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CR CLASSIFICATION SOCIETY

GUIDELINES FOR HYBRID POWER PROPULSION SYSTEM

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GUIDELINES FOR HYBRID POWER PROPULSION SYSTEM

CONTENTS

Abbreviations

BMS	Battery Management System
ECS	Energy Control System
EHPS	Electric Hybrid Power System
EESS	Electric Energy Storage System
FMEA	Failure Mode and Effect Analysis
HMPS	Hybrid Mechanical Propulsion System
PB	Power Back up
PM	Power Management
PMS	Power Management System
PTIB	Power Take In Booster
PTIFE	Power Take In Fully Electric
PTO	Power Take Off
ZE	Zero Emission
IEC	International Electrotechnical Commission

Figure Annotations

	AC to DC Converter
	AC to AC Converter
	DC to DC Converter
	DC to AC Inverter
	3-Phase Switchboard
	2-Phase Switchboard
	Transformer
	Electric Propulsion Motor
	Electric Propulsion Motor/Generator
	Generator set
	Electric Energy Storage System
	Diesel Engine
	Gearbox

Preamble

CR Classification Society (hereinafter referred to as the Society) has published a series of Guidelines for hybrid electric technologies (e.g. Guidelines for Fuel Cell Installation, Guidelines for Lithium-ion Batteries Applied to Marine System / Equipment (hereinafter referred to as the GD-LI-BAT), etc.). In view of the hybrid power systems in wide use in the marine for the future, the Society focuses on the integration of those new technologies with conventional power generation to develop the Guidelines for Hybrid Power Propulsion System (hereinafter referred to as the Guidelines).

The Part A of the Guidelines describes the electric hybrid power system which includes electric energy storage system supporting electric propulsion and/or the main electrical distribution system. The EESS is different from the main and emergency power sources and capable of providing power without interruption in the event of generator failure. For this purpose, the Power Management System (PMS) is required for synchronizing power source and load sharing.

The Part B of the Guidelines describes the hrbrid mechanical propulsion system which combines diesel and electric propulsion modes. The propulsion system allows for either independent or combined operation of both propulsion modes. Hybrid propulsion system arrangement provides with a higher flexibility and efficiency, over a range of operating modes for the propulsion system, and applies to slow speed operation up to boosting mode.

Part A Electric Hybrid Power System

Chapter 1 Electric Hybrid Power System

1.1 Application

1.1.1 The class notation **EHPS** may be assigned to ships provided with an Electric Energy Storage System (EESS) used to supply the electric propulsion and/or the main electrical power distribution system of the ship.
The notation **EHPS** is to be completed, between brackets, by at least one of the following complementary notations:

(a) **PM** (Power Management) mode : at least one of the following power management modes is available:
(i) Load smoothing mode
(ii) Peak shaving mode
(iii) Enhanced dynamic mode
as defined in 1.2.3 of Part A

(b) **PB** (Power Back up) mode : as defined in 1.2.4 of Part A, is available

(c) **ZE (**Zero Emission) mode : as defined in 1.2.5 of Part A, is available

Examples of notations are given below:
- **EHPS (PB)**
- **EHPS (PM, ZE)**

1.1.2 The EESS aims to assist the electric propulsion and/or the main electrical distribution system with the power demand, and/or to take over from the main source of electrical power.

1.1.3 The notation **EHPS** applies to the following cases, as illustrated in Fig. A 1-1 of Part A:

(a) The EESS supplies the main switchboard

(b) The EESS supplies a propulsion switchboard

(c) The EESS supplies both the main switchboard and a propulsion switchboard

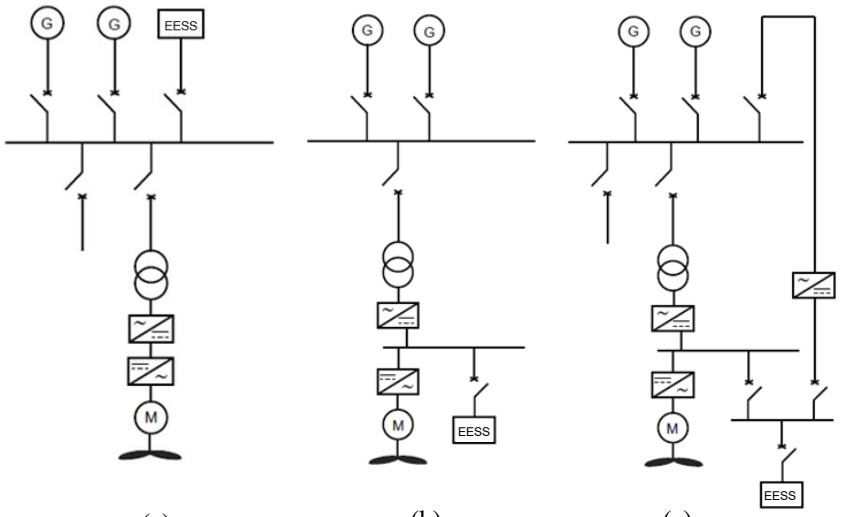

Fig. A 1-1
Typical EESS Supply Arrangements

Note:
(1) The examples given in Fig. A 1-1 of Part A are for an AC network. The same principles apply to a DC network.

1.2 Definitions

1.2.1 Electric Energy Storage System (EESS)

The EESS is a system based on battery packs, semiconductor converter (if any) and transformer (if any). It is used to supply the electric propulsion and/or the main electrical power distribution system of the ship.

The EESS may be based on the following configurations (see Fig. A 1-2 of Part A):

(a) direct supply (DC switchboard)

(b) supply through a DC/DC semiconductor converter (DC switchboard)

(c) supply through a DC/AC semiconductor converter and/or a transformer (AC switchboard)

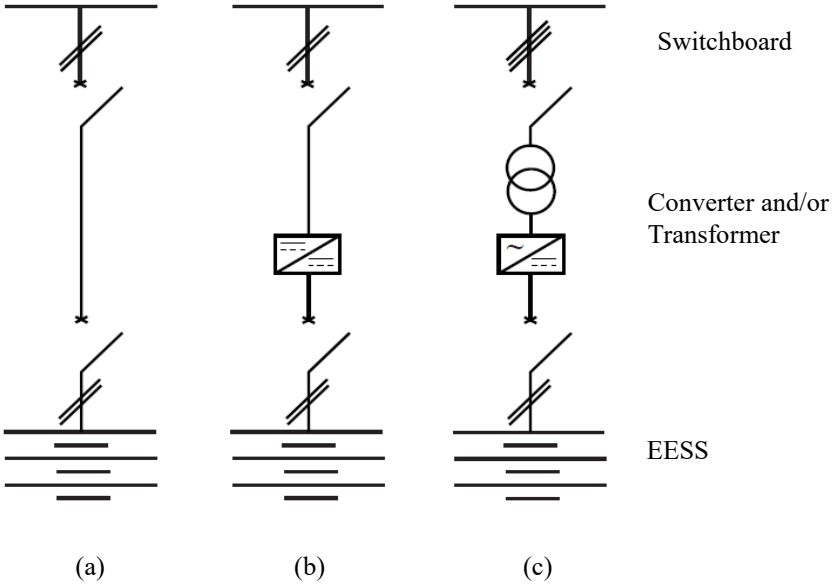

Fig. A 1-2
EESS Possible Configurations

1.2.2 Energy Control System (ECS)

The ECS ensures the overall control and monitoring of the EESS including battery, converter, transformer and circuit breaker.

1.2.3 Power Management mode (PM mode)

For the purpose of this section, the term PM mode is used for one of the following power management modes (see Fig. A 1-3 of Part A):

(a) Load smoothing mode:

Load smoothing mode is a mode where the EESS is charged and discharged all the time to compensate for the network load variations within a given amplitude above or below the average.

This will result in limited load fluctuations of the main generating sets, allowing optimised fuel consumptions and reduced exhaust gas emissions.

Note:
This mode is also named load optimising mode.

(b) Peak shaving mode:

Peak shaving mode is a mode dedicated to instant power demand. The goal is to supply peaks of a highly variable load (e.g. during manoeuvring) and to avoid the connection of an additional main generating set.

(c) Enhanced dynamic mode:

Enhanced dynamic mode is mainly related to gas fuel or dual fuel generating sets. In case of sudden load increase, the EESS instantaneously supplies the corresponding power demand, thus enhancing the generator dynamic performance, and, for dual fuel engines, preventing the possible switch-over to fuel oil due to ramping-up.

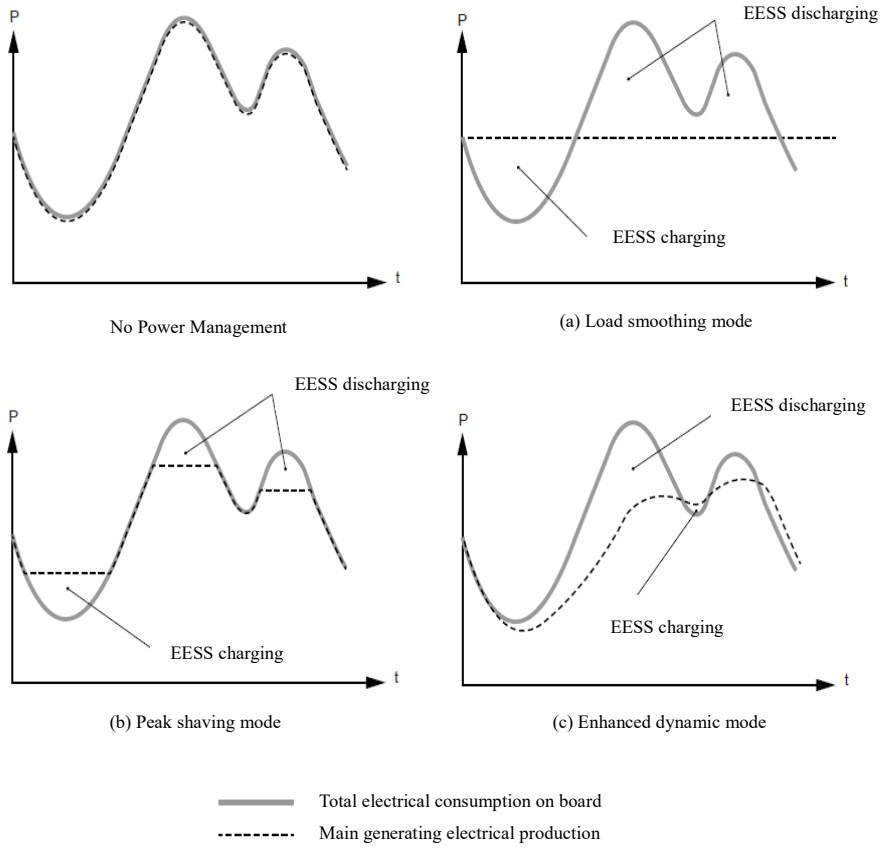

Fig. A 1-3
PM Modes

1.2.4 Power Back up mode (PB mode)

The PB mode is a mode where the EESS is permanently connected to the main electrical power distribution system of the ship and is able to deliver power immediately in case of failure of one main generating set.

Note:
This mode is also named spinning reserve mode.

1.2.5 Zero Emission mode (ZE mode)

The ZE mode is a mode where the EESS is temporarily the only source of power connected to electrical network. This mode allows stopping all the main generating sets, the main diesel engines, boilers and incinerators, if any, and the associated emission of exhaust gas for a specified period of time (manoeuvring, ship at berth).

Note:
The ZE mode, unlike the PB mode, is activated on a voluntary basis.

1.2.6 State of charge

Available capacity in a battery expressed as a percentage of rated capacity.

1.2.7 State of health

An indication of the general condition of a battery compared to its ideal conditions (i.e., a new battery). The unit of state of health is percent points (100% = the battery's conditions match the battery's specifications).

1.2.8 Battery support system

A battery support system is a group of interconnected and interactive parts that performs an essential task as a component of a battery system.

Note : Such systems are, for example, electrolyte circulation pumps, cooling and heating devices or fire extinguishers.

1.3 Documents to be Submitted

1.3.1 The documents to be submitted are listed in Table A 1-1 of Part A

Table A 1-1 Documents to be Submitted

No.	I/A(1)	Documents
1.	I	General description of the EESS and the different operating modes
2.	I	Power balance(2)
3.	A	Failure Mode and Effect Analysis (FMEA) regarding the availability of ship propulsion and main electrical source of power
4.	A	List of alarms and defaults. This list is to describe alarms and defaults directly connected to the battery system and interfaces with other ship systems
5.	I	Operation manual of EESS
6.	A	Test programs related to type approval, factory acceptance test and onboard tests including the standards used for design and testing procedures
7.	I	Reports related to test programs for type approval, factory acceptance test and onboard tests
8.	I	Maintenance manual and maintenance schedule
9.	I	For ZE mode: Electrical load balance and specified design autonomy period, see 3.5.3 of Part A
10.	I	For PB mode: Electrical load balance(s) for power back up, see 3.5.2 of Part A
Notes: (1) I: to be submitted for information. A: to be submitted for approval. (2) The load balance is to include the battery charging phase. See 2.2.10 of Part A.		

Chapter 2 System Design

2.1 Quality of Power Supply

2.1.1 In principle, the electrical power quality of EHPS should be designed, manutactured and maintained within the requirements specified in 1.5 of Part VII of the Rules, which are the standards followed by electrical power systems, components and the equipment for constructing electrical power systems.

In cases where the electrical devices are to be designed to operate outside of these limits and justifications are to be submitted by the manufacturers to the Society.

2.2 Power Distribution

2.2.1 The EESS is not considered as forming part of the main source of electrical power, as definition in 11.2.1 of Part VII of the Rules.

2.2.2 The EESS is to remain independent of the emergency source or transitional source of power, if any, required in 11.3 &11.4 of Part VII of the Rules.

2.2.3 For PM mode, where generators can be paralleled, a PMS is to be provided. The system is to include automatic start, synchronizing, connecting and load sharing. Where the number of generators in service is to vary according to operating conditions, starting and connecting of supplementary generators, entailed by the use of equipment during manoeuvring, is not to require intervention in machinery spaces.

2.2.4 For PB mode, the EESS is to be able to maintain without a break the continuity of the power supply, in case of failure of one main generating set.

2.2.5 A FMEA is to be carried out in accordance with IEC Publication 60812 or any other recognised standard in order to demonstrate the availability of ship propulsion and main electrical source of power in case of failure of the EESS.

2.2.6 The EESS may be used in addition to the emergency source or transitional source to supply services other than those listed in 11.3 &11.4 of Part VII of the Rules.

2.2.7 The EESS is to be able to be charged either by the ship electrical network or at quay through a shore supply.

2.2.8 In all operating modes, the electrical protection selectivity of the distribution system is to be ensured.

2.2.9 The short-circuit current calculation is to take into account the EESS. In calculating the maximum prospective short-circuit current, the source of current is to include the most powerful configuration of generators which can be simultaneously connected (as far as permitted by any interlocking arrangements), and the maximum number of motors which are normally simultaneously connected in the system.

2.2.10 PB mode and ZE mode

An electrical load balance corresponding to battery charging mode is to be submitted for information.
The maximum battery charging current is to be taken into account.

Chapter 3 Electric Energy Storage System

3.1 Battery Pack

3.1.1 Battery pack cooling

Battery pack cooling is to be ensured either by the ventilation of the battery compartment or by direct cooling (dedicated cooling circuit).

When a direct cooling is installed, the following alarms are to be provided, where applicable:

(a) High temperature of the cooling air of battery pack provided with forced ventilation(1)

(b) Reduced flow of primary and secondary coolants of battery packs having a closed cooling system with a heat exchanger(1)

Note:

(1) As an alternative to the air temperature and to the cooling flow, the supply of electrical energy to the ventilator may be monitored.

3.1.2 Protection against ingress

IP rating of the batteries is to be fitted in relation with the location of the installation and the risk of ingress. The minimum required degree of protection is as follows:

(a) IP 4X for battery packs with nominal voltages in excess of 500 V DC

(b) Not less than IP 44 for battery packs located within areas protected by fixed water-based local application fire-fighting systems

3.1.3 Lead-acid batteries

The requirements of this section apply to permanently installed storage batteries (not to portable batteries). The requirements mentioned in Chapter 6 of Part VII of the Rules apply to these types of batteries.

3.1.4 Lithium batteries

Lithium battery pack charging and discharging are to be controlled with a Battery Management System (BMS) in accordance with 2.2 and 4.2.2(g) of the GD-LI-BAT. The installation and operation of lithium battery systems are to comply with the GD-LI-BAT.

3.1.5 Risk assessment

A risk assessment is to be conducted and submitted to the Society for review in accordance with 3.2 of the GD-LI-BAT. Other types of batteries may be accepted by the Society on a case-by-case basis.

3.2 Semiconductor Converter

3.2.1 The EESS semiconductor converter, if any, is to be in accordance with Chapter 15 of Part VII of the Rules.

The semiconductor converter may be rated for intermittent power demand. The rating is to be determined on the basis of the operating profile of the ship.

3.3 Transformer

3.3.1 The EESS transformer, if any, is to be in accordance with Chapter 7 of Part VII of the Rules.

The transformer may be rated for intermittent power demand. The rating is to be determined on the basis of the operating profile of the ship.

3.4 Energy Control System

3.4.1 The ECS is to be independent of:

(a) BMS, and

(b) PMS

3.4.2 The electronic components of the ECS are to be constructed to withstand the tests required in 2.11 and 2.12 of Part VIII of the Rules.

3.5 Capacity

3.5.1 PM mode

In PM mode, the capacity of the EESS is to be such that it covers the operating profile of the ship in normal operation during 24 hours, including at least one maneuvering cycle, without reaching the EESS state of charge low level.

3.5.2 PB mode

An electrical load balance corresponding to PB mode is to be submitted for information. Load shedding of nonessential services and services for habitability may be considered for definition of this load balance.

The capacity of the EESS for PB mode is to be sufficient to supply, in this condition, the main switchboard during at least twice the time necessary to start a standby source (refer to 11.2.1 of Part VII of the Rules).

3.5.3 ZE mode

An electrical load balance corresponding to ZE mode is to be submitted for information.

The capacity of the EESS is to be such that ZE mode can be maintained in this condition during a design autonomy period specified by the designer and at least twice the time necessary to start a standby source (refer to 11.2.1 of Part VII of the Rules).

3.6 Charging

3.6.1 After partial or full discharge, the charging current of the batteries will be limited due to the high temperature of the battery cells.

Therefore, in PB and ZE mode, the charging current and the time to charge completely the batteries is to be evaluated during a charging test, just after the EESS has been discharged in the conditions of load balance for PB or ZE mode, as defined in 3.5.2 and 3.5.3 of Part A respectively.

3.7 Control and Instrumentation

3.7.1 The EESS is to be easily disconnectable from the main machinery control room. Further to this operation, starting of a standby source, if necessary, is to be automatic.

3.7.2 The following information is to be permanently displayed at the main machinery control room:

(a) Active operating mode (load smoothing mode, peak shaving mode, enhanced dynamic mode, PB mode, ZE mode)

(b) Charging/Discharging status of the EESS

(c) State of charge of the EESS

(d) Remaining autonomy for ZE mode and PB mode

(e) State of health of the EESS

(f) Values of the current/voltage of the EESS

(g) Values of the current/voltage at the battery pack

(h) Active power delivered

3.7.3 EESS parameters are to be monitored or controlled in accordance to Table A 3-1 of Part A.

3.7.4 Additional control and instrumentation for ZE mode and PB mode.

(a) The EESS state of charge low level alarm is to correspond to, at least, the minimum state of charge allowing the time necessary to start a standby main generating set.
This alarm is to be indicated on the navigating bridge.

(b) The EESS state of charge low-low level alarm is to correspond to an imminent shut-down of the EESS.
This alarm is to be indicated on the navigating bridge.

(c) Automatic starting and connecting to the main switchboard of standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required, is to be carried out in the following case:
(i) Failure of the EESS
(ii) State of charge low level alarm of the EESS

Table A 3-1 Monitoring of Electric Energy Storage System

Symbol convention H= high, G= group alarm L= low, LL=low-low I= individual alarm, X= function is required	Monitoring	Automatic control		
		Electric energy storage system	Main generating set	Propulsion motor
Identification of system parameter	Alarm	Shut-down	Standby start	Slow-down
Short-circuit current I max	I	X	X(1)	
Overload	I	X	X(1)	
Overvoltage	I	X	X(1)	
Undervoltage	I	X	X(1)	
State of charge	L		X(1)	X(1)
	LL	X(1)		
Converter(2) air cooling temperature	H			
Transformer(2) air cooling temperature	H			
Converter(2) ventilation fan failure	G			
Transformer(2) ventilation fan failure	G			

Notes:
(1) Applicable only for ZE mode and PB mode.
(2) If any.

Chapter 4 Installation on Board

4.1 Battery Space

4.1.1 General

In general, requirements mentioned in 6.1 of Part VII of the Rules are to be referred to. For lithium batteries, requirements mentioned in the GD-LI-BAT are to be applied.

The power supplied for the EESS ventilation fans is to be provided from two alternative circuits; one of which is the main power source and the other is the emergency source. The supply circuits are to be managed through a change-over switch.

In principle, within the battery room; open deck area within 1 m from natural ventilation outlet, and open area within 3 m from power ventilation outlet are to be regarded as hazardous areas.

(a) Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

(b) Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

(c) Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

(d) Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

4.1.2 Protection against water entry and/or liquid leakage in battery compartment

It should not be possible to have sea water entering battery compartment under normal operating conditions.

The piping systems not involved in battery operation are not to be located in the battery compartment. Departure from this requirement may be accepted by the Society, with the following minimum conditions:

(a) Efficient detection of fluid leakage is implemented in compartment

(b) Pipes are provided with welded joints inside the battery compartment

(c) No flammable fluid is conveyed

(d) Only pipes which are used in low pressure and low temperature seawater systems on ships like cooling, ballast, ballast water treatment system and exhaust gas management systems etc. will be accepted

4.1.3 Protection against falling objects

Access hatches to batteries are to prevent falling of objects directly on battery cells, connections, elements of BMS, and cooling system if any.

4.1.4 Protection against electrostatic hazard

When hazardous areas may be created regarding criteria of IEC 60079 series, the battery room is to be painted with antistatic paintings in the circulating area.

Battery rooms containing lithium batteries need not be painted with antistatic paintings, provided it is confirmed by the risk analysis.

4.1.5 Fire protection

(a) The fire protection for battery rooms should comply with the requirements specified in SOLAS II-2 and the International Code for Fire Safety Systems (FSS Code) with amendments, except for ships engaged in domestic voyages or ships of less than 500 gross tonnage. Ships engaged in domestic voyages or less than 500 gross tonnage will be considered on a case-by-case basis by the Society.

(b) The fire safety for battery rooms containing lithium-type batteries should comply with 3.1.2 of the GD-LI-BAT to ensure their safety in maritime operations.

(c) Combined heat and smoke detection is to be installed in battery rooms for lithium-type batteries.

4.1.6 Accessibility for maintenance

It is to be possible to enter the battery compartment for common maintenance and to overhaul battery system elements in a safe manner.

Chapter 5 Testing

5.1 Factory Acceptance Tests

Each individual component is to be tested separately.

5.1.1 EESS battery pack and associated BMS

(a) General

Battery pack are to be constructed and tested in accordance with the relevant IEC publications 62619 and 62620.
Battery pack constructed and tested in accordance with other standards may be accepted, provided they are in accordance with an acceptable and relevant international or national standard and are of an equivalent or higher safety level, to the satisfaction of the Society.

(b) Factory acceptance tests

The following items, at least, are to be checked:

(i) Ability to achieve safety functions

(ii) Proper working of alarms and defaults and related functions and/or interfacing to the other ship systems

(iii) Proper working of monitoring systems

(iv) Temperature rise test[(1)(2)]

(v) Insulation tests (High voltage test and insulation resistance test according to 5.8.2 and 5.8.3 of Part VII of the Rules respectively)

(vi) IP characteristics

Notes:
(1) When this test is impractical at the factory, the following alternative may be considered:
- a calculation based on a method validated by tests is to be submitted to the Society, and
- proper working of the cooling circuit is to be checked after installation onboard

(2) The test condition to be selected is the most unfavorable nominal operating conditions of the batteries. (maximum charging or discharging current which will produce the maximum heating losses.)

5.1.2 EESS semiconductor converter

Refer to the requirements mentioned in 15.2 of Chapter 15 of Part VII of the Rules.

5.1.3 EESS transformer

Refer to the requirements mentioned in 7.4 of Chapter 7 of Part VII of the Rules.

5.2 Onboard Tests

5.2.1 The following items, at least, are to be checked:

(a) Proper working of monitoring systems

(b) Proper working of alarms and defaults and related functions and/or interfacing to the other ship systems

(c) Quality of the power supply in the different modes (see 3.5.4 of Part VII of the Rules)

(d) Disconnection of the EESS (see 3.7.1 of Part A) in different operating modes, and automatic start of a standby source, if necessary

5.2.2 Tests to be carried out for PM mode

In PM mode, the following tests are at least to be carried out:

(a) Increasing load steps: The EESS is to deliver power to the electrical network, to compensate for the load steps. In case of continuous load, the load is to be gradually transferred to the running diesel engine. The load is to be shared equally between the diesel engines (see 3.5.4 of Part VII of the Rules)

(b) Additional increasing load steps: The load dependent start of a standby main generating set is to be activated

(c) Checking of the operation if the EESS during 6 hours at least in normal working condition. The EESS state of charge is not to be less than 80% at the end of the 6 hours period
A load analysis curve corresponding to this period is to be submitted for information. This document is to detail the total electrical production on board, the main generating sets electrical production and the EESS electrical production (with charging and discharging cycles)

5.2.3 Tests to be carried out for PB mode

In PB mode, the following tests are at least to be carried out:

(a) Failure of one generator and automatic connection of the EESS

(b) Failure of one generator and EESS autonomy measurement (starting of the standby generator is blocked)

(c) Automatic start of a standby source in case of failure of the EESS or low state of charge of the EESS

(d) Charging test, see 3.6.1 of Part A

5.2.4 Tests to be carried out for ZE mode

In ZE mode, the following tests are at least to be carried out:

(a) Load discharge test with EESS autonomy measurement up to EESS state of charge low level

(b) Automatic start of a standby source in case of failure of the EESS or low state of charge of the EESS

(c) Charging test, see 3.6.1 of Part A

5.3 Tests of Battery Compartment and Fire-Extinguishing System

The following items, if fitted, are to be carried out:

5.3.1 Fire detection

Efficiency of fire detection is to be tested.

5.3.2 Dangerous gas detection

Efficiency of dangerous gas detection is to be tested. This includes testing that detectors were properly positioned to detect dangerous gas concentration in any normal circumstance of operation of the ventilation system.

5.3.3 Fire-extinguishing system efficiency

Efficiency of fire-extinguishing system is to be tested. Gas concentration after fire-extinguishing system operation is to be measured and found high enough to prevent an explosion or stop a fire. Other criteria may be defined or asked for, to the satisfaction of the Society.

5.3.4 Accessibility of battery compartment

Accessibility for common maintenance and devices used for battery overhaul, if any, are to be tested.

Part B Hybrid Mechanical Propulsion System

Chapter 1 Hybrid Mechanical Propulsion System

1.1 Application

1.1.1 The additional class notation **HMPS** may be assigned to ships provided with a propulsion plant which combines a diesel mechanical propulsion system and an electric propulsion system.

1.1.2 In hybrid propulsion, the diesel mechanical propulsion system and the electric propulsion system may be used separately or together.

Hybrid propulsion configuration offers a higher flexibility and efficiency of the propulsion system, over a range of operating modes, for slow speed operation up to boosting mode.

1.1.3 In addition to the additional class notation **HMPS**, the additional notation **EHPS** may be granted to the ship when an EESS is used and the ship complies with the requirements 1.2.1 of Part A.

1.2 Definitions

1.2.1 Power Take In Fully Electric (PTIFE) mode

This mode describes the functionality of an electrical rotating machine used as motor for propulsion and working alone, i.e. with the diesel engine stopped.

1.2.2 Power Take In Booster (PTIB) mode

This mode describes the functionality of an electrical rotating machine used as motor for propulsion and working in parallel to the diesel propulsion engine.

1.2.3 Power Take Off (PTO) mode

This mode describes the functionality of an electrical rotating machine used as a generator. A part of the energy generated in the main engine is taken off by the generator to produce electricity as an alternative to the generating sets. This mode is also called shaft generator mode.

1.3 Documents to be Submitted

1.3.1 The documents listed in Table B 1-1 of Part B are to be submitted.

Table B 1-1 Documents to be Submitted

No.	I/A(1)	Documents
1.	I	General description of the propulsion systems with their different operating modes
2.	I	Operation manual of the hybrid propulsion system
3.	I	Operating procedure to switch from one propulsion system to another one
4.	A	Power balance in diesel propulsion mode Power balance in PTIFE mode Power balance in PTIB mode, if any
5.	A	List of alarms and defaults
Note: (1) I: to be submitted for information. A: to be submitted for approval.		

Chapter 2 System Design

2.1 Propulsion Systems

2.1.1 The propulsion arrangements defined in Fig. B 2-1 of Part B are accepted. Batteries may be considered instead of diesel generators. Other arrangements may be considered on a case by case basis.

2.1.2 The following propulsion modes are to be made available:

(a) Diesel propulsion mode

(b) PTIFE mode

Note:
For the purpose of granting the additional class notation **HMPS**, the PTIB mode is considered as optional.

2.1.3 As a general principle, the diesel propulsion mode is considered as the main propulsion mode and has priority over the electric propulsion mode.

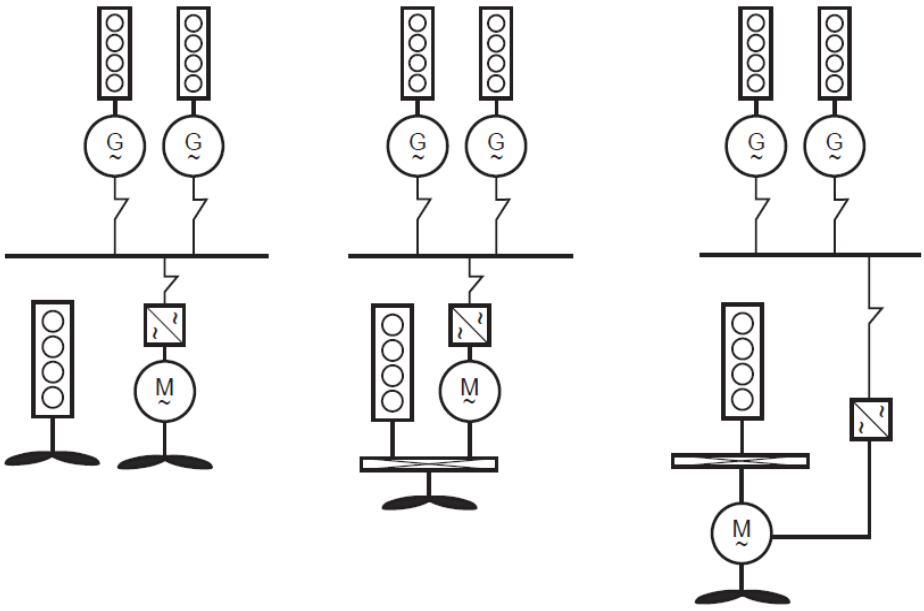

Fig. B 2-1
Propulsion Arrangements

2.2 Electric Production Systems

2.2.1 If the electric motor can work as a generator, such as shaft generator which is intended to operate at constant speed (e.g. a system where ship speed and direction are controlled by varying propeller pitch), it may be accepted as forming part of the main source of electrical power if, in all sailing and manoeuvring conditions including the propeller being stopped, the capacity of these generators is sufficient to provide the electrical power to comply with 11.2.1 of Part VII of the Rules. They are to be not less effective and reliable than the independent generating sets.

2.2.2 In PTIFE mode and in addition to 2.2.1 of Part B, it is not required to have a main source of electrical power complying with 11.2 ~ 11.4 and 11.6 of Part VII of the Rules. When the rotating machine is reversible and can work in PTIB mode or PTO mode (see Fig. B 2-2 of Part B), provided that:

(a) The main source of electrical power complies with 11.2.1 of Part VII of the Rules, in diesel propulsion mode, and

(b) Upon loss of power of one generator, the rotating machine used in PTIB mode switches automatically to PTO mode and connects to the main switchboard in less than 30 seconds

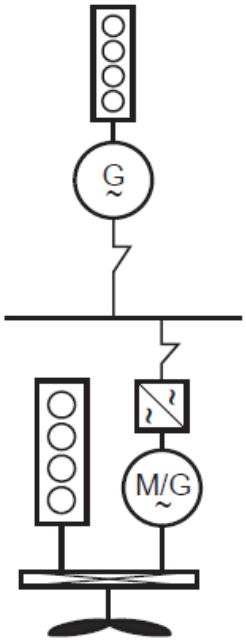

Fig. B 2-2
Specific Arrangement of Electrical Production with PTO Mode

2.2.3 Where the number of generators in service is intended to vary according to operating conditions, the installation is to include automatic start, synchronising, connecting and load sharing.

2.2.4 A longer time than defined in 2.2.2 of Part B may be accepted provided that the ship is granted with the additional class notation **EHPS (PB)** (see 1.2 of Part A). For this particular case, the autonomy of the EESS in PB mode is to be twice the time necessary to switch from electric motor to shaft alternator (see Fig. B 2-3 of Part B).

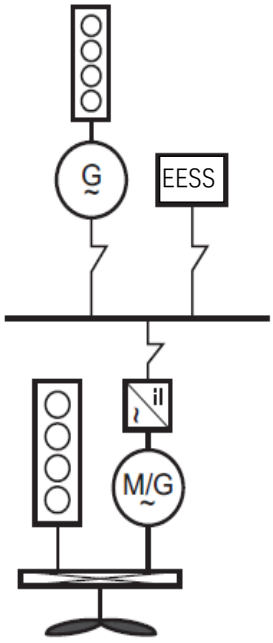

Fig. B 2-3
Electrical Production with EESS

2.3 Diesel Propulsion Systems

2.3.1 The diesel propulsion system is to comply with the requirements of:

(a) Chapter 3 of Part IV of the Rules (diesel engine)

(b) Chapter 6 of Part IV of the Rules (shafting)

(c) The relevant section of Chapter 5 of Part VIII of the Rules if an **CAU** additional class notation is to be granted to the ship

2.4 Electric Propulsion Systems

2.4.1 The electric propulsion system is to allow the ship to proceed at a reference speed in the reference weather conditions, taking into account the foreseen operational area and operating profile. Both the reference speed and the reference weather conditions are to be defined by the owner.

2.4.2 The electric propulsion system is to comply with Chapter 13 of Part VII of the Rules and the relevant section of Chapter 5 of Part VIII of the Rules if an **CAU** additional class notation is to be granted to the ship.

2.4.3 When compliance with 2.4.2 of Part B is not fulfilled, the switch over from the electric propulsion mode to diesel propulsion mode is to be done in less than 45 seconds.

In addition, and as a minimum, the electric propulsion system is to be in accordance with 13.2 and 13.7~13.8 of Part VII of the Rules.

2.5 Combined Diesel and Electric Propulsion Systems

2.5.1 In the case of diesel engines and electric motors acting in parallel on the propeller, provisions are to be made to allow isolating the electric motors from the reduction gear (for instance by means of a clutch or bolted link). In case of failure of the electric motor, it is to be possible to isolate the electric motor from the reduction gear and start the diesel engine in less than 30 minutes.

Chapter 3 Control of Propulsion Machinery

3.1 Remote Control from Navigating Bridge of the Propulsion Machinery

3.1.1 Arrangements are to be made to allow each propulsion mode to be started from the navigating bridge.

3.1.2 It is to be possible to control separately each propulsion mode (diesel propulsion mode, PTIFE mode, PTIB mode, if any) along all the propulsion power range.

3.1.3 Functionalities are to be provided in the navigating bridge to set the diesel propulsion engine in standby mode (diesel engine started, running, declutched).

3.1.4 The type of propulsion in use is to be clearly indicated at each control position.

3.1.5 The control may be performed by:

(a) a single lever combining the diesel propulsion mode, PTIFE mode, PTIB mode if any

(b) 2 levers, one for the PTIFE mode, one for the diesel propulsion mode

3.1.6 Emergency stops required in 13.7.7 of Part VII and 2.8.4 of Part VIII of the Rules are to be independent and separated for both propulsion systems. two separate buttons, installed close to each other, are required.

3.1.7 The propulsion control system is to ensure that the shaft power does not exceed the limit for which it has been designed.

3.2 Local Control of the Propulsion Machinery

3.2.1 The diesel and PTIFE modes are to be provided with direct local controls. The direct local control is to be independent from the remote control circuits, and to take over any remote control.

3.3 Switch over from One Propulsion Mode to Another One

3.3.1 The switch over from one propulsion mode to another one is to be feasible from the navigating bridge. It is not to necessitate any human intervention in the machinery.

3.3.2 The switch over is to require a limited number of actions on the control system. Starting of the auxiliaries necessary for each propulsion mode (cooling, lubricating, etc.) is to be automatic.
When transferring the propulsion mode from one type to another one (for instance from diesel mode to PTIFE mode), no significant alteration of the propeller thrust is to occur.

3.3.3 When only 1 lever is used to control the propulsion, the propulsion mode is to switch automatically from PTIFE mode to diesel propulsion mode when the propulsion power request exceeds the capacity of the PTIFE mode.

3.3.4 When 2 levers are used to control the propulsion, the propulsion mode is to switch automatically from PTIFE mode to diesel propulsion mode when the diesel propulsion lever is used.

3.3.5 It is to be possible to switch manually from one propulsion mode to another one locally.

3.3.6 The local control is to have priority over the remote control. The principles of control transfer, as specified in Chapter 2 of Part VIII of the Rules are applicable for both propulsion modes.

3.4 Displays and Alarms

3.4.1 In addition to the monitoring required in Chapter 2 of Part VIII of the Rules, the following information is to be displayed at each control position:

(a) Indication that diesel propulsion engine is running

(b) Indication that electric propulsion motor is running

(c) Indication of the diesel engine ready to start

(d) Indication of the electrical motor ready to start

(e) Indication of the diesel engine in standby mode

Chapter 4 Testing

4.1 Onboard Tests

4.1.1 The following propulsion modes are to be tested:

(a) PTIFE mode and PTIB mode, if available, according to the manufacturer's test manual and the following:

(i) Dock trials

(1) The dock trials are to include the test of the electrical production system, the power management and the load limitation.

(2) A test of the propulsion plant at a reduced power, in accordance with dock trial facilities, is to be carried out. During this test, the following are to be checked:

a) electric motor rotation speed variation

b) functional test, as far as practicable (power limitation is to be tested with a reduced value)

c) protection devices

d) monitoring and alarm transmission including interlocking system

(3) Prior to the sea trials, an insulation test of the electric propulsion plant is to be carried out.

(ii) Sea trials

Testing of the performance of the electric propulsion system is to be effected in accordance with an approved test program. This test program is to include at least:

(1) Speed rate of rise

(2) Endurance test:

a) operation at normal continuous cruise power for at least 4 hours

b) 1 hour at 100% rated output power with winding temperature rise below 2°K per hour, according to IEC publication 60034-1

c) operation in reverse direction of propeller rotation at the maximum torque or thrust allowed by the propulsion system for 10 minutes

(3) Check of the crash astern operation in accordance with the sequence provided to reverse the speed from full ahead to full astern, in case of emergency. During this test, all necessary data concerning any effects of the reversing of power on the generators are to be recorded, including the power and speed variation

(4) Test of functionality of electric propulsion, when manoeuvring and during the ship turning test

(5) Test of power management performance: reduction of power due to loss of one or several generators to check, in each case, the power limitation and propulsion availability

(b) Diesel propulsion mode, refer to 3.11.4 of Part IV of the Rules

4.1.2 The following tests are to be carried out on the control system:

(a) Proper working of alarms and defaults and related functions and/or interfacing to the other ship systems

(b) Manual switch from diesel propulsion mode to PTIFE mode and to PTIB mode, if available

(c) Manual switch from PTIFE mode and from PTIB mode, if available, to diesel propulsion mode

(d) Transfer of control between the different control positions

(e) Automatic switch from PTIFE mode to diesel propulsion mode (see 3.3.3 and 3.3.4 of Part B)