accordance with the battery technology and design subject for test.
- The test should be repeated 3 times and be successful each time.
- The test should be performed at an ambient temperature of the maximum operating temperature (+/-5°C) for the battery system.
- All cells within the module must be electrically connected, except if overcharge method is used for initiating the thermal runaway, then the cell being overcharged can be electrical disconnected.
- The module should be considered under test for 24 hours after thermal runaway.
- If a coolant media is used to prevent propagation it should be released automatically. The EES should be tested in the same configuration which it will be installed.

6. Acceptance criteria is defined as:

- only the cell which is directly caused to fail by testing, show fire or off-gassing, and
- all other cells in a module show no external signs of thermal runaway and still produce a measurable voltage within the normal operating range.

7. Neighbouring cells equipped with CID may have no measurable voltage if the cells' CID is activated due to high temperature. For such cells, it is acceptable that the voltage is not measurable.

10. Design

1. External connections between and from EES system module(s) to first short circuit protection should be short circuit proof as defined by requirements adopted by IEC or a classification society recognised by the NMA, whichever provides the most rigid requirement.
2. EES system should only use flame-retardant material according to IEC 60092-101.
3. Liquid cooled EES system should be designed such that the risk of leakage of the internal cooling liquid in the EES is minimized and do not lead to hazardous creeping currents, electrolysis, short circuit, electric arcing, earth faults or other hazards. Internal leakage detection should be arranged and initiate an alarm at a manned control station.
4. Emergency isolation of the EES system should be arranged easily accessible (outside of the EES space) to ensure and prevent that no energy flows to or from the EES.
5. The emergency isolation should be arranged as hardwired circuitry separated from components and cables used for control, monitoring and alarm functions.
6. The emergency isolation circuitry should be monitored for cable break and short-circuit and be arranged as fail-safe (fail-safe condition should be subject to evaluation and defined by the shipowner).
7. Cable break or short-circuit of emergency isolation circuitry should initiate an alarm at manned control station.
8. The outgoing circuits on an EES system should be provided with switchgear for isolating purposes to facilitate maintenance.
9. Main electrical connections of EES system should be located at the top of the enclosure and be protected from water ingress. Other arrangement may be accepted provided it is demonstrated to be sufficiently shielded or otherwise suitably protected.
10. Minimum ingress protection rating of EES system and its electrical connections should not be lower than IP 44.
11. The electrical converter used by EES system should communicate with and operate within the limits given by the BMS in accordance with the capacity specified by the EES application. The electrical converter and EES should operate as an integrated system.
12. The electrical converter used by the EES system should protect the EES system against overvoltage and undervoltage. The voltage protection should be independent of the BMS, i.e. utilize independent voltage sensors. The protection level should be within the allowable operating values of the EES system.
13. Charging and discharging failure should initiate an alarm at manned control station.
14. When the charging system for the onboard EES system is located onshore, the integration should be documented and verified. As a minimum, the following should be defined and verified:

- electrical interface (including functional test of electrical protection)
- BMS control and monitoring (including failure alarms)
- emergency disconnect function
- safety functions
- fail-safe response

15. The EES system should be arranged to permit safe access for replacing components, inspecting, testing, replenishing, and cleaning.
16. Where the EES system is the main source of electrical power, the system should be able to provide electrical power to a main switchboard independent of any remote control (e.g. PMS, IAS) system which is not part of the EES system.
17. EES system manufacturers or suppliers should maintain records of any safety-related changes made on EES system as a result of defects being detected in hardware and software and inform end user as well as the NMA of the need for modification in the event of defect/failure.

11. Safety philosophy

1. The arrangements of an EES space should ensure that the safety of passengers, crew and vessel is not compromised.
2. The safety philosophy for the EES space should be documented and should address any actual and potential hazards represented by the type of EES system installed and should as a minimum address the following:

- gas development hazard (toxic, flammable, corrosive)
- fire hazard
- explosion hazard
- necessary detection, monitoring and alarm systems (off-gas detection, fire detection etc.) and ventilation
- ventilation handling in case of off-gas release or fire, including safe ventilation after an event
- external hazards (fire, water ingress, submersion in freshwater, submersion in seawater, etc.).

3. Recommended minimum training and competence of crew to ensure safe operation, including emergency situations, should be described.
4. The safety philosophy should be based on the actual vessel and the EES system to be used. The safety description for the EES system, as required by certifying recognized classification society, should be used as basis.

12. Source of electrical power

1. Where the main source of electrical power is based on a maritime EES system only, the following conditions should be satisfied:

- Redundancy should be arranged in accordance with requirements stated in regulations referred to in section 5 (“References”).
- An energy management system (EMS) should be installed which complies with requirements of a classification society recognised by the NMA .

2. The following conditions should be monitored at a manned control station:

- available energy of the EES systems
- available power of the EES systems

3. When a maritime EES system is used as the main source of electrical power, due considerations should be given to the capacity of the EES system in order to adequately cover the required range and environmental conditions of which the vessel is intended to operate in.
4. When a maritime EES system is used as the main or emergency source of electrical power, periodical verification of SOH should be performed in accordance with the manufacturer's instructions.

13. Arrangements

1. The EES system should be installed in compliance with instructions given in the manufacturer's installation manual and EES manufacturer's safety description.
2. The EES system should be installed in an easily accessible space (hereby referred to as EES space) located behind the collision bulkhead. For ships not required to have a collision bulkhead, EES space should not be located forward of 0.05L (m) from the forward perpendicular.
3. The EES space should not be a part of the vessel's accommodation space.
4. The EES space ambient temperature should be monitored. Alarm and indication should be independent of the EES system.
5. For vessels of 15 meters in overall length or more should equipment only associated with the EES system be placed within the EES space.
6. For vessels of less than 15 meters in overall length should no high risk fire objects, combustion machinery, flammable liquids/gases or similar, not integral to the EES system, be located in the EES space.
7. Pipes should not be installed in the EES space so that it may be endangered in the event of leaks. If installation of pipes close to the EES system is unavoidable, the pipes should not have any flanged or screwed connections in this area.
8. The EES space should be protected from any sea water ingress through openings, including ventilation inlets and outlets, considering the ships operational parameters.
9. The EES system should be shielded or otherwise suitably protected to avoid as far as practicable any spray or leakages.
10. Fire hydrants should be avoided inside the EES space.
11. The EES system installation should be mechanically secured considering vessel motion, impact, etc.

14. Monitoring and alarm, safety control systems

1. As a minimum, the following conditions should be monitored at a control station:

- ambient temperature in EES space.
- indication of ventilation running in the EES space and EES cabinets as applicable.

2. As a minimum, the following abnormal conditions should initiate an alert at a manned control station:

- high ambient temperature in EES space.
- low ambient temperature in EES space.
- failure of EES space ventilation.
- Request for manual load reduction
- EES system common failure
- EMS common failure
- EES out-of-energy (shutdown imminent warning)

Note:

The above list is not exhaustive. Any safety related parameter should be added if needed to ensure the safety of passengers, crew, and vessel.

3. Any monitored parameter or alert included in the design evaluated by a classification society recognised by the NMA in connection with the type approval(s) issued, should be included as stipulated by the design, subject for type approval application.
4. No single failure should cause loss of both safety and alarm functions of the EES system.
5. The safety system and the system for indication, control, and alarm of the EES system should be mutually independent. Mutually independence is considered attained when a single system failure occurring in either of the systems has no consequences for the maintained operation of the other system.

6. Indication, control, alarm, and safety control systems should comply with the requirements of the classification society recognised by the NMA.

Note:

For alerts, reference is made to "IMO Code on alerts and indicators (2009)"

15. Ventilation of EES space

1. The EES space should be arranged with a dedicated mechanical ventilation system which, as a minimum, should be fitted with manual control located outside the space served and grouped with the monitoring and alerts station addressed in section 14.
2. If the mechanical ventilation system is continuously running, it should be designed to prevent that the environment of the space is resulting in damaging conditions (e.g. temperature, salinity, humidity) for the EES system.
3. If the mechanical ventilation system is not continuously running, the space shall be treated as a confined space with regards to entering.
4. The mechanical ventilation system of the EES space should be designed for a capacity of not less than six (6) air changes per hour (ACH).
5. The ducting of the mechanical ventilation system for EES space should have exhaust outlet directly to open air and have separated ducting from the accommodation.
6. Ventilation ducts to and from the EES space should be made of steel and able to withstand the air temperature originating from the space in case of an incident.
7. When a EES space ventilator is fitted with a closing device, a warning notice should be provided at the closing device to mitigate the possibility of inadvertent closing.
8. All ventilation inlet and exhaust from EES spaces and EES enclosures should be evacuated directly to open air where any possible toxic gases will not endanger crew or passengers (e.g. away from muster stations, emergency exits or lifeboats/rafts).
9. Inside the EES space, the ventilation exhaust should be located within 0.4 metre measured from the ceiling. The inlet should be located as close to the flooring as practical to ensure the air is well circulated inside the EES space.
10. Local start/stop of EES space ventilation should be possible upon any failure in the remote or automatic control system without entering the EES space(s).

16. Off-gas ventilation

1. The ventilation of EES systems with an integrated off-gas ventilation duct should be arranged as follows:

1.1. If duct inlets are arranged, these should be provided with non-return valves/flaps.

1.2. Integrated off-gas ventilation ducts should not be fitted with fire dampers.

1.3. Areas on open deck within 1.5 m of the exhaust openings of the EES off-gas ventilation duct are classified as extended hazardous areas zone 2.

1.4. A mechanical ventilation inlet should be provided in the EES space, delivering over-pressure in the EES space in relation to the EES' integrated off-gas ventilation duct.

1.5. If the EES system is the only main source of electrical power, ventilation dampers and EES space entrances to be closed to retain any existing overpressure in the EES space.

2. For EES systems which ventilate possible off-gas directly into EES space during a failure incident, as defined in section 9, it should be documented that the onboard arrangement fulfils IEC 60079-10-1 requirements resulting in the EES space to be classified as zone 2 NE (negligible extent).

17. Fire safety

1. Fire integrity of the EES space for fishing and cargo vessels, both of less than 15 meters in overall length should as a minimum be A0 or FRD60, insulated on the EES side.
2. Fire integrity for passenger ships irrespective of length, and fishing or cargo vessels both of 15 meters in overall length or more, should comply with the following standards:

2.1. Minimum A0

2.2. A30 towards:

2.2.1. spaces containing high risk fire objects, combustion machinery or flammable liquids. Insulated on both sides when build is aluminium.

2.2.2. control stations, accommodation spaces, muster and embarkation stations, insulated on EES side when build is aluminium.

2.3. For FRP construction, fire integrity of the EES space should be FRD60, insulated on EES side and both sides towards high risk fire objects.

3. Access to the EES space should be through normally closed doors with alarm or self-closing doors.
4. Normally locked access hatches do not need to be equipped with alarm.
5. Fixed fire detection system should be provided in EES spaces.

5.1. Combined smoke and heat detectors or a combination of smoke and heat detectors should be installed.

5.2. The vessel's fixed fire detection system can be utilized also for fire detection in EES space.

6. Fire extinguishing capacities should be arranged as follows:

6.1. Information given in the safety description for the EES should be taken into consideration when selecting fire extinguishing system for the EES space.

6.2. Fishing and cargo vessels both of overall length between 8 meters and 15 meters should have a fixed fire extinguishing system approved for use in engine rooms on such vessels, installed in the EES space.

6.3. In passenger ships irrespective of length, fishing and cargo vessels, both of 15 meters in overall length or more should be protected by a fixed fire extinguishing system. One of the following systems should be applied:

- a water-based system according to IMO MSC/Circ. 1165, as amended by MSC.1/Circ.1269 and MSC.1/Circ.1386.
- an *inert* gaseous agent according to FSS Code Ch.5, IMO MSC/Circ.848, as amended by IMO MSC/Circ. 1267.
- a CO_2 system as specified in FSS Code Ch.5.

6.3.1. If a water-based system is used, the system:

- should be designed to discharge fresh water for 30 minutes operation.
- should be served by dedicated fresh-water tank(s) or from utility service tanks with low-level alarms.
- is not required to be arranged for change-over to seawater upon completed discharge of stored fresh water.
- Suitable arrangements should be made for the drainage of water discharged upon activation of the system.

6.3.2. Gaseous agents or CO_2 systems should be provided with a second, independent charge with same capacity as the first charge.

6.4. If the extinguishing strategy involves closed ventilation during a fire, a strategy for safe ventilation of the EES space after an incident should be developed with due regards to explosion risk and toxic gases. The strategy for safe ventilation should be included as part of the safety philosophy of EES system installation onboard as described in section 11.1.

Note:

Water-based extinguishing system is recommended due to its inherent heat absorbing capabilities. Any intended use of seawater should be evaluated with regards to the potential risk involved.

18. Complete EES system

1. An EES system intended to be designed as a self-contained and standalone enclosure is referred to as a "complete EES system". The term "EES space" used in this guideline, will then be considered as the internal space of the standalone enclosure.
2. For complete EES systems this guideline applies with the following amendments:

2.1. Complete EES system should be designed to ventilate possible off-gas into an integrated off-gas ventilation duct, shielding the gas from possible ignition sources. Guidance on ventilation stipulated in section 15 and 16.1.4 is not applicable.

2.2. Demands for fixed fire extinguishing is considered fulfilled when the complete EES system is installed in a space protected by a fixed fire extinguishing system, or when the complete EES system is installed on open deck.

2.3. For other EES system design, e.g. EES-systems with exposed battery modules installed on open deck, this guidance should not hinder the testing, development or use of an innovative solution provided it is justifiable in terms of safety.

3. A complete EES system when placed on open deck should be designed to withstand any expected external influences and forces, including external cooling e.g. by saltwater during a thermal event.
4. A complete EES system design should be subject to an ISO 9001 certified 3rd party evaluation. The design evaluation should include system testing, and should as a minimum verify compliance with these guidelines and confirm that no single failure would:

- directly results in conditions more severe than those which apply for the EES type testing
- results in loss of any function or designed construction required for the safe operation of EES system.

19. Documentation

1. The following documentation should be submitted to the NMA:

1.1. Safety philosophy as described in section 11, including:

- Copy of valid type approval certificate(s)
- Safety description by EES supplier
- Arrangement drawing(s) of EES space
- Hazardous area classification
- Conformance with the guidelines

1.2. Fixed fire extinguishing system in EES space

1.3. Ventilation arrangement of the EES space

1.4. Onboard test procedure (EES system - equipment and vessel specific)

1.5. Onboard test report (EES system - equipment and vessel specific)

2. The following documented procedures should be kept onboard:

- charging procedure
- normal operation procedures of the EES system
- local operation procedure, if applicable
- conditions and procedures to prepare the EES system for extended period of standby
- emergency procedure
- procedure for safe ventilation of the EES space after an incident

3. When one of the main sources of electrical power or the emergency source of electrical power is based on maritime the EES system, SOH verification procedure should be kept onboard.

20. Deviations

1. A company that wishes to satisfy the provisions of the Ship Safety and Security act in other ways than set out in this guideline, the NMA presupposes that for new and alternative technology, a technical analysis is carried out based on MSC.1/Circ.1455 Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments.

21. EES systems below 20kWh

1. Vessels which have EES systems of less than 20kWh installed should conform with the requirements of ISO/TS 23625 “Small craft — Lithium ion battery”.
2. Risk analysis should be carried out and documented based on the risk of gas formation, explosion and fire, cf. Regulations of 1 January 2005 No. 8 on working environment, health and safety for persons working on board ships, section 2-2.

22. Cold ironing (shore-to-ship power, alternative maritime power)

1. Vessels with a maritime EES system based on Li-ion batteries or similar technology (hybrid vessels) installed, should have shore-to-ship power connection arranged in order to facilitate main and auxiliary engines to be turned off while at berth. The shore-to-ship power connection should be arranged in accordance to recognized international standard (IEC) or applicable rules by a classification society recognised by the NMA.

Knut Arild Hareide
Director General

Håvard Gåseidnes
Acting Head of Department

This document is approved electronically and therefore does not have handwritten signatures