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INTLREG GUIDANCE FOR BATTERY OPERATED VESSELS 2023

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CHAPTER 1 GENERAL

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SECTION 1 APPLICATION AND DOCUMENTATION

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1.1. Application

1.1.1. This requirement in this Chapter apply to the ships intended to be registered as ships provided with battery systems power and batteries are used for powering main propulsion systems.

1.1.2. Items not specified in this Guidance shall be in accordance with each relevant requirement of INTLREG Rules and Regulations for the Classification of Steel Vessels except for the requirements inapplicable to battery systems on board of ships.

1.1.3. Items not included in this Guidance may comply with IMO, IEC, or equivalent recognized standards by the appropriate consideration of the Society.

1.1.4. Since the battery system has different characteristics depending on the classification of the battery being constructed, this Guidance applies when a battery system with a capacity of 50 kWh or more using lithium secondary battery is used on ships.

1.1.5. Even though the design of the battery systems deviates from those specified in this Guidance, it shall be approved after inspection if it complies with the Rules and Guidance of the Society.

1.1.6. Additional class notation **BATTERY OP** shall be assigned to vessels where the battery systems are used for ship propulsion

1.2. Documents submission

1.2.1. General

For a the vessel where battery power propulsion installed, drawings and data, specified documents below mentioned in [1.2.2] and [1.3] shall be submitted before the work is commenced. Apart from that if the Society need additional documents also shall be submitted

1.2.2. Documents for approval

a) **Drawings**

(i) Arrangement for battery systems

(ii) Drawings showing dangerous hazardous spaces if any.

b) **Battery system**

(i) Specifications

(ii) Dimension, material, operation temperature and weight

(iii) Description and application criteria of the components of the battery system including cell

(iv) Voltage and capacity per unit

(v) Electrical circuit diagram

(vi) Alarm and monitoring items

(vii) List of safety devices (Emergency stop condition)

c) **Energy management system**

(i) Drawings and data for control and monitoring system

(ii) Drawings and data for system configuration algorithm

(iii) Drawings and data for computer based systems

d) **Electrical equipment**

(i) Investigation table of electrical load analysis

(ii) Wiring diagram for power systems

(iii) Calculation sheets of short-circuit current in the circuits

e) **Fire protection and fire extinction**

(i) Arrangement and specification of fire extinguishing systems

(ii) Arrangement of fire detection systems

(iii) Arrangement of fire integrity

(iv) Arrangement of ventilation ducts

(v) Gas detection systems (as applicable)

f) **Risk assessment.**

g) Test programs shall include functional tests (alarm system, safety system, control system,) and further tests, if any, resulting from the risk assessment for the specific battery chemistry (may be included in programme for sea trials or on-board test)

1.3. Reference documents

a) Description fire extinguishing system (detailed description of firefighting, fire monitoring, ventilation system)

b) Maintenance plan.

c) Operation manual for battery management system (classification of upper and lower battery management system and description of interface, charging/discharging condition at rapid/slow speed)

d) Reference Standards For Batteries

IEC 62619

IEC 62620

IACS UR E10

1.4. Definitions

Following definitions of terms are to follow INTLREG Rules and Regulations for the Classification of Steel Vessels, unless otherwise specified in this Guidance.

1.4.1. Battery management system- (BMS) means a device for monitoring the charge/discharge status to that the battery can be efficiently managed by measuring the values of current, voltage, temperature, etc. and for safely controlling the function of the battery such as operating the safety device in case of abnormal operation. The BMS acts both on a system level and on cell level: On a system level, the BMS calculates the actual power limits for charging and discharging the battery in dependence of SOC and temperature. The BMS provides these limits to the onboard power management system (PMS) so that the power flowing in and out of the battery does not exceed the operational limits. The BMS furthermore determines the SOC and state of health (SOH) on a pack level and provide this information to the operator.

1.4.2. Power management system- (PMS): a system providing monitoring and control of the on board Power sources. When the function of the energy management system is included in the power management system, the power management system is regarded as an energy management system.

1.4.3. Lithium Secondary Battery- means a secondary battery that stores electric energy obtained by an oxidation/ reduction reaction of lithium ions between an anode and a cathode.

1.4.4. Cell- An individual electrochemical unit of a battery consisting of electrodes, separators, electrolyte, container and terminals

1.4.5. Module- Assembly of cells including some level of electronic control and/or monitoring. The smallest unit that can be electrically isolated in an assembled battery system. For some systems, the modules may consist of blocks of cells with some electronic monitoring included.

1.4.6. Battery pack- means an energy storage device, which is comprised of one or more cells or modules electrically, connected.

1.4.7. Battery system- means an independently operable device connected to the battery control device and an assembly in which one or more modules or battery packs are connected in series or in parallel. Battery system may include a power converter for charging/discharging the battery.

1.4.8. Battery space- means the enclosed area where the battery is installed.

1.4.9. Rated capacity- means capacity value of a cell or battery (Ah) determined under specified conditions and declared by the manufacturer.

1.4.10. State Of Charge (SOC)- means the available capacity expressed as a percentage of rated capacity.

1.4.11. State Of Health- (SOH): general condition of a battery, including its ability to deliver the specified performance compared with a new battery.

1.4.12. Failure mode and effect analysis (FMEA)- means a failure analysis methodology used during design to postulate every failure mode and the corresponding effect or consequences.

1.4.13. Electric power converter- a device capable of both of the function of suppling power to the power system by converting the designated DC power from the battery to AC or suppling power directly to the AC load and the function to charge the battery by converting AC power from the power system to DC.

1.5. Class notations

a) In all other cases, except for cases where the requirements for main source of electrical power of the ship are satisfied by only the battery system complying with the requirements of this guidance, the ship may be assigned with the additional installations notation Battery-A.

b) If only the battery system in accordance with the requirements of this guidance satisfies the requirements for main source of electrical power of the ship, the ship may be assigned with the additional installations notation Battery-M. Basically, the requirements corresponding to the Battery-A notation shall be satisfied.

1.6. Class Approval

For class approval, both a safety description and a safety assessment are required (two separate documents). The safety description describes battery cell chemistry and design and includes identification, assessment and documentation of the safety hazards that are relevant for the specific

battery system. This document should describe the primary features of the battery with regard to safety, and a philosophy on how these are all interrelated and the system is able to ensure safe operation. In the class setting, the safety description is the battery manufacturer's responsibility. It is recommended to consider these battery system safety issues as part of the procurement process.

The safety assessment shall be required to submit for approval for vessels being classed by INTLREG. This assessment shall evaluate the specific battery system hazards and their potential consequences as applicable for the specific installation including the battery space and the integration of the battery system on board the vessel.

CHAPTER 2 EQUIPMENTS

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SECTION 1 BLOCK DIAGRAM, CONTSRUCTION, LOCATION

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1.1. General

1.1.1. Electrical equipment not specified in this chapter shall comply with the requirements in Part 6 of INTLREG Rules and Regulations for the Classification of Steel vessels

1.1.2. The battery system is generally configured as shown below and can be changed according to the manufacturer's design

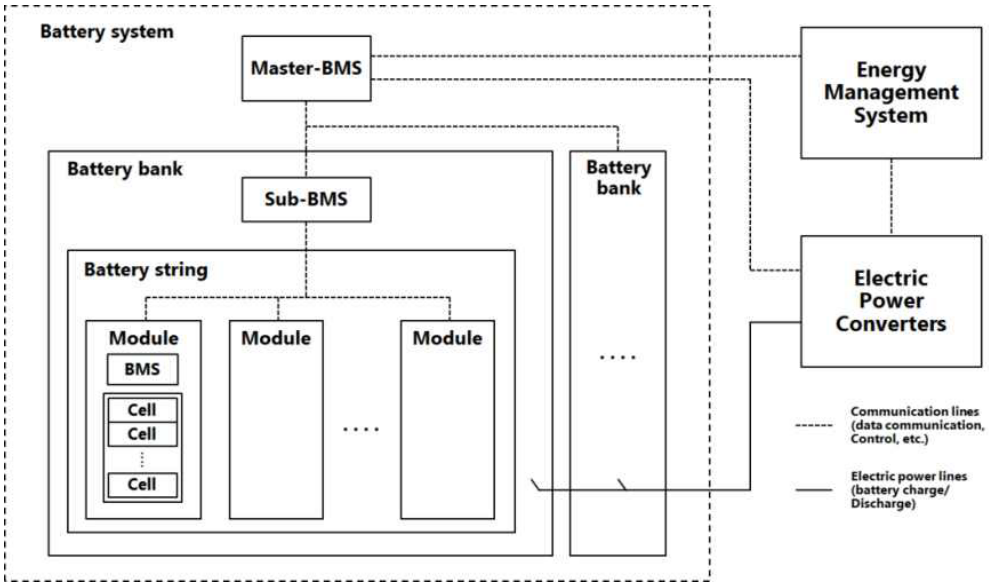


Figure 2.1.1 Block diagram of battery system

1.2. Materials

1.2.1. Parts and related materials used in the battery system shall be flame-retardant and moisture- resistant.

1.2.2. Materials shall be of a material or coating that is corrosion-resistant to corrosion at the place of installation and at the environmental conditions of use.

1.2.3. The conductive material shall be copper, copper alloy, stainless steel or equivalent, with sufficient electrical, thermal and mechanical safety.

1.3. Construction

1.3.1. All components shall be of a secure construction that is resistant to distortion, relaxation and other damage.

1.3.2. Resolvable panels, covers, etc. shall be constructed in such a way that it is not possible to replace them in other locations.

1.3.3. Parts that are likely to come into contact with people and those that require periodic maintenance and inspection shall be constructed in a structure free of sharp protrusions or corners.

1.3.4. Connection parts between live parts or connection parts between live parts and non-live parts are to be of a structure which does not cause relaxation under the use environment conditions

1.3.5. Parts that can replace or disassemble parts of the main body shall be easy to replace or disassemble and be of a safe construction.

1.3.6. A dual-rated device with the ability to convert the rated input voltage or frequency shall be able to easily identify the converted voltage and frequency. However, except for devices with automatic conversion.

1.3.7. Electrical components and accessories shall be applied with a maximum voltage or maximum power.

1.3.8. Compared to traditional batteries with water based electrolytes such as lead acid and nickel cadmium batteries, lithium-ion batteries can store between two and eight times more energy per weight unit. The high energy density as well as the use of a flammable electrolyte makes a safe design more challenging. Lithium based battery systems therefore depend on a well designed and tested electronic control system and physical design for safe operations.

1.4. Battery Room

1.4.1. The battery room shall be permanently fixed to the hull by welding or the like, and the hull substructure shall be adequately reinforced. The battery space is the physical enclosure in which the batteries are located and it includes all functions and components which contribute to keep the battery system in the defined space at a specified set of environmental conditions. Depending on the application of the battery system, there are certain important elements to consider. INTLREG Class rules require that the battery space has to meet a general fire integrity level of A-0 and A-60 towards any muster stations or evacuation routes. If the battery power shall be used for propulsion under normal operation, dynamic positioning or other relevant operations, it shall also meet a fire integrity level of A-60 towards any machinery space of category A as defined in SOLAS Reg. II-2/3. The battery space can also not be located in the forward collision bulkhead.

For High Speed and Light Crafts according to the HSC-code, the battery space can be defined as “Areas of major fire hazard” according to HSC Code Chapter 7.

1.4.2. Safe access to the battery room shall be provided.

1.4.3. Power supply

When essential services are powered from the battery system, they must be configured so that power supply to essential services can be maintained or recovered immediately if any component of the battery system fails

1.4.4. Protective devices

Electrical equipment shall be adequately protected against all over currents, including short circuits.

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2.1. Battery Types

2.1.1. Batteries can be generally classified as primary and secondary batteries. Primary batteries are those that are non-rechargeable. The secondary batteries i.e. batteries which can be recharged have further variants based on the battery chemistry. The type of electrolyte used, aqueous (acid, alkaline) or non-aqueous play a major role in battery energy density and safety. These guidelines focus on secondary batteries i.e. the batteries which can be recharged.

2.1.2. Lithium secondary batteries shall be adequate to national standards, recognized international standards or equivalent standards.

2.1.3. A single failure in the battery system shall not affect other systems in the ship.

2.1.4. The battery system shall be able to block abnormal current flow, and effective protection shall be provided.

2.2. Battery system design

2.2.1. The lithium secondary battery shall not overflow the electrolytes under the normal operational environment conditions of the ship, such as vibration and inclination of the ship.

2.2.2. The electrolytes shall be injected into the integrated cell and not exposed to the outside.

2.2.3. The battery module shall be designed so as to relieve the rise of internal pressure.

2.2.4. The battery system shall be configured with appropriate protective devices and protective coordination against fault currents.

2.2.5. The battery shall be protected against excessive temperature rise, and the protection function shall be fail safe. In addition, the protective device for this shall be separated from temperature indication, alarm and control functions.

2.2.6. The battery system shall set the limits for the followings so that the temperature is maintained within a certain range.

2.2.6.1. Maximum charge and discharge current rate (C-rate)

2.2.6.2. Maximum and minimum battery voltage (overcharge and over-discharge protection)

2.2.7. The battery system shall be equipped with short-circuit and over-current protection in the minimum unit forming the system voltage.

2.2.8. The overcurrent protection device shall be installed as close as possible to the battery output terminal. Both the anode and cathode shall be operated simultaneously to prevent overcurrent.

2.2.9. A device that limits the energy flow between the battery and the charging voltage source is to be installed to prevent damage to the battery.

2.2.10. The fault current of the battery system shall be designed taking into account the manufacturer's instructions or the rated capacity (Ah) of the battery pack.

2.2.11. Means of disconnection

2.2.11.1. A disconnecting device is to be installed outside the battery system for maintenance.

2.2.11.2. The battery disconnecting device shall be capable of simultaneously disconnecting and isolating anode and cathode.

2.2.11.3. The automatic disconnector shall be manually reset and operator shall not be exposed to high voltage and arc when resetting.

2.2.11.4. For the operation of a manual disconnecting device, tools or excessive force shall not be required by the operator.

2.2.11.5. The battery disconnecting device shall be applied considering the designed current and voltage and short-circuit fault current.

2.2.11.6. Emergency shut down

It shall be possible to disconnect the battery system in an emergency situation. This should be done by implementing an emergency shutdown circuit that disconnects the battery contactor/breaker. This emergency shutdown must be arranged as a separated hardwired circuit and, depending on the application it should be possible to shut down the battery both locally and from the bridge.

2.3. Degree of protection (IP)

2.3.1. Batteries and related systems shall have a degree of protection suitable for the installation site.

2.3.2. When water-based fire extinguishing system is used in the battery room, the degree of protection of the battery modules or its enclosures are to be at least IP 44.

2.4. Battery capacity

2.4.1. Batteries shall have adequate capacity, taking account of aging deterioration and capacity required for ships.

2.4.2. In the case of the battery used as an additional source of electrical power, then the battery capacity shall be sufficient for the intended operation of the ship and data on the basis and calculation of the design capacity shall be submitted.

2.4.3. In the event of an excessive temperature rise in the battery system, a audible and visual alarm signal for manual load reduction shall be transmitted to the bridge or the load reduction shall be performed automatically.

2.5. Installation

2.5.1. The battery shall be installed in an enclosed space consisting of hull bulkheads or in separate dedicated compartments.

2.5.2. The battery room shall not be located forward of the collision bulkhead.

2.5.3. The battery room shall not contain other systems related to the essential services of the ship, pipes shall not penetrate into the battery room as leakage of the pipe may cause damage or failure of the battery system. However, in case of unavoidable installation of pipes, the pipe joints shall be welded joints, and flanges, threaded joints or mechanical joints shall not be used

2.6. Operation and maintenance

2.6.1. A detailed operating manual shall be provided on board for emergency situations and shall include the followings:

2.6.1.1. Measures shall be taken in case of a fire accident due to internal or external factors

2.6.1.2. In case of an emergency, the local operation procedure of the battery (charge, stop procedure, etc.)

2.6.1.3. The normal use of the batteries should be fully automatic. There should be no need for manual interaction.

2.6.2. A plan for functional test and maintenance shall be provided on board and shall include the followings:

2.6.2.1. Detailed test plan and maintenance method

2.6.2.2. Verification method for state-of-charge (SOC) and state-of-health (SOH)

2.7. Battery system used for main source of electrical power

2.7.1. The battery system used as the main source of electrical power of sufficient capacity to supply essential services and services for habitability shall be provided. This battery system is to consist of at least two independent systems located in two independent battery spaces.

2.7.2. The capacity of these battery systems shall be such that in the event of any one battery system being stopped it will still be possible to supply essential services and services for habitability necessary to provide normal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability shall also be ensured which include at least

adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

2.7.3. Where the main source of electrical power is necessary for propulsion and steering of the ship, the system shall be so arranged that the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the ship will be maintained or immediately restored in the case of loss of any one of the battery systems in service. Preference tripping or other equivalent arrangements shall be provided to protect the battery systems against sustained overload.

2.7.4. The battery system shall be capable of operating at a local position. The local control panel can be located at the battery system, switchboard or converter. It is intended to provide a control station accessible as an alternative to that located at the bridge, in case of emergency. The local control shall be independent of all remote control systems.

2.7.5. Full Electric Propulsion

Figure 2.2.1 shows a power supply system for a purely battery-driven vessel. For this option the batteries will be charged through an AC/DC converter which can be located either on the vessel or on shore. On demand charging from an external electric power supply source is then required. Ferry operations where the voyage is of limited and repeated nature, such as fjord crossings, may utilize pure battery powered propulsion provided that the infrastructure on land allows for proper charging between crossings. Class rules require that two independent battery systems are installed to provide propulsion power in case one system fails. . The battery (power) notation applies to this configuration.

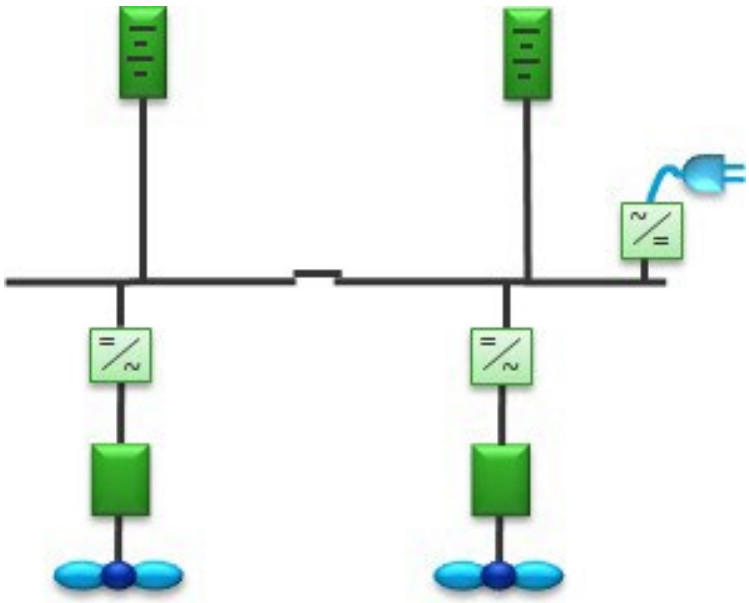


Figure 2.2.1 Battery propulsion for an all electric ship

2.7.6. Redundancy

(i) For pure battery powered vessels, at least two completely independent battery systems need to be installed.

(ii) For hybrid battery powered vessels (battery and internal combustion engine), at least two completely independent power systems are needed. The battery system may be part of one of these.

2.7.7. Battery Installation Process

The process of installing battery system onboard marine and offshore units will generally follow normal practice for marine applications. Figure 2.2.2 illustrates the ship building process and the responsible party for the different project phases.

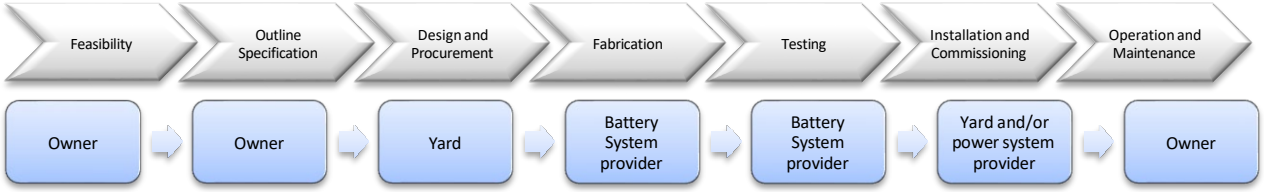


Figure 2.2.2. The battery system in the shipbuilding process and the responsible party

2.8. Application of Hybrid System

2.8.1. Rotating machinery used as generating sources shall comply with the requirements in INTLREG Rules and Regulations for Classification of Steel Vessels Part 6 /Chapter 4

2.8.2. Generally, power generation sources may include fixed speed and variable speed generators, fuel cells, batteries, and other types of energy sources. These energy sources can be used as independent power sources or as main power sources in combination with other energy sources.

2.9. Charging facility

2.9.1. The equipment charging battery shall be able to supply enough power to charge the battery.

2.9.2. When the battery system is being charged from the outside of the ship, it shall be equipped with the function to cut off the shore power automatically or manually. The degree of protection of the charging plug and the receptacle shall be at least IP56.

2.10. Battery management systems

2.10.1. General

2.10.1.1. The battery management system should be supplied from a separate power source other than its own battery, and should be configured as a system compatible with the communication system so that it can be monitored or controlled with other systems such as a power management system or an energy management system.

2.10.1.2. The battery management system shall include important alarm and stop functions.

2.10.1.3. The Master-BMS shall be able to detect major faults in the Sub-BMS and disconnect the associated module or battery pack.

2.10.1.4. Communication between the Master-BMS and the power management system shall be communicated clearly in normal operation and in the event of an accident.

2.10.1.5. Electric power converter shall be able to communicate with the battery management system and be designed to be sufficient for the capacity of the battery system.

2.10.2. Design

The battery management system shall have the following functions.

2.10.2.1. The Master-BMS shall monitor all the states of the Sub-BMS and forward the information to the power converter or host controller.

2.10.2.2. The battery management system shall control charge/discharge according to information transmitted from a power converter or an energy management system which is a host controller, and the power converter shall supply power to meet the charging/discharging conditions.

2.10.2.3. It shall be able to monitor the status of battery voltage, current, temperature, etc. in real time to maintain the optimal state. The battery system shall be monitored even when the battery system is not operating.

2.10.2.4. BMS shall prevent overcharge, over discharge, and overheating of the battery cell and monitor the battery to operate stably.

2.10.2.5. The Master-BMS shall detect major failure of the Sub-BMS and forward it to the power converter so that it can immediately shut down the related battery system.

2.10.2.6. Communication between the battery management system and the power converter or upper controller shall be redundant to increase the safety of the system.

2.10.3. Energy management

2.10.3.1. When applying an energy management system, the energy management system shall be installed as an upper controller of the battery system.

2.10.3.2. The energy management system shall always monitor the followings:

(i) The available energy or power of the battery system.

(ii) State-of-charge (SOC)

(iii) State-of-health (SOH)

2.10.3.3. The energy management system shall be designed so that the battery system operates within the specified limits and shall always monitor the followings in the engine control room.

(i) Maximum charge current and discharge current

(ii) Maximum and minimum voltage of battery (prevention of overcharge and over discharge)

SECTION 3 ELECTRIC POWER CONVERTERS

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3.1. Design

3.1.1. All power converters shall use approved products from the Society and comply with the following requirements.

(i) Designed and tested in accordance with the Rules of the Society and the recognized standards by the Society.

(ii) Designed in accordance with the marine environmental conditions of the installation site.

(iii) Designed considering the electrical characteristics of the equipment to be connected.

(iv) It shall be designed in consideration of equipment and life safety.

3.1.2. The enclosure shall be designed to protect personal injury due to sharp edges and excessive temperature rise.

3.1.3. For the safety of life, a lock that can be used during maintenance and inspection shall be provided.

3.1.4. When the operating voltage exceeds 50V, safety earth shall be carried out using earth wire.

3.1.5. Power converters shall be equipped with separate control and monitoring systems.

3.1.6. The power converter shall comply with the requirements in INTLREG Part 6 Electrical Installations and control systems/Chapter 2/Section 4 [4.1.2.8]

3.1.7. The power conversion device shall be equipped with an emergency stop function and shall be composed of independent wiring.

3.1.8. The components of the power inverter shall be easy to repair and replace.

3.1.9. The capacity of the power converter shall be selected considering the electrical specifications of the connected load.

3.1.10. The power converter shall meet the following performance requirements.

(i) Charge/discharge shall be controlled in accordance with the instruction of the upper controller responsible for the power control of the ship.

(ii) In case of failure of the power converter, the power converter shall be immediately disconnected from the system so that the effect of the failure does not spread to the power system.

3.2. Installation

3.2.1. Power converter shall be installed in a dry place as far as possible from steam pipes, water pipes, oil pipes, etc.

3.2.2. Emergency stop devices for emergency isolation shall be provided for power converters of 50 kVA or more.

3.2.3. Power converter shall be installed in a space where the proper temperature can be maintained in consideration of the charge/discharge characteristics.

3.2.4. It shall be installed in a place where workers can access easily.

3.2.5. It shall be installed away from heat sources such as engine exhaust manifolds.

3.2.6. It shall have space for operation and maintenance.

3.2.7. It shall be installed in a place where it can be firmly fixed to withstand vibration and so on.

3.2.8. In the case of air-cooled type, it shall be installed in a place where the inlet air temperature does not exceed the limit of the manufacturing specification.

3.2.9. The power converter shall not be installed on the battery.

3.3. Degree of protection (IP)

3.3.1. Power converters shall have a degree of protection suitable for the installation site.

3.4. Power converters for battery charging and power supply shall meet the following requirements.

3.4.1. Protection against overcharging and overvoltage shall be provided, and a indicator for the state-of-charge shall be provided.

3.4.2. A protection system against reverse flow of charge current shall be installed.

3.4.3. It shall be designed to charge the battery at the current and voltage appropriate for the specifications of the battery system.

3.4.4. In the event of a power converter failure, a visual and audible alarm shall be issued to the bridge or engine control room.

3.5. Electric power converter

3.5.1. A battery system operates electrochemically using DC power, and will require an inverter or **power converter** in order to interface with an AC ship distribution system. However, these inverters provide the additional capability to produce reactive power, voltage and frequency support as well as increase power factor throughout the ship. Depending on interface voltage and desired function, the battery can be installed on any bus or switchboard on the ship, allowing a great deal of flexibility with regard to placement.

3.5.2. Temperature monitoring of power semiconductor devices or other heat sources of power converters shall be performed.

3.5.3. If the power converter provided with an emergency stop function, it must be independent of the signals of other control systems.

3.5.4. The internal capacitor shall be discharged to less than 60 V within 5 seconds of power removal.

However, except when the residual charge amount is 50 μC or less, if this is not possible, the warning shall be displayed in a position easily visible to the operator so that it can wait for a certain time before opening the enclosure.

3.6. Protection system

3.6.1. The power converter shall be protected from damage due to transient overvoltage, such as surge voltage due to circuit opening and closing, and voltage rise due to regenerative braking.

3.6.2. Under normal operating conditions, the semiconductor device shall be controlled so as not to exceed the allowable current.

3.6.3. The system to which the power converter is connected shall be provided with an overcurrent limiting device

CHAPTER 3 CLASSIFICATION SURVEYS

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SECTION 1 SURVEYS

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1.1. Survey requirements

The classification surveys of battery systems on board of ships, except where specially required in this chapter, are to comply with the requirements specified in INTLREG Rules and regulations for Classification of Steel vessels ,Part 1 ,Classification Regulations

1.2. Periodical Surveys

1.2.1. Annual Survey

Annual survey of ships fitted with battery system on board on ships shall include the followings.

1.2.1.1. Visual inspection and functional test

(i) Inspection for battery room including exposed battery system and their openings, battery system installation area skylights, ventilator openings and their closing appliances.

1.2.1.2. Functional test of measuring devices

1.2.1.3. Safety devices test (including at least the followings)

(i) Fire detector and gas detector

(ii) Check the safety function related to ventilation in the battery system installation area

(iii) fire extinction test

1.2.1.4. Operating instructions, name plates and lists

(i) Check operating instructions for battery system operation and maintenance

(ii) Check the name plates and the list of name plates required for battery system

1.2.1.5. Performance test of battery system

(i) Performance test of electric power converter

(ii) Performance test of battery (charge/discharge test)

1.2.1.6. Energy management system tests

(i) Functional test

(ii) Check the interface between battery system and energy management system

(iii) Check the interface between power management system and energy management system (if applicable)

1.3. Special Survey

In addition to the annual survey items, the special survey shall include the followings.

i) Emergency stop device test

ii) Overcharge and overvoltage protection devices test

SECTION 2 TESTS AND INSPECTIONS

Contents

2.1. General 34

2.1. General

2.1.1. Manufacturing, testing, inspection and data shall conform to the specifications and recognized standards required by this Guidance.

2.1.2. Manufacturing, testing and inspection of equipment related to battery system not covered by this Guidance shall be in accordance with the relevant requirements of Part 6 of INTLREG Rules and Regulations for Classification of Steel Vessels

2.1.3. Test and Inspection

2.1.3.1. The battery cells, modules, system, and related control system shall be subjected to the type approval test and inspection in accordance with the following tables. However, operating conditions in the marine environment shall be considered.

2.1.3.2. The test result conducted by nationally recognized institutes for battery cells in Table 3.2.1 may be accepted.

2.1.3.3. Some test items for battery system in Table 3.2.3 may be added or changed at the request of the Society.

2.1.3.4. If verification of the safety and reliability of the battery system and associated equipment (such as power converters) is required, pre-installation integration tests may be required.

Table 3.2.1 Battery cell

No:	Tests	Test Standard	Test Subject	Classification
1	Temperature Cycling Test(1)	IEC 62281 6.4.2 / UN38.3 T-2	Cell	Type Approval
2	External Short Circuit Test(1)	IEC 62619 7.2.1(2)	Cell	Type Approval
3	Collision Test	IEC 62619 7.2.2(2)	Cell	Type Approval
4	Overcharge Test	IEC 62619 7.2.5(2)	Cell	Type Approval
5	Forced Discharge Test	IEC 62619 7.2.6(2)	Cell	Type Approval
6	Heating Test	IEC 62619 7.2.4(2)	Cell	Type Approval
7	Internal Short Circuit Test	IEC 62619 7.3	Cell	Type Approval

Notes:
(1) The test 1 and 2 are sequentially tested with the same battery.
(2) Alternatively, relevant tests of IEC 62281 or UN38.3 may be accepted.

Table 3.2.2 Battery module

No.	Test	Test Standard	Subject	Classification
1	Discharge performance Test	IEC 62620, 6.3.1	Module	Type Approval
2	Charge Capacity Retention and Recovery Test	Specifications / IEC 62620, 6.4	Module	Type Approval
3	Vibration Test	Annex 1/ Type Approval / Automatic and remote control systems, Etc.(3)	Module	Type Approval
4	High Temperature and Drying Test	Annex 1/Type Approval /Automatic and remote control systems, Etc.(4)	Module	Type Approval
5	Temperature and Humidity Test	Annex 1/Type Approval /Automatic and remote control systems, Etc.(4)	Module	Type Approval
6	Low Temperature Test(1)	Annex 1/Type Approval /Automatic and remote control systems, Etc.(4)	Module	Type Approval
7	Salt water spray test(1)	Annex 1/Type Approval /Automatic and remote control systems, Etc.(4)	Module	Type Approval
8	Flame-Resistance Test(2)	Annex 1/Type Approval /Automatic and remote control systems, Etc.(4)	Module	Type Approval
9	Propagation test(5)	IEC 62619, 7.3.3	Module / Pack	Type Approval

Notes:
(1) Applied only when installed on open deck
(2) Applied only when using flammable materials
(3) References : IACS UR E10 / IEC 60092-504 / UN38.3 / IEC 62281
(4) References : IACS UR E10 / IEC 60092-504
(5) Perform thermal runaway propagation test on battery cell or module basis.

Table 3.2.3 Battery system

No.	Test	Test Standard	Type Approval	Testing and Inspection
1	Overcharge Voltage Control Test	IEC 62619, 8.2.2 / IEC 62133-2	○	
2	Overcharge Current Control Test	IEC 62619, 8.2.3 / IEC 62133-2	○	
3	Overheating Control Test	IEC 62619, 8.2.4 / IEC 62133-2	○	
4	Cell Balancing Test	Specifications	○	
5	SOC Test	Specifications	○	
6	High Voltage Test	Annex 1/Type Approval /Automatic and remote control systems, Etc.	○	○
7	Insulation Resistance Test	Annex 1/Type Approval /Automatic and remote control systems, Etc.	○	○
8	Safety Function Test(1)	Specifications	○	○
9	Sensor Failure Test	Failure Mode and Effect Analysis (FMEA)	○	
10	Maximum C-rate Checking Test	Specifications	○	○
11	Environmental test	Refer to Table 3.2.5	○	
12	Electromagnetic Compatibility Test	Refer to Table 3.2.5	○	

Notes:

Some functions may be replaced by type approval tests in consultation.

1) The safety function test shall include the followings.

- An emergency stop function
- An alarm and Shutdown function
- BMS function (temperature, overvoltage, low voltage protection etc.)
- Failure of communication signals
- Other tests related to safety functions (loop safety check etc.)

Table 3.2.4 Power conversion system

No.	Test	Test Standard	Type Approval	Testing and Inspection
1	Visual inspection(1)	–	○	○
2	Functional test	Refer to Table 3.2.5	○	○
3	Electrical power supply failure test	Refer to Table 3.2.5	○	
4	Input voltage/frequency variation test	IEC 62040-3, 6.4.1	○	
5	Temperature rise test(2)	IEC60146-1-1, 7.4.2	○	
6	High voltage test	IEC 61800-5-1, 5.2.3.2 IEC 60146-1-1, 7.2	○	○
7	Insulation resistance test	IEC 60146-1-1, 7.2.3.1	○	○
8	Capacitor discharge test	IEC 61800-5-1, 5.2.3.7	○	
9	Rated current / Full load test	IEC 62040-3, 6.4.3	○	
10	Short circuit current test	IEC 62040-3, 6.4.2.10	○	
11	Cooling failure test(4)	IEC 61800-5-1, 5.2.4.5	○	○
12	Cooling pipe/hose water pressure test(4)(5)	Refer to Table 3.2.5		○
13	Environmental test	Refer to Table 3.2.5	○	
14	Electromagnetic compatibility test	Refer to Table 3.2.5	○	

Notes:
(1) Checking for degree of protection, clearance and creepage distance, items(name plate, etc.) shown on specifications
(2) Additional temperature rise due to harmonics shall be considered.
(3) Applicable only for battery charging
(4) Applicable only for forced type
(5) Applicable only for water-cooling type

Table 3.2.5 Test criteria of power conversion System

No:	Test	Description
1	Functional test	(a)The functions of the power conversion system specified in the specifications shall be basically checked. (b)Emergency stop and restart function of power conversion system shall be checked. (c)Other functions required by the Society shall be checked.
2	Electrical power supply failure test	(a) Check the operating condition of the EUT when source of power is cut 3 times for 30 seconds once for 5 minutes. (b) It may exceed 5 minutes if longer time is required to start the EUT (boot se- quence). However, one additional power shutdown shall be performed. (c) Acceptance criterion: According to specification of EUT at power failure or power recovery
3	Cooling pipe/hose water pressure test	a) The hydraulic test shall be carried out for a minimum of 1 hour at a pressure of at least 2.5 times the rated pressure of the pipe/hose. b) Acceptance criterion: No leakage or damage to joints shall occur.
4	Environmental test	a) The following environmental tests shall be carried out and the relevant test re- port shall be submitted after the test. For detailed test methods and standards, refer to Annex 1/ Type Approval/ Automatic and remote control systems Etc. – High temperature drying test – Temperature and humidity test – Vibration test – Inclining experiments – Low temperature test – Salt water spray test – Test for degree of protection (IP) b) The worst case scenario conditions that may occur during the vibration test shall be considered.
5	Electromagnetic compatibility test	a) The following electromagnetic compatibility test shall be carried out and the relevant test report shall be submitted after the test. For detailed test methods and standards, refer to Annex 1/ Type Approval/ Automatic and remote control systems Etc. -Electromagnetic interference Test • Conducted emission test • Radiated emission test -Electromagnetic immunity test • Electrostatic discharge immunity test • Radiated radio frequency immunity test • Conducted low frequency immunity test • Conducted high frequency immunity test • Burst immunity test • Surge immunity test

SECTION 3 TESTS AFTER INSTALLATION

Contents

3.1. General 40

3.1. General

i) Tests after installation shall be performed under all load conditions.

ii) The test procedure shall be submitted to the Society.

iii) Visual inspection shall be carried out on the components.

IV) Tests after installation of ships fitted with a battery systems shall include the following test items in addition to the test requirements carried out basically on ships. However, when it is deemed necessary by the Society, test items and requirements may be added or changed.

Table 3.3.1 Test after installation

No.	Test	Description
1	Interface checking Test	Check the interface between electric power converter and battery
		Check the interface between battery system and energy management system
		Check the interface between power management system and energy management system (if applicable)
2	Operation test of alarm and safety device	Check alarm device and automatic stopping device such as overcharge, voltage abnormality, temperature abnormality of the charging/discharging system and flammable gas detector
3	Check the function of important equipment	Check the functions of all important equipment related to batter system, including batteries, battery management systems, power converters, energy management systems, etc.
4	Check the function of fire extinguishing/ventilation equipment	Check the functions of ventilation, cooling facility, gas detector, fire detector, alarm device, etc.
5	Synchronization test	For synchronization of generator and battery power, measure whether voltage for DC and voltage, phase and frequency for AC are suitable for synchronization conditions and check if synchronization operation is possible.
6	Check interlock operation	Check the interlock operation for various possible combination of power generation.

CHAPTER 4 FIRE PREVENTION AND EXTINCTION

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SECTION 1 GENERAL

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1.1. Requirements

1.1.1. The requirements in this Section apply in addition to INTLREG Rules and Regulations for the Classification of Steel Vessels ,Part 5A, Machinery equipment Installation and piping system Chapter 13 and Part 7B/Special type ships /Chapter 3

1.1.2. Battery rooms may generally be considered as an “Other machinery spaces“ for fire protection purposes.

1.1.3. The battery room shall be enclosed by an A-0 class bulkheads and the boundary between the following compartments shall be A-60 class.

(i) Machinery spaces of category A specified by SOLAS Reg.II-2/3

(ii) Cargo area for the transportation of dangerous goods

1.1.4. Where a water injection system is applied for the arrangement of fire extinguishing systems in the battery room and for the cooling of batteries or other components, the necessity and safety shall be approved by the Society.

1.2. Fire detection system

1.2.1. Smoke detectors shall be used for fire detection. However, for areas where malfunction of the smoke detector may occur, a heat detector may be used.

1.2.2. The fire detection system shall be provided in accordance with the FSS code.

1.2.3. When a fire is detected in the battery room, the operation of the battery shall be stopped automatically. Functions shall be designed to fail-safe.

1.3. Ventilation

The gasses produced during a lithium-ion cell failure will typically consist of many individual components – including, but not limited to: hydrogen, CO, CO2, DEC, MEC, C2H4, CH4, HF, HCl, HCN. Gases that are produced, and whether they are self consumed by the fire, will also depend on the temperature of the fire. Mixing of different gases might pose a combined risk effect that would not be identified by analyzing the individual gases separately. Lower and Upper Explosive Limits (LEL/UEL), self-ignition levels and toxicity are parameters that can be found by analyzing the combined composition of the emitted gases. These factors are key for determining ventilation requirements.

The gases should be classified according to the potential risk. Possible risk factors include flammability, formation of an explosive atmosphere, corrosivity or toxicity etc.

If there is a possibility of generating flammable gas in the battery room through a risk assessment, the ventilation system shall comply with the following requirements.

1.3.1. The ventilation fan shall be of a non-sparking type.

1.3.2. The ventilation system of the battery room shall be operated independently of other HVAC systems.

1.3.3. The power supplied to the ventilation system shall be supplied from outside the battery room. For the **Battery-M** notation, the power supply to the ventilation system in the battery room is to be redundant.

1.3.4. The air of exhaust outlets shall be monitored at all times and an alarm shall be issued when 30% of the lower explosion limit is reached. In addition, the gas detection system shall be interlocked with the relevant equipment to automatically shut down the battery. When 60% of the lower explosion limit is reached, all electrical circuits in the battery compartment must be deactivated and the function of the trip condition is to be designed to fail-safe.

1.4. Fire prevention

1.4.1. The battery room shall not contain the essential services related systems and heat sources which are highly likely to cause fire explosion.

1.4.2. The door of battery room shall be kept closed at all times and an alarm signal shall be issued upon opening or a self-closing door shall be installed.

1.5. Fire extinction and Cooling

Many lithium-ion battery fires are self oxygenating and thus very challenging to extinguish. Cell size, the number of cells on fire and access to the fire are generally very important in terms of how difficult it is to extinguish the fire. Heat removal and extraction is a key requirement of the extinguishing system in order to minimize damage. This is the reason for the class requirements. Battery fires may persist for extended periods so ample quantities of water should be ensured.

1.5.1. The fire extinguishing system for the room installed battery system shall be provided in accordance with the FSS code.

1.5.2. Because battery system has different materials according to battery type, the type and amount of fire shall be selected considering the method of fire extinguishing according to the material of the battery used. The type and amount of such fire extinguishing media shall be selected according to the risk assessment and additional fire fighting equipment or cooling means may be required (e.g. whether it is fixed or portable depending on capacity).

1.5.3. When an automatic fire extinguishing system is applied in the battery system area, the operation signal of the fire extinguishing system shall be operated as a separate redundant signal and also be operated manually.

1.5.4. Two portable dry powder fire extinguishers or two CO_2 fire extinguishers of at least 5 kg capacity shall be provided near the battery room and a portable fire extinguisher may be required depending on the capacity of the battery system.

SECTION 2 COOLING

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2.1. General

2.1.1. The single failure of the cooling system shall not affect the operation of the battery system.

2.1.2. In order to prevent overheating in the event of a cooling system failure, the current shall be automatically reduced and then limited operation shall be performed.

2.1.3. In case of forced cooling type, a means of monitoring the condition of the cooling system shall be provided and a visual and audible alarm shall be issued to the engine control room in the event of a failure.

2.1.4. In the case of air-cooled type, it shall be designed so that it does not cause trouble due to salt air or moisture.

2.2. Water-cooled type

2.2.1. Forced water-cooled type

(i) In case of forced water cooling, the state of cooling water shall be monitored at all times.

(ii) In relation to [2.1.2] above, where limited operation of the power converter is not possible, an additional cooling pump shall be provided.

(iii) Leak detection device shall be installed and a visual and audible alarm shall be issued to the engine control room when leaked.

(iv) In the event of leakage, the leaked liquid shall be collected in one place and leakage shall not cause failure of the power converter and nearby equipment.

(v) Cooling water is not to be in contact with the conductive part.

2.3. Air-cooled type

2.3.1. Forced air-cooled type

(i) For forced air cooled type, the failure of the cooling fan shall be monitored at all times.

(ii) In relation to [2.1.2] above, where limited operation of the power converter is not possible, an additional cooling fan shall be provided.

SECTION 3 MONITORING AND SAFETY SYSTEMS

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3.1. General

3.1.1. Measurement and automation including computer-based control and monitoring shall comply with the requirements specified in Pt 6, Ch 8 of the INTLREG Rules and Regulations for the Classification of Steel vessels in addition to the relevant requirements of this section.

3.1.2. The battery system shall be provided with means for emergency stop at the following locations and the emergency stop circuit shall be configured independently of the control, monitoring and alarm system.

(i) Navigation bridge

(ii) Engine control room

(iii) Near the battery room

3.1.3. The battery system shall be equipped with a device capable of monitoring the alarm and status information of **[3.2]** below

3.2. Alarm and status information

3.2.1. If the following situation occurs in the battery system, a visual and audible alarm shall be issued to the engine control room. However, in case of [3.2.2], a visual and audible alarm shall be issued to the bridge.

(i) Battery breaker trip

(ii) Gas detection (if applicable), fire detection

(iii) Overcurrent, overvoltage, undervoltage, overdischarge

(iv) Voltage unbalance between battery cells

(v) Charging/discharging failure

(vi) Temperature rise of the cell

(vii) Failure of ventilation system

(viii) Failure of cooling system

(ix) Failure of energy management system, power converter and battery management system

(x) Input of incorrect setting value

3.2.2. The battery system shall ensure that the following items are transmitted to the engine control room and continuously monitored.

(i) Battery

(a) System voltage

(b) maximum, minimum and average cell voltage and temperature (2020)

(c) Battery pack current

(d) Output of battery

(e) Available energy of battery

(f) Battery operating time

(ii) Power converters

(a) Voltage, current

(b) Cooling medium temperature

(c) Internal temperature of the power converter

(iii) Battery room

(a) Battery room temperature

(b) Operating condition of the ventilation system in the battery room

(c) Operating condition of the cooling system in the battery room

3.2.3. The battery voltage and temperature shall be monitored at the lowest cell-level voltage of the battery and always monitored during charging and discharging

SECTION 4 RISK ASSESSMENT

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4.1. General

4.1.1. A risk assessment shall be carried out with an emphasis on ship and life safety. And, causes and effect analysis for all possible accident scenarios and remedies for high risk potential shall be presented.

(i) Risks due to reasonably foreseeable failure with regard to installation, operation and maintenance shall be considered.

(ii) Risks shall be analysed using recognized analytical techniques and at least the loss of function, damage to components, fire, explosion, possible generation and ignition of flammable gases, and electrical shock shall be considered.

(iii) Risk analysis shall ensure that risks are eliminated wherever possible, and risks that can not be eliminated shall be mitigated as necessary.

(iv) Details of the risks and means to mitigate the risks shall be included in the operating manual.

4.1.2. In the event of any revision or supplementation of the risk assessment result, it shall be revalidated by the Society.

4.2. Risk assessment factors

4.2.1. Various methods can be used for risk assessment and at least an analysis of the following risk factors shall be included.

(i) Risk of toxic, flammable, corrosive gas leaks

(ii) Fire and Explosion Hazards

(iii) Risk of electric shock

(iv) Suitability of monitoring, alarm and ventilation systems according to the risk

(v) Protection measures against the risk factors (fire, flooding, vibration, etc.) surrounding the battery installation area

(vi) Protection and prevention measures against battery failure

(vii) Risk of electrical accidents (over discharge, overcharge, electromagnetic compatibility, electrical shock, short circuit due to external factors, short circuit due to internal factors, overheating, etc.)

(viii) Suitability of fire extinguishing systems and fire extinguishing equipment

(ix) Means for detecting off-gas released from battery cell(s) caused by internal pressure rise, etc. and control measures when off-gases are released.

4.2.2. Fire and explosion within the area containing the battery system shall not cause damage or failure as follows.

(i) Damage to any area other than the place where fire and explosion occurred

(ii) Interference with proper functioning of other areas

(iii) Ship damage in the form of flooding under the main deck or gradual flooding

(iv) Damage to service areas or accommodation spaces in the form of injury to persons in service areas or accommodation spaces under normal operating conditions

(v) Obstruction of the proper functioning of control room and switchboard room for essential power supply

(vi) Damage to life-saving equipment or related facilities

(vii) disruption of the proper functioning of fire extinguishing facilities located outside the area damaged by fire and explosion

(viii) Affecting other areas of the ship in the form of a chain reaction involving cargo, gas and fuel oil

4.2.3. If it is deemed necessary by the Society, additional risk considerations may be required depending on the type of lithium secondary battery.

ANNEX 1 TYPE APPROVAL / AUTOMATIC AND REMOTE CONTROL SYSTEMS

SECTION 1 AUTOMATIC AND REMOTE CONTROL SYSTEMS 55

SECTION 1 AUTOMATIC AND REMOTE CONTROL SYSTEMS

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1.1. Application

1.1.1. The requirements of this Section apply to tests and inspection for the type approval of the automatic and remote control systems (device, units and sensors, etc) including basic software's (if any) for use in the marine environment in accordance with the requirements in of the INTLREG Rules and Regulations for the Classification of Steel vessels Part 6, Chapter 8. However, the automatic and remote control systems that are to be installed less than 5 m from magnetic compass are to comply with the requirement in following (i) and fire detection system and gas detection system are to comply with the requirements in following (ii) to (iv).

(i) Compass safe distance test for the automatic and remote control systems that are to be installed less than 5 m from magnetic compass is to be carried out in accordance with IEC 60945:2002 11.2.

(ii) Fire detection system is to comply with the EN 54 series or equivalent standard.

(iii) Design requirements and performance tests for gas detection system for measurement and detection of fixed/portable combustible gases are to comply with IEC 60079-29-1 or equivalent standard. However audible alarm level and signal characteristics are to comply with IMO Res. A.830(19).

(iv) Gas detection system for oxygen detection and measurement is to comply with the EN 50104 or equivalent standard, However audible alarm level and signal characteristics are to comply with IMO Res. A.830(19).

1.1.2. Electrical and electronic equipment on board ships, required neither by the Rules of the Society nor by International conventions, liable to cause electromagnetic disturbance are to be of type which fulfil the test requirements of test specification item 20 and 21 of Table A1.1.1

1.1.3. The automatic and remote control systems shall be provided with a degree of protection appropriate to the location in accordance with the requirements Refer ANNEX 2 Construction and Installation.

1.2. Data submission

The following reference data shall be submitted to the Society in addition to those specified in ANNEX 3 Approval Application

1.2.1. General

(i) All documentation shall provide relevant information in a clear and unambiguous manner..

(ii) Symbols and abbreviations used shall be explained, or referenced to an appropriate international standard or code recognized by the Society.

1.2.2. Hardware

(i) System block diagram, showing the arrangement, input and output devices and interconnections

(ii) Wiring diagram (electrical systems), piping diagram (pneumatic or hydraulic systems)

(iii) Details of input and output devices

(iv) Details of power supplies

1.2.3. System functional description

(i) System specifications

(ii) System performance for normal or abnormal equipment operation.

(iii) Instructions for normal and abnormal operating modes;

(iv) Transfer of control

(v) Redundancy or reversionary mode

(vi) Test facilities

(vii) Failure detection and identification facilities (automatic and manual)

(viii) Data security

(ix) Access restriction

(x) Special aspects requiring user attention.

(xi) In addition, documentation shall be provided concerning procedures for:

(a) start-up

(b) restoration of functions

(c) maintenance and periodical testing

(d) data back-up

(e) software reload and system regeneration

(f) failure location and repair

1.2.4. Software

(i) Quality plan

(ii) Software shall be fully described, e.g.:

(a) a description of the basic software installed in each hardware unit;

(b) a description of the communication software installed on nodes in a network;

(c) descriptions of application software (not program listings);

(d) tools for system set-up and process equipment configuration.

(iii) The description of application software shall include, e.g.:

(a) information of system modules that must be operative in order to maintain functions including dependencies on other systems;

(b) detail of each module at a level sufficient to understand its function;

(c) relationship between the software modules that must be operative in order to maintain each function;

(d) data and control flow between software modules;

(e) configuration of the software, including priority schemes;

(f) switching mechanisms for redundant systems.

(iv) A schedule of anticipated equipment operation ranges and limits for alarm and safety functions shall be provided.

1.2.5. User interface

(i) Control station design and arrangement shall be detailed including drawings, dimensions, pictures, etc. of each user input or output device at a level sufficient to asses the working principles.

(ii) Details of screen-based computer dialogue shall be produced, including:

(a) description of the functions allocated to each input device;

(b) details of individual screen views, e.g. schematics, colour photos, etc.;

(c) description of menu operation.

1.2.6. Failure analysis for safety related functions only is to be carried out using appropriate means such as FMEA and the results are to be submitted to the Society,

1.3. Type test report

1.3.1. Upon completion of the type test, the manufacturer is to submit to the Society the complete test report including test conditions, test results and required information.

1.4. Type test

1.4.1. Hardware

1.4.1.1. **General**

(i) Tests are to be carried out under following atmosphere conditions, rated electrical source voltage and rated electrical source frequency unless otherwise specified.

(a) temperature : 25 ± 10 ℃

(b) relative humidity : 60 ± 30 %

(c) atmospheric pressure : 96 kPa ± 10 kPa

(ii) Measuring and testing equipment used in the type test are to be calibrated in accordance with the related standards and/or codes.

(iii) The number of EUT(Equipment Under Test) is, as a rule, to be one for each type. However, additional EUT may be required when deemed necessary by the Society.

(iv) Raising and lowering rate of temperature is to be within 1℃/min (mean value for 5 minutes) unless otherwise specified.

(v) Power supply variation test and pressure test are applied on pneumatic and hydraulic type equipment only.

(vi) Flame retardant test is to be generally applied by manufacturer's option to demonstrate that plastic components of the equipment under test with a large mass are flame retardant and self-extinguishing under the influence of flame.

1.4.1.2. **Test methods and criteria**

(a) After the drawings and documents submitted in accordance with the requirements in Section [1.2] have been examined, tests shall be carried out in accordance with the testing condition and method of Table A1.1.1 in the presence of the Society's surveyor, and they shall be proven to satisfy the criteria of Table A1.1.1

(b) Where tests which do not fully comply with the testing condition and method, and the criteria of **Table A1.1.1** they may comply with a standard deemed appropriate by the Society.

(c) In contrast to a complete performance test, a functional test is a simplified test sufficient to verify that the equipment under test(ETU) has not suffered any deterioration caused by the individual environmental tests.

(d) In application to high voltage test of Table A1.1.1**,** if agreed by the Society, the test may be carried out.

1.4.2. Software

(i) **Module tests**

Software module tests are to provide evidence that each module performs its intended function and does not perform unintended functions.

(ii) **Subsystem tests**

Subsystem testing is to verify that modules interact correctly to perform the intended functions and do not perform unintended functions.

(iii) **System test**

System testing is to verify that subsystems interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

1.4.3. Performance tests

(i) **Integration tests**

Programmable electronic system integration testing is to be carried out using satisfactorily tested system software, and as far as practicable intended system components.

(ii) **Fault simulation**

Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>1</td><td>Visual inspection</td><td>Examine the external, structure, etc., of the equipment.</td><td>• The equipment comply with the specifications.</td></tr>
<tr><td>2</td><td>Performance test</td><td>• Check the operation of the equipment.
• Check the self monitoring features if provided.
• Check the specified protection against an access to the memory.
• check against the effect of unerroneous use of control elements in the case of computer systems.
• When the EUT is required to comply with an international performance standard, e.g. protection relays, verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing.</td><td>• The equipment operates satisfactory.</td></tr>
<tr><td>3</td><td>Electrical power supply failure test</td><td>• Check the operation of the equipment when the electrical power supply is interrupted 3 times during 5 minutes. (interruption time is 30 seconds each time)
• The time of 5 minutes may be exceeded if the equipment under test needs a longer time for start up, e.g. booting sequence. For equipment which requires booting, one additional power supply interruption during booting to be per- formed
• Check the possible corruption of programme or data held in programmable electronic systems (where applicable)</td><td>The equipment operates satisfactory without manual calibration after restoration of the electrical power supply.</td></tr>
<tr><td>4</td><td>Electrical power supply variation test</td><td>• Check the operation of the equipment when the electrical power supply varies as shown in the following AC supply
<table>
<tr><th>Combination</th><th>Voltage variation permanent (%)</th><th>Frequency variation permanent (%)</th></tr>
<tr><td>1</td><td>+6</td><td>+5</td></tr>
<tr><td>2</td><td>+6</td><td>-5</td></tr>
<tr><td>3</td><td>-10</td><td>-5</td></tr>
<tr><td>4</td><td>-10</td><td>+5</td></tr>
<tr><td></td><td>voltage transient (%)</td><td>frequency transient (%)</td></tr>
<tr><td></td><td>1.5 sec</td><td>5sec</td></tr>
<tr><td>5</td><td>+20</td><td>+10</td></tr>
<tr><td>6</td><td>-20</td><td>-10</td></tr>
</table>
DC supply
<table>
<tr><td rowspan="2">For the equipment not related to a battery (%)</td><td>Voltage tolerance continuous</td><td>±10</td></tr>
<tr><td>Voltage cyclic variation</td><td>5</td></tr>
<tr><td></td><td>Voltage ripple</td><td>10</td></tr>
<tr><td rowspan="2">For the equipment related to a battery (%)</td><td>For the equipment connected to a battery during charging</td><td>-25 ~ +30</td></tr>
<tr><td>For the equipment not connected to a battery during charging</td><td>-25 ~ +20</td></tr>
</table></td><td>No abnormality is observed. The equipment operates satisfactory.</td></tr>
</table>

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

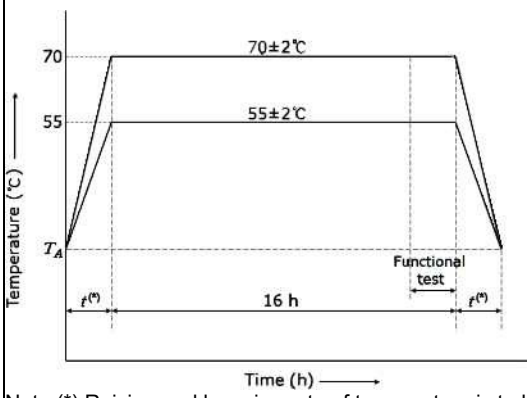
No.	Test item	Testing condition and method	Criteria
5	Power supply variation test	• Check the operation of the equipment when the pneumatic and the hydraulic power supplies are maintained continuously +20 % and -20 % of the working pressure for at least 15 minutes.	• No abnormality is observed. • The equipment operates satisfactory.
6	Dry heat test	• The test shall be carried out at 25 ±2 ℃ in atmospheric temperature. • The absolute humidity shall not exceed 20 g of water vapor per cubic meter of air(corresponding approximately to 50 % relative humidity at 35℃). • Test A : The equipment is at an operating condition and apply the environmental condition of +70 ±2 ℃ for 16 hours. • Test B : For the equipment installed in air conditioned spaces, the environmental condition of +55 ±2 ℃ for 16 hours may be applied. Where the equipment is attached with other equipment's in the console and housing, test A is to be performed. • Dry heat at 70 °C is to be carried out to automation, control and instrumentation equipment subject to high degree of heat, for example mounted in consoles, housings, etc. together with other heat dissipating power equipment. • The operation of the equipment during conditioning and testing shall be checked and functional test carry out during the last 1 hour at the test temperature. However, for heat dissipating equipment, the operation of the equipment during conditioning and testing with cooling system on if provided is to be checked. • For equipment specified for increased temperature, the dry heat test is to be conducted at the agreed test temperature and duration. • Detailed test methods are referred to the follows. For non-heat dissipating equipment: Test Bb of IEC 60068-2-2:2007 For heat dissipating equipment: Test Be of IEC 60068-2-2:2007  Note (*) Raising and lowering rate of temperature is to be within 1°C/min.(mean value for a period within 5 minutes **Figure A1.1.1 Program of dry heat test**	• No abnormality is observed. • The equipment is comply with the requirements of performance test and functional test.

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

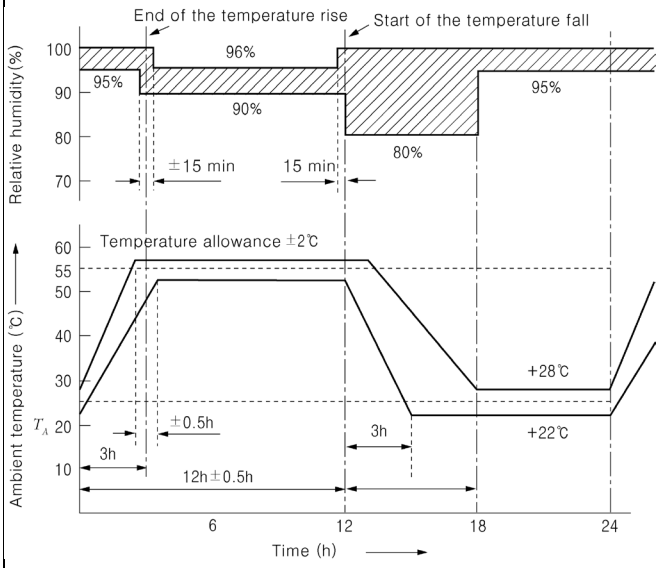
No.	Test item	Testing condition and method	Criteria
7	Damp heat test	• The test shall start with 25 ±3 ℃ in atmospheric temperature and at least 95 % humidity. • The temperature in the chamber shall be continuously raised to 55 ±2 ℃ during 3h±30 min. During this period, the relative humidity shall be not less than 95 %, except during the last 15min when it shall be not less than 90 %. (Refer Figure A1.1.2) • The temperature shall then be maintained 55 ±2 ℃ until 12h ±30 min from the start of the cycle. During this period, the relative humidity shall be 93±3%, except for the first and last 15 min when it shall be between 90% and 100%. • 2 cycles shall be carried out as shown in Figure A1.1.2 . The equipment is kept under operating condition during complete 1st cycle and switched off during 2nd cycle except for the operation test. And functional test is to be carried out during the first 2 hours of the 1st cycle at the environmental condition, during the last 2 hours of 2nd cycle at the environmental condition and after recovery. And duration of the second cycle can be extended due to more convenient handling of the functional test. • Insulation resistance measurements are carried out before and after test. • Detailed test methods are referred to Test Db of IEC 60068-2-30:2005.  **Figure A1.1.2 Program of damp heat test**	• No abnormality is observed. • The equipment is comply with the requirements of performance test and functional test.

Table **A1.1.1** Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>8</td><td>Vibration test</td><td>
The equipment is at an operating condition and apply the sweeping of vibration specified in the following over the frequency range of 2(+3, -0) Hz ~ 100 Hz in order to find resonance points.(points of which amplification factor : Q≥2 are considered resonance points.)
<table>
<tr><td>Frequency</td><td>Amplitude or Acceleration</td></tr>
<tr><td>2(+3, -0) ~ 13.2 Hz</td><td>Amplitude ±1.0 mm</td></tr>
<tr><td>13.2 ~ 100 Hz</td><td>Acceleration ±0.7 g</td></tr>
</table>

When resonance points do not exist, apply the vibration of acceleration ±0.7 g at 30 Hz for 90 minutes as an endurance test.
When resonance points exist, repeat the test with necessary provisions to avoid resonance or apply the vibration (same amplitude or acceleration of resonance point) at the resonance frequency for 90 minutes as an endurance test. However, where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies is detected close to each other, duration of the test is to be 120 min.
Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate. Critical frequency is a frequency at which the equipment being tested may exhibit:
malfunction and/or performance deterioration
mechanical resonances and/or other response effects occur, e.g. chatter
during the vibration test, functional tests are to be carried out;
The test is carried out in three axis direction.
It is recommended as guidance that Q does not exceed 5.
For the equipment intended to be installed in severe vibration conditions such as diesel engines, air compressors, the vibration level specified in the following is applied.

<table>
<tr><td>Frequency</td><td>Amplitude or Acceleration</td></tr>
<tr><td>2(+3, -0) ~ 25.0 Hz</td><td>Amplitude ±1.6 mm</td></tr>
<tr><td>25.0 ~ 100 Hz</td><td>Acceleration ±4.0 g</td></tr>
</table>

More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified for increased vibration levels the vibration test is to be con- ducted at the agreed vibration level, frequency range and duration. Values may be required to be in these cases 40 Hz to 2000 Hz- acceleration ±10.0 g at 600 ℃ duration 90 minutes.
Detailed test methods are referred to Test Fc of IEC 60068-2-6:2007.

</td><td>

No abnormality is observed.
The equipment is comply with the requirements of performance test and functional test.

</td></tr>
</table>

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>9</td><td>Inclination test</td><td>• The equipment is at an operating condition and check the operation of the equipment with 22.5° static inclination.
• The equipment is at an operating condition and check the operation of the equipment with rolling of 22.5° at period of about 10 seconds for not less than 15 min.
• The test is carried out in three axis directions.
• These inclination tests are normally not required for equipment with no moving parts.
• Detailed test methods are referred to IEC 60092-504:2016.</td><td>• No abnormality is observed.
• The equipment operates satisfactory.</td></tr>
<tr><td>10</td><td>Insulation resistance test</td><td>Measure the insulation resistance between current carrying parts and between current parts and earth when measured with the following application voltage.
<table><tr><td>Rated voltage : Un(V)</td><td>Test voltage(D.C. voltage)(V)</td></tr><tr><td>Un ≤ 65</td><td>2 × Un, min. 24</td></tr><tr><td>Un ＞ 65</td><td>500</td></tr></table>• Measurements are carried out before and after; other series of environmental tests, damp heat test, cold test and salt mist test.
• For the equipment containing circuits in which the application of the test voltage is not desirable, the test voltage is ap- plied after removing the circuits.</td><td>• The insulation resistance (MΩ) is not less than the value specified in the following.
<table><tr><td>Rated voltage</td><td>Before test</td><td>After test</td></tr><tr><td>Un≤65</td><td>10</td><td>1.0</td></tr><tr><td>Un＞65</td><td>100</td><td>10</td></tr></table></td></tr>
<tr><td>11</td><td>High voltage test</td><td>• Apply the following test voltage, alternating of a frequency of 50 Hz or 60 Hz, between current carrying parts and between current-carrying parts connected and earth for 1 minute.
<table><tr><td>Rated voltage : Un(V)</td><td>Test voltage(V)</td></tr><tr><td>Un ≤ 65</td><td>2 × Un + 500</td></tr><tr><td>65 ＜ Un ≤ 250</td><td>1,500</td></tr><tr><td>250 ＜ Un ≤ 500</td><td>2,000</td></tr><tr><td>500 ＜ Un ≤ 690</td><td>2,500</td></tr></table>For the equipment containing circuits in which the application of the test voltage is not desirable, the test voltage is applied after removing the circuits.</td><td>• No abnormality is observed.</td></tr>
</table>

Table **A1.1.1** Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

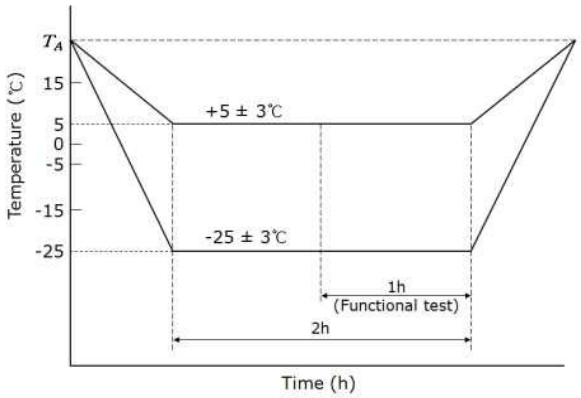
No.	Test item	Testing condition and method	Criteria
12	Cold test	• The test shall be carried out at 25 ±10 ℃ in atmospheric temperature. • The equipment is switched off except for the operation test and apply the environmental condition of +5 ±3 ℃ for 2 hours. And functional test is to be carried out during the last hour at the test temperature and after recovery. • For the equipment installed in open decks, etc., the environmental condition of -25 ±3 ℃ is applied for 2 hours. • Insulation resistance measurements are carried out before and after cold test. • Detailed test methods are referred to Test Ab or Test Ad of IEC 60068-2-1:2007.  **Figure A1.1.3 Program of cold test**	• No abnormality is observed. • The equipment is comply with the requirements of performance test and functional test.
13	Salt mist (2) test	• Salt mist test is to be carried out for equipment installed in weather exposed areas. • The equipment is switched off except when its operation is checked. Apply four cycles of the environmental condition of spraying NaCl liquid (saline solution, 5 % NaCl, pH 6.5 ~ 7.2, 20 ±2℃) for 2 hours and leaving for 7 days. Check the operation of the equipment during the 7th day of each cycle and after recovery. • Damp chamber conditions for storage are to be maintained as follows; Temp. : 40℃±2℃ Relative humidity : 93% +2% -3% • The test is carried out according to the following procedure Insulation resistance and functional test before test Functional test on the 7th day of each cycle period Insulation resistance and functional test : 4 to 6 hours after recovery • On completion of exposure, the equipment is to be examined to verify that deterioration or corrosion (if any) is superficial in nature. • Detailed test methods are referred to Test Kb of **IEC 60068-2-52:2017.**	• No abnormality is observed. • The equipment is comply with the requirements of performance test and functional test.

Table **A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)**

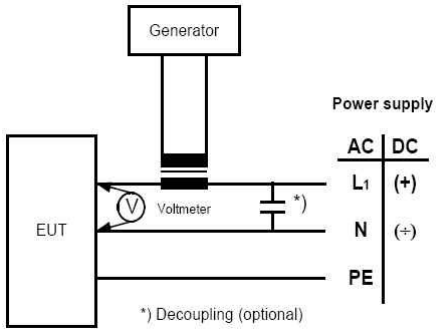
<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>14</td><td>Electrostatic discharge immunity test</td><td>• Check the operation of the equipment when the electrostatic discharge immunity test is carried out according to the following condition.
<table><tr><td>Contact discharge</td><td>6 kV</td></tr><tr><td>Air discharge</td><td>2 kV, 4 kV, 8 kV</td></tr><tr><td>Interval between single discharge</td><td>1 sec.</td></tr><tr><td>No. of Pulses</td><td>10 per polarity</td></tr></table>• The test is to be confined to the points and surfaces that can normally be reached by the operator.
• Detailed test methods are referred to Test level 3 of IEC 61000-4-2:2008.</td><td>• Performance Criterion B(1)</td></tr>
<tr><td>15</td><td>Electromagnetic field immunity test</td><td>Check the operation of the equipment when the radiated radio frequency immunity test is carried out according to the following condition.
<table><tr><td>Frequency range</td><td>80 MHz ~ 6 GHz</td></tr><tr><td>Modulation</td><td>80 % AM at 1,000 Hz</td></tr><tr><td>Field strength</td><td>10 V/m</td></tr><tr><td>Frequency sweep rate</td><td>≤1.5 × 10^{-3} decades/sec.
(or 1 %/3 sec.)</td></tr></table>• If for tests of equipment an input signal with a modulation frequency of 1,000 Hz is necessary, a modulation frequency(80 % AM) of 400 Hz may be chosen.
• The test is to be confined to the appliances exposed to di- rect radiation by transmitters at their place of installation.
• If an equipment is intended to receive radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller), then the immunity limits at its communication frequency do not apply.
• Detailed test methods are referred to Test level 3 of IEC 61000-4-3:2020.</td><td>• Performance Criterion A(2)</td></tr>
<tr><td>16</td><td>Conducted low frequency immunity test</td><td>• Check the operation of the equipment when the conducted low frequency immunity test is carried out according to the following condition. (values in round brackets are shown where the rated frequency of the equipment is 50 Hz)


Figure A1.1.4 Test Set-up - Conducted Low Frequency Test</td><td>• Performance Criterion A(2)</td></tr>
</table>

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>16</td><td>Conducted low frequency immunity test</td><td>
<table>
<tr><td>Frequency range</td><td colspan="3">60 Hz ~12 kHz
(50 Hz~10 kHz)</td></tr>
<tr><td rowspan="4">Test voltage</td><td rowspan="3">AC</td><td>10 % of supply voltage</td><td>60 Hz~900 Hz
(50 Hz~750 Hz)</td></tr>
<tr><td>10 % to 1 % of supply voltage</td><td>900 Hz~6 Hz
(750 Hz~5 kHz)</td></tr>
<tr><td>1 % of supply voltage</td><td>6 kHz~12 kHz
(5 kHz~10 kHz)</td></tr>
<tr><td>DC</td><td>10 % of supply voltage
(at least 3 V)</td><td>50 Hz~10 kHz</td></tr>
<tr><td rowspan="2">Maximum power</td><td>AC</td><td colspan="2">min 3 V r.m.s, max 2 W.</td></tr>
<tr><td>DC</td><td colspan="2">2 W</td></tr>
</table>
• For keeping max. 2 W, the voltage of the test signal may be lower.
• In case of marine navigational and radio communication equipment and systems, this test can be exempted.
</td><td>Performance Criterion A(2)</td></tr>
<tr><td>17</td><td>Conducted radio frequency immunity test</td><td>
• Check the operation of the equipment when the conducted high frequency immunity test is carried out according to the following condition.
<table>
<tr><td>Frequency range</td><td>150 kHz ~ 80 MHz</td></tr>
<tr><td>Modulation</td><td>80 % AM at 1,000 Hz</td></tr>
<tr><td>Amplitude</td><td>3 Vrms(3)</td></tr>
<tr><td>Frequency sweep rate</td><td>≤1.5 × 10-3 decades/sec.
(or 1 %/3 sec.)</td></tr>
</table>
• If for tests of equipment an input signal with a modulation frequency of 1 kHz is necessary a modulation frequency(80 % AM) of 400 Hz should be chosen.
• Detailed test methods are referred to Test level 2 of IEC 61000-4-6:2013.
</td><td>Performance Criterion A(2)</td></tr>
<tr><td>18</td><td>Electrical fast transients / Burst immunity test</td><td>
• Check the operation of the equipment when the electrical fast transients / burst immunity test is carried out according to the following condition.
<table>
<tr><td>Single pulse rise time</td><td>5 nS (10 ~ 90 % value)</td></tr>
<tr><td>Single pulse width</td><td>50 nS (50 % value)</td></tr>
<tr><td>Amplitude(peak)</td><td>line on power supply port/earth : 2 kV
line/line on I/O data control and signal lines : 1 kV</td></tr>
<tr><td>Pulse period</td><td>300 mS</td></tr>
<tr><td>Burst duration</td><td>15 mS</td></tr>
<tr><td>Duration</td><td>5 min./polarity</td></tr>
</table>
• Detailed test methods are referred to Test level 3 of IEC 61000-4-4:2012.
</td><td>Performance Criterion B(1)</td></tr>
</table>

Table **A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)**

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>19</td><td>Surge immunity test</td><td>
• Check the operation of the equipment when the surge immunity test is carried out according to the following condition.
<table>
<tr><td colspan="3">Test applicable to AC and DC power ports</td></tr>
<tr><td rowspan="3">Open-circuit voltage</td><td>Pulse rise time</td><td>1.2 μs (front time)</td></tr>
<tr><td>Pulse width</td><td>50 μs(time to half value)</td></tr>
<tr><td>Amplitude(peak)</td><td>line/earth :1 kV
line/line : 0.5 kV</td></tr>
<tr><td rowspan="2">Short-circuit current</td><td>Pulse rise time</td><td>8 μs (front time)</td></tr>
<tr><td>Pulse width</td><td>20 μs (time to half value)</td></tr>
<tr><td colspan="2">Repetition rate</td><td>at least 1 pulse/min.</td></tr>
<tr><td colspan="2">No. of pulse</td><td>5 per polarity</td></tr>
</table>
• Detailed test methods are referred to Test level 2 of IEC 61000-4-5:2017.
</td><td>Performance Criterion B(2)</td></tr>
<tr><td>20</td><td>Radiated emission test</td><td>
• Radiated emission test is to be carried out according to the following.

(Limits below 1,000 Mhz)
<table>
<tr><td colspan="2">For equipment installed in the bridge and deck zone.</td></tr>
<tr><td>Frequency range</td><td>Quasi peak limits</td></tr>
<tr><td>150 kHz ~ 300 kHz</td><td>80 ~ 52 dB μ V/m</td></tr>
<tr><td>300 kHz ~ 30 MHz</td><td>52 ~ 34 dB μ V/m</td></tr>
<tr><td>30 MHz ~ 1,000 MHz</td><td>54 dB μ V/m</td></tr>
<tr><td>156 MHz ~ 165 MHz</td><td>24 dB μ V/m</td></tr>
</table>
For equipment installed in a zone other than bridge and deck zone
<table>
<tr><td>150kHz ~ 30MHz</td><td>80 ~ 50 dB μ V/m</td></tr>
<tr><td>30MHz ~ 100MHz</td><td>60 ~ 54 dB μ V/m</td></tr>
<tr><td>100MHz ~ 1,000MHz</td><td>54 dB μ V/m</td></tr>
<tr><td>156MHz ~ 165MHz</td><td>24 ddB μ V/m</td></tr>
</table>
(Limits above 1,000 MHz)
<table>
<tr><td>Frequency range</td><td>Average limit</td></tr>
<tr><td>1,000 MHz ~ 6,000 MHz</td><td>54 dB μ V/m</td></tr>
</table>
• Distance between equipment and antenna is to be 3 m.
• For the frequency band 156 MHz to 165 MHz the measurement shall be repeated with a receiver bandwidth of 9 kHz (as per IEC 60945).
• Alternatively the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz is to be 30 $\mathrm{dB}\,\mu\,\mathrm{V/m}$ peak. (as per IEC 60945:2002).
• Equipment intended to transmit radio signals for the purpose of radio communication (e.g. wifi router, remote radio controller) may be ex- empted from limit, within its communication frequency range.
• Detailed test methods are referred to CISPR 16-2-3:2016 and IEC 60945:2002(for 156 ~ 165 MHz).
</td><td>Radiated emission is to be within limits in the table.(4)</td></tr>
</table>

Table **A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)**

<table>
<tr><th>No.</th><th>Test item</th><th>Testing condition and method</th><th>Criteria</th></tr>
<tr><td>21</td><td>Conducted emission test</td><td>• Conducted emission test is to be carried out according to the following.
For equipment installed in the bridge and deck zone.<table><tr><td>Frequency range</td><td>Limits</td></tr><tr><td>10 kHz ~ 150 kHz</td><td>96 ~ 50 dB μ V</td></tr><tr><td>150 kHz ~ 350 kHz</td><td>60 ~ 50 dB μ V</td></tr><tr><td>350 kHz ~ 30 MHz</td><td>50 dB μ V</td></tr></table>For equipment installed in a zone other than bridge and deck zone<table><tr><td>Frequency range</td><td>Limits</td></tr><tr><td>10 kHz ~ 150 kHz</td><td>120 ~ 69 dB μ V</td></tr><tr><td>150 kHz ~ 500 kHz</td><td>79 dB μ V</td></tr><tr><td>500 kHz ~ 30 MHz</td><td>73 dB μ V</td></tr></table>• Test applicable to AC and DC power ports.
• Detailed test methods are referred to CISPR 16-2-1:2017</td><td>Conducted emission is to be within limits in the table.</td></tr>
<tr><td>22</td><td>Flame resistance test</td><td>• . Flame resistance test is to be carried out according to the following condition.<table><tr><td>Flame application</td><td>5 times 15 sec. each</td></tr><tr><td>Interval between each application</td><td>15 sec. or 1 time 30 sec.</td></tr></table>• The test is performed with the EUT or housing of the EUT applying needle-flame test method.
• Detailed test methods are referred to IEC 60092-101:2018 or IEC 60695-11-5:2016.</td><td>• The burnt out or damaged part of the specimen by not more than 60 mm long.
• No flame, no incandescence or
• In the event of a flame or in c a n de s c e n c e being present, it shall extinguish itself within 30 s of the removal of the needle flame without full combustion of the test specimen.
-Any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.</td></tr>
<tr><td>23</td><td>Pressure test</td><td>• .Apply the pneumatic or hydraulic pressure of 1.5 times the designed pressure.</td><td>No abnormality is observed.</td></tr>
</table>

Table A1.1.1 Environmental Test Items, Testing Conditions and Methods, and Criteria (continued)

(Note)

(1) Performance Criterion B: The Equipment Under Test is to continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self recoverable is however allowed but no change of actual operating state or stored data is allowed.

(2) Performance Criterion A: The EUT is to continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer.

(3) For equipment installed on the bridge and deck zone, the test levels shall be increased to 10 V rms for spot frequencies in accordance with **IEC 60945:2002** at 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.

(4) The upper frequency of the radiated emission test may be reduced depending on the highest internal frequency of the EUT, as per **7.6.6.2.2** of **CISPR 16-2-3:2016**. If the highest frequency of the EUT is: *(2022)*

- below 108 MHz : emission shall be measured up to 1 GHz,
- between 108 MHz and 500 MHz : emission shall be measured up to 2 GHz,
- between 500 MHz and 1 GHz : emission shall be measured up to 5 GHz,
- above 1 GHz : emission shall be measured up to the lower of 5 times of the highest internal frequency and 6 GHz.

The conditional testing procedure cannot be applied unless the highest internal frequency of the EUT is documented.

ANNEX 2 CONSTRUCTION AND INSTALLATION

SECTION 1 SYSTEM DESIGN 73

SECTION 1 SYSTEM DESIGN

Contents

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1.3. Installation of propulsion machines 74
1.4. Consideration of magnetic compass 75
1.5. Electromagnetic compatibility 75

1.1. Construction and installation

1.1.1. Construction

Electrical equipment shall be so constructed as to provide easy accessibility to all parts requiring inspection, overhaul and repair.

1.1.2. Protection against corrosion

1.1.2.1. Bolts, nuts, pins, screws, terminals, studs, springs and such other small parts are to be made of corrosion resistant materials or those suitably protected against corrosion.

1.1.2.2. If electrical fittings, not of aluminium, are attached to aluminium, suitable means are to be taken to prevent corrosion.

1.2. Protection against electrical shock

1.2.1. Where the operators are liable to inadvertently touch the live part of electrical apparatus due to ship′ s inclination and vibration, such parts are to be protected with suitable means to prevent electrical shock.

1.2.2. The moving parts, reciprocating parts, high temperature parts or charged parts of electrical equipment are to be provided with suitable protections for one who watches, operates or approaches the equipment to avoid injury.

1.2.3. To minimize shock from high-frequency voltage induced by the radio transmitter, handles, handrails, etc. of metal on the bridge or upper decks are to be in good electrical connection with the hull or superstructure.

1.3. Installation of propulsion machines

Means shall be provided to prevent the accumulation of bilge under propulsion machines (generators, motor-generators, motors, electro-magnetic slip couplings).

1.3.1. Installation and protective enclosure

Electrical equipment shall be accessibly placed in well ventilated and adequately lighted spaces in which inflammable gases cannot accumulate and where it is not exposed to the risk of mechanical injuries or damage from water, steam or oil, and is to be so installed that space is available for maintenance. Where, however, electrical equipment are unavoidably installed in spaces not fulfilled the above conditions, they are to be of the following construction.

1.3.1.1. Drip-proof construction where water drip and oil are liable to drop.

1.3.1.2. Water-proof construction where installed on exposed decks liable to get wet by sea water, rain or bilge water.

1.3.1.3. Submersible construction where employed in water.

1.3.1.4. Explosion-proof construction where explosive or inflammable materials are stored or liable to accumulate.

1.3.2. Insulating materials and insulated windings

Insulating materials and insulated windings are to be of resisting quality against moisture, sea air and oil vapour.

1.3.3. Power source control switches

Electrical equipment is not to remain alive through the control circuits or pilot lamps when switched off by the control switch.

1.3.4. Mechanical lock

All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

1.4. Consideration of magnetic compass

Electrical equipment and cables are to be placed at such a distance from the magnetic compasses that the interfering external magnetic field is negligible, even when circuits are switched on and off.

1.5. Electromagnetic compatibility

Electrical and electronic equipment on the bridge shall be so installed that electromagnetic

interference does not affect the proper function of navigational systems and equipment

ANNEX 3 APPROVAL APPLICATION

SECTION 1 APPROVAL AND DATAS 77

SECTION 1 APPROVAL AND DATAS

Contents

1.1. Approval application 78
1.2. Submission of Datas 78

1.1. Approval application

1.1.1. The applicant

The applicant is, in principle, shall be the manufacturer of the materials and equipment. However, the applicant, where deemed appropriate by the Society, need not always be the manufacturer of the materials and equipment.

1.1.2. The manufacturer wishing to obtain a type approval shall submit a copy of the application of type approval , together with three copies of the required data for approval and two copies of the required data for reference, to the Society. However, the required data previously submitted to the Society may be exempted from submission.

1.2. Submission of Data's

1.2.1. Data for approval

(a) Type test program and applicable standards, codes or rules (when the test methods, procedures, etc. in the Guidance, IMO Resolution–apply, their number and subject stipulation instead of submission may be accepted except details of test specimens.)

(b) Relevant drawings (fully detailed sectional assembly, drawings for main component parts) and documents as below.

(i) Product specifications

(ii) All product details, catalogues, data sheets, calculations and functional descriptions, parts list, etc,(if any)

(iii) Application and operational limitation

(iv) Drawings showing the interaction between the main component(if any)

(v) PCB(Printed Circuit Board) Lay-out/circuit diagram(if any)

(vi) Wiring diagram, connection diagram(if any)

(vii) System block diagram(control logic)(if any)

(viii) Name and version No of software to be installed and Quality Assurance Plan(if any)

(ix) Installation and operation manual(if necessary)

(x) marking methods

1.2.2. Data for reference

(a) Particulars and specifications of products

(b) Outline of company

(i) Data on history, outline and layout of manufacturing plants

(ii) Organisation and management structure, including subsidiaries to be included in the approval/ certification

1.2.3. Notwithstanding the requirements in the preceding [1.2.2] **,** where the applicant is already approved by the Society and the attachments are entirely equal in content to the documents previously submitted the submission of documents may be partly or wholly exempted except for the approval test Program