Excerpt from ABS Rules Developed for an Electric Motor Generator

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Excerpt from ABS Rules Developed for an Electric Motor Generator

American Bureau of Shipping

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Foreword

Purpose

This booklet is an excerpt from the ABS Rules. It has been created to support equipment manufacturers in identifying the appropriate ABS Rules for their products.

Application

Equipment manufacturers seeking to have their products approved for marine and offshore applications under ABS classification or certification will find this booklet a practical reference for determining which sections of the ABS Rules are applicable to their specific equipment types.

This excerpt does not replace or supersede the complete ABS Rules. Users are responsible for consulting the full text of the applicable Rules and ensuring compliance with the most current edition, including any published corrigenda and notices.

Additional Information

For questions regarding the applicability of specific Rules to your equipment. Please contact your local ABS office.

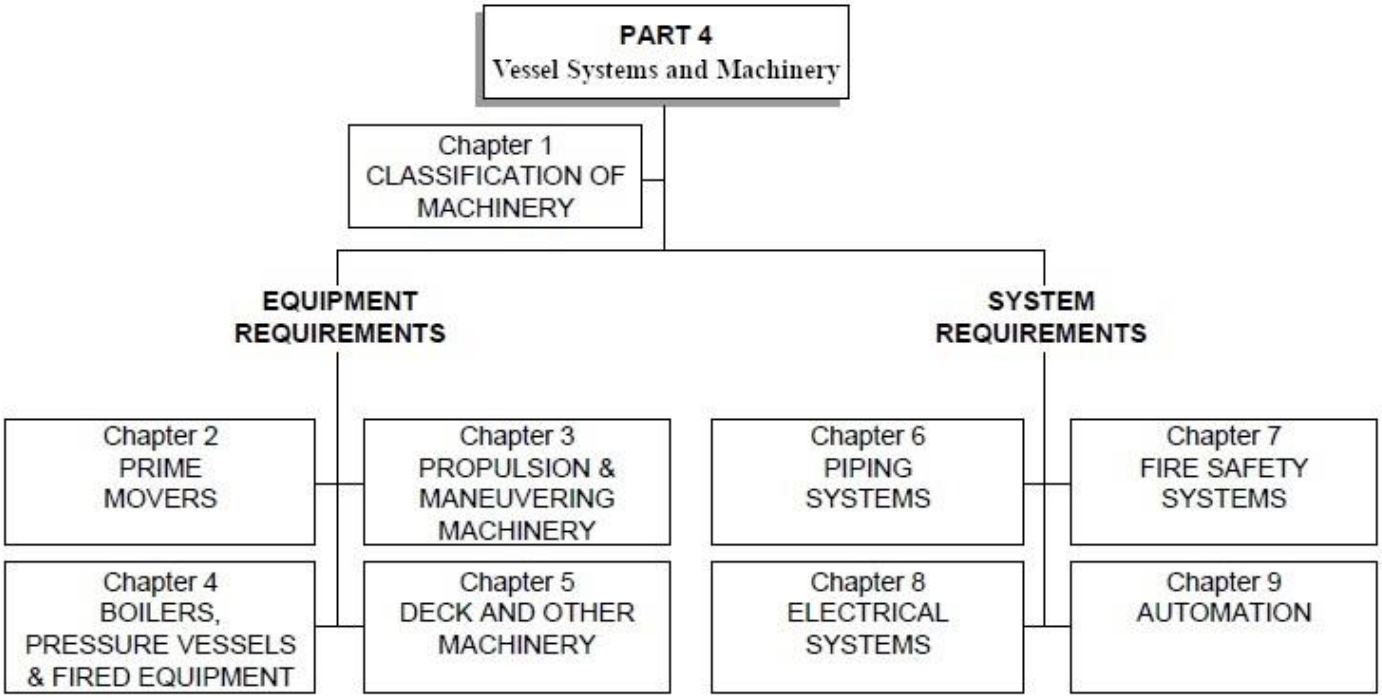
The ABS Rules are available in their complete form at American Bureau of Shipping (ABS) Eagle.org.

1 General

1.1 Organization of Part 4

Part 4 provides classification requirements for machinery. These requirements are organized in two broad segments: that specific to equipment, and that specific to systems. FIGURE 1 shows the overall organization of Part 4.

FIGURE 1
Organization of Part 4



1.2 Objective (2024)

1.2.1 Goals

The machinery covered in this section is to be designed, constructed, operated, maintained to:

Goal No.	Goal
POW 1	Provide safe and reliable storage and supply of fuel/energy/power.
POW 5	Enable supply/power for essential services to be restored after malfunction.
PROP 1	Provide sufficient thrust/power to move or maneuver the vessel when required.
PROP 2	Provide redundancy and/or reliability to maintain propulsion.
PROP 3	*Provide sufficient power for going astern...to secure proper control and bring the ship to rest in all normal circumstances.*
SAFE 1	Promote the occupational health and safety of personnel onboard.

Goal No.	Goal
SAFE 1.1	Minimize danger to persons on board, the vessel, and surrounding equipment/installations from hazards associated with machinery and systems.

The goals in the cross-referenced Rules/Regulations are to be met.

1.2.2 Functional Requirements

In order to achieve the above stated goals, the design, construction, installation and maintenance of machinery are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Propulsion, Maneuvering, Station Keeping (PROP)	
PROP-FR1 (POW)	Operate under anticipated environmental and vessel conditions, such as weather and vibrations.
PROP-FR2	Propulsion machinery is to effectively operate in and efficiently switch over to astern mode without abnormal responses.
PROP-FR3	Propulsion machinery is to provide sufficient astern power to bring the vessel to rest from maximum ahead service speed to avoid a dangerous situation.
PROP-FR4 (POW)	Provide adequate ventilation to allow machinery and personnel to work effectively and machinery for propulsion and emergency services to operate continuously.
Safety of Personnel (SAFE)	
SAFE-FR1	Materials that harm human health are not to be used in machinery.

The functional requirements in the cross-referenced Rules/Regulations are to be met.

1.2.3 Compliance

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

1.3 Requirements for Classification

1.3.1 Scopes of Part 4, Part 5C, Part 5D, and Part 6 **(2024)**

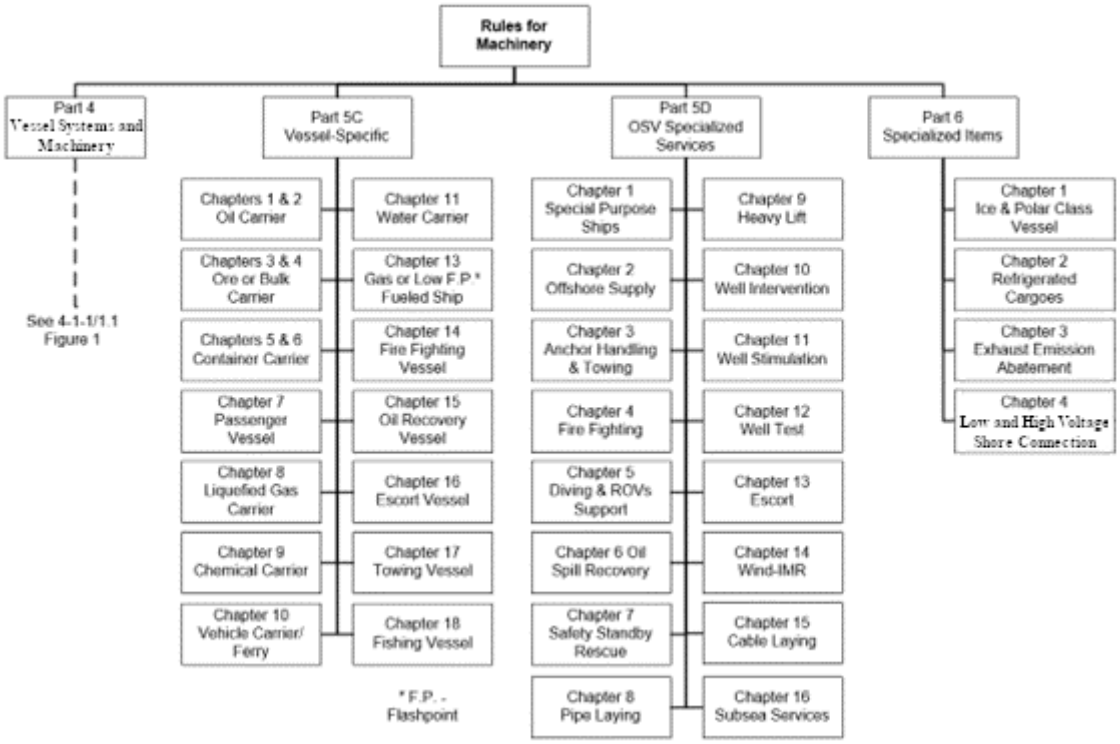
FIGURE 2 shows the overall organization of machinery requirements included in all Parts of the *Marine Vessel Rules*.

Part 4 provides the minimum requirements for machinery of self-propelled vessels. Compliance with Part 4 is a condition for classification of all such vessels, and for assigning the appropriate machinery class notations indicated in 1.5.

Additional requirements for machinery, which are specific for each vessel type, are provided in Part 5C and Part 5D. Compliance with the requirements of Part 5C or Part 5D is a condition for assigning the vessel type class notation specified therein, such as *Oil Carrier*, *Passenger Vessel*, *Liquefied Gas Carrier*, etc.

Additional requirements for specialized items and systems are provided in Part 6. These items and systems used for specific operations include those for navigation in ice, for carrying refrigerated cargoes, for exhaust emission abatement, and for high/low voltage shore connection. Optional class notations in each chapter may be assigned upon compliance with the corresponding requirements in Part 6, such as *Ice Class 1E*, *Ice Class I AA*, *Ice Breaker*, *Ice ClassPC1*, and ✠ *RCC*.

FIGURE 2
Organization of Rules for Machinery in Marine Vessel Rules (2024)



1.3.2 Fundamental Intent of Machinery Rules

1.3.2(a) Propulsion and Maneuvering Capability **(2024)**

Part 4 of the Rules is intended to address the propulsion and maneuvering capability of the vessel through specification of appropriate design, testing, and certification requirements for propulsion, maneuvering and other equipment and their associated systems. See FIGURE 1 for equipment and systems included in the scope.

Loss of propulsion and maneuvering of the vessel may lead to collision or pollution or damage to the vessel and danger to persons on board. Means are to be provided whereby normal operation of propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. ABS, having regard to overall safety considerations, may accept a partial reduction in propulsion capability from normal operation.

1.3.2(b) Machinery Hazards

Part 4 of the Rules is also intended to identify and address hazards associated with machinery aboard a vessel, particularly those hazards which are capable of causing personal injury, flooding, fire or pollution.

1.3.2(c) Cargo Hazards

Hazards associated with cargoes carried (such as oil, dangerous goods, etc.) or to the specialized operations of the vessel (such as navigating in ice) are addressed in Part 5C, Part 5D, or Part 6, as applicable.

1.3.2(d) Hazard Considerations **(2024)**

Design and testing of machinery are to consider the hazards noted in 1.3.2(b) and 1.3.2(c). They are to comply with requirements in the Rules considering the conditions onboard, or in absence of such requirements, with general engineering principles, codes or standards.

The Rules require at least a level of protection for equipment or components such that, when operated incorrectly or failed, will not lead to injury to personnel, damage to asset or pollution. The severity of the consequences upon failure are also to be considered when determining the level of protection to be applied.

In addition, hazardous cargo or related systems are to be designed to mitigate risks considering loss of a single equipment or component. Control and instrumentation systems provided for local, remote control or automation systems are designed to aid machinery operations and their failure are not to lead to injury to personnel, damage or pollution.

Arrangements onboard are to separate sources of ignition from flammable substances and separate hazards from personnel.

Despite risk mitigation, if incidents occur, safety systems are to be provided to help crew address them. Operational aids (such as manuals, training, damage control plans and fire control plans) are also to be provided to assist the crew to respond to emergency and hazardous situations.

1.7 Alternative Standards **(2024)**

Equipment, components and systems for which there are specific requirements in Part 4 may comply with requirements of an alternative standard, in lieu of the requirements in the Rules if the alternative standard is determined by ABS to be equivalent to the Rules. Requirements may be imposed by ABS in addition to those contained in the alternative standard so that goals and functional requirements of the Rules are met. In all cases, the equipment, component, or system is subject to design review, survey during construction, tests, and trials, as applicable, by ABS for purposes of verification of its compliance with the alternative standard. The verification process is to be to the extent as intended by the Rules. See also 1A-1-1/1 of the ABS *Rules for Conditions of Classification (Part 1A)*.

1.9 Definitions

Definitions of terms used are defined in the chapter, sections or subsections where they appear. The following are terms that are used throughout Part 4.

1.9.1 Control Station **(2024)**

A location where controllers or actuators are fitted, along with monitoring devices, as appropriate, for purposes of effecting desired operation of specific machinery.

Control Station is defined solely for purposes of Part 4, Chapter 7 “Fire Safety Systems”, as intended by SOLAS, in 4-7-1/11.21.

Centralized Control Station is defined in 4-9-1/5.1.15 to refer to the space or the location where the following functions are centralized:

- Controlling propulsion and auxiliary machinery,
- Monitoring propulsion and auxiliary machinery, and
- Monitoring the propulsion machinery space.

1.9.2 Machinery Spaces **(2024)**

Machinery Spaces are machinery spaces of Category A and other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces, and trunks to such spaces.

Machinery spaces of Category A are spaces and trunks to such spaces which contain:

i. Internal combustion machinery used for main propulsion; or
ii. Internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 KW (500 hp); or
iii. Any oil fired boiler or oil fuel unit; or
iv. Any oil-fired equipment other than boilers, such as inert gas generator, incinerator, waste disposal units, etc.

Commentary:

Item iv applies only to fire safety requirements similar to SOLAS Chapter II-2. See IMO MSC/Circ.847 and 4-7-1/11.15.

End of Commentary

1.9.3 Essential Services *(2004)*

For definition of essential services, see 4-8-1/7.3.3.

1.9.4 Hazardous Areas **(2024)**

Areas where flammable or explosive gases or vapors are normally present or likely to be present in quantities that require special precautions for the construction, installation and use of electrical equipment. The flammable or explosive atmosphere may exist continuously or intermittently. Hazardous areas are more specifically defined for certain machinery installations, storage spaces and cargo spaces that present hazards. For example:

- Helicopter refueling facilities, see ;
- Paint stores, see ;
- Cargo oil tanks and other spaces of oil carriers; see
- Cargo tanks and other spaces of an offshore support vessel carrying hazardous and noxious liquid substances with flashpoints not exceeding 60°C (140°F) or carrying hazardous and noxious liquid substances which evolve substances with flashpoints not exceeding 60°C (140°F);
- Recovered oil tanks and other spaces of an offshore support vessel with oil spill response
- Ro-ro cargo spaces; see .

1.9.5 Toxic or Corrosive Substances

Toxic Substances (solid, liquid or gas) are those that possess the common property of being liable to cause death or serious injury or to harm human health if swallowed or inhaled, or by skin contact.

Corrosive Substances (solid or liquid) are those, excluding seawater, that possess in their original state the common property of being able through chemical action to cause damage by coming into contact with living tissues, the vessel or its cargoes, when escaped from their containment.

1.9.6 Dead Ship Condition

Dead ship condition means a condition under which:

i. The main propulsion plant, boilers and auxiliary machinery are not in operation due to the loss of the main source of electrical power, and
ii. In restoring propulsion, no stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliary machinery is assumed to be available.

1.9.7 Blackout **(1 July 2022)**

Blackout situation means the main and auxiliary machinery installations, including the main power supply, are out of operation but the services for bringing them into operation (e.g., compressed air, starting current from batteries, etc.) are available.

1.9.8 Weathertight **(2024)**

Weathertight means that in any sea conditions, water will not penetrate into the vessel.

1.9.9 Watertight **(2024)**

Watertight means the capability of preventing the passage of water through the structure in any direction under pressure under a head of water for which the surrounding structure is designed.

1.9.10 Normal Operational and Habitable Condition **(2024)**

Normal Operational and Habitable Condition is a condition under which the ship as a whole, the machinery, services, means and aids maintaining propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, and emergency boat winches, as well as the designed comfortable conditions of habitability, are in working order and functioning normally.

1.9.11 Main Source of Electrical Power **(2024)**

Main Source of Electrical Power is a source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

1.9.12 Main Generating Station **(2024)**

Main Generating Station is the space in which the main source of electrical power is situated.

1.9.13 Main Switchboard **(2024)**

Main Switchboard is a switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ship's services.

1.9.14 Emergency Switchboard **(2024)**

Emergency Switchboard is a switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of power or the transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

3 Certification of Machinery

3.1 Basic Requirements

The Rules define the extent of evaluation, to varying degrees, required for products, machinery, equipment, and their components based on the level of criticality of each item. There are three basic evaluation constituents:

- Design review; type/prototype testing, as applicable;
- Survey during construction and testing at the plant of manufacture; and
- Survey during installation on board the vessel and at trials.

Where design review is required by the Rules, a letter will be issued by ABS upon satisfactory review of the plans to evidence the acceptance of the design. In addition to, or independent of, design review, ABS may require survey and testing of forgings, castings and component parts at the various manufacturers' plants, as well as survey and testing of the finished product. A certificate or report will be issued upon satisfactory completion of each survey to evidence acceptance of the forging, casting, component or finished product. Design review, survey and the issuance of reports or certificates constitute the *certification* of machinery.

Based on the intended service and application, some products do not require certification because they are not directly related to the scope of classification or because normal practices for their construction within the industry are considered adequate. Such products are accepted based on the manufacturers' documentation on design and quality.

Surveys during installation on board the vessel and at trials are required for all items of machinery. This is not considered a part of the product certification process. There may be instances, however, where letters or certificates issued for items of machinery contain conditions which are to be verified during installation, tests or trials.

3.3 Type Approval Program

Products that can be consistently manufactured to the same design and specification may be Type Approved under the ABS Type Approval Program. The ABS Type Approval Program is a voluntary option for the demonstration of the compliance of a product with the Rules or other recognized standards. It may be applied at the request of the designer or manufacturer. The ABS Type Approval Program covers Product Type Approval (1A-1-4/7.7.3 of the ABS *Rules for Conditions of Classification (Part 1A)*), but is also applicable for a more expeditious procedure towards Unit-Certification as specified in 1A-1-4/7.7.2 of the ABS *Rules for Conditions of Classification (Part 1A)*.

See the "ABS Type Approval Program " in Appendix 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)*.

3.5 Non-mass Produced Machinery

Non-mass produced critical machinery, such as propulsion boilers, slow speed diesel engines, turbines, steering gears, and similar critical items are to be individually unit certified in accordance with the procedure described in 3.1. However, consideration will be given to granting Type Approval to such machinery in the category of Recognized Quality System (RQS). The category of Product Quality Assurance (PQA) will not normally be available for all products and such limitations will be indicated in TABLE 1 to TABLE 6. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS will require some degree of product specific survey during manufacture.

3.7 Details of Certification of Typical Products **(2024)**

TABLE 1 through TABLE 6 summarize certification requirements of typical machinery based on the specific requirements of the Rules for machinery. The tables also provide the applicability of the Type Approval Program for each item.

The tables contain six product categories as follows:

- Prime movers
- Propulsion, maneuvering and mooring machinery
- Electrical and control equipment
- Fire safety equipment
- Boilers, pressure vessels, and fired equipment
- Piping system components

Commentary:

The approval tiers indicated in the tables are the minimum tiers of certification requirements. Refer to Appendix 1A-1-A4 of the ABS *Rules for Conditions of Classification (Part 1A)* for details of each Tier of Approval.

End of Commentary

3.9 ABS Marking on Finished Components and Equipment **(2021)**

All finished component/equipment issued with unit certificates are to be permanently marked at an accessible location for identification and traceability. The identification is to include, but not limited to the model number or part number, serial number and other data that are necessary to comply with other ABS Rule requirements.

At the request of the manufacturer, an ABS Marking may be applied. The marking includes the ABS mark (✠) and a unique identification number generated by ABS.

An example of ABS marking: ✠ 123456.

Markings are to be permanently marked (i.e. steel-die-stamped, laser etched, etc.) at an accessible location by the manufacturer on each finished component or equipment.

ABS Certificates for the components and equipment are to be provided to the responsible party (e.g. owner or shipyard) and Surveyor at installation.

5 Machinery Plans

5.1 Submission of Plans **(2024)**

Machinery and systems plans required by the Rules are to be submitted electronically by the manufacturer, designer, or shipyard to ABS. Where so stated in the shipbuilding contract, the Owner may require the shipyard to provide it with copies of approved plans and related correspondence. A fee will be charged for the review of plans which are not covered by a contract of classification with the shipyard.

All plans are to be submitted and approved before proceeding with the work.

5.3 Plans **(2024)**

Machinery plans required to be submitted for review and approval by ABS are listed in each of the sections in Part 4. Equipment plans are to contain performance data and operational particulars; standard of compliance

where standards are used in addition to, or in lieu of, the Rules; construction details such as dimensions, tolerances, welding details, welding procedures, material specifications, etc.; and engineering calculations or analyses in support of the design. System plans are to contain a bill of material with material specifications or particulars, a legend of symbols used, system design parameters, and are to be in a schematic format. Lists of subsystems/components that make up the systems or equipment in the scope of ABS, along with the details of the suppliers responsible for submitting drawings to ABS, are to be provided. Booklets containing standard shipyard practices of piping and electrical installations are required to supplement schematic system plans.

5.3.1 Repair and Modification of Machinery **(2024)**

When repairs or modifications are made to ABS approved systems and equipment, documentation identifying the changes, as well as any documentation that supersedes or replaces previously approved documentation is required to be submitted for ABS review and approval by the equipment designer or responsible party. Repairs and modifications are to be carried out to the satisfaction of the Surveyor.

If the service or product bulletin indicates modification or alterations to the component that would impact the Class approval, these details are to be submitted to ABS Engineering for review and approval.

7 Miscellaneous Requirements for Machinery

7.1 Construction Survey Notification

Before proceeding with the manufacture of machinery requiring test and inspection, ABS is to be notified that survey is desired during construction. Such notice is to contain all the necessary information for the identification of the items to be surveyed.

7.3 Machinery Equations **(2024)**

Equations for rotating parts of the machinery in Part 4 of the Rules are based on strength considerations only and their application does not relieve the manufacturer of the responsibility for mitigating excessive vibrations and other considerations in the machinery at speeds within the operating range.

7.5 Astern Propulsion Power

7.5.1 General **(2026)**

The minimum astern power required by SOLAS II-1/28.1 to secure proper control of the vessel in all normal circumstances is to be determined by the vessel designer and is not to exceed the maximum permissible astern power (MPAP) for which the propulsion plant is designed. Astern trials are to be conducted in accordance with the provisions of ISO 19019:2005, section 5.4: Astern trials. Main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive are to be designed for the maximum permissible astern power, which is not to lead to overload of the propulsion machinery.
Note: The designed maximum astern power, as referred to in SOLAS II-1/3.15, defining the maximum astern speed for the design of the main steering gear and rudder stock as per 3-2-14/3.1 and SOLAS II-1 / 29.3.4, are not to be taken less than the MPAP.

The astern tests are to be carried out from control positions. A test plan is to be provided by the shipyard and accepted by the Surveyor. If specific operational characteristics have been defined by the manufacturer these are to be included in the test plan.The ability of the machinery, including the blade pitch control system of controllable pitch propellers, to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded during trials, see 4-3-3/9.11.2.

7.5.2 Steam Turbine Propulsion **(2026)**

Where steam turbines are used for main propulsion, the astern trial is to demonstrate that they are to be capable of operating at their maximum permissible astern power (MPAP) for a period of at least 15 minutes. The astern trial is to be limited to 30 minutes or is to be in accordance with manufacturer’s recommendation to avoid overheating of the turbine due to the effects of “windage” and friction.

7.7 Dead Ship Start

Means are to be provided to bring the machinery into operation from a “dead ship” condition, as defined in 1.9.6. See 4-8-2/3.1.3 and 4-8-4/1.13 for the required starting arrangements.

7.9 Inclinations, Ship Accelerations and Motions **(2025)**

7.9.1 General **(2025)**

Machinery installations are to be designed to allow proper operations under the conditions as shown in 4-1-1/9 TABLE 7and in 4-1-1/7.9.2.

7.9.2 Shipboard Accelerations **(2025)**

Main propulsion and steering machinery and auxiliary machinery that is essential to the propulsion and steering and to the safety of the vessel is to be capable of operation under the effects of acceleration and motions. The requirements in 4-1-1/7.9.3 to 4-1-1/7.9.5 apply where documented evidence of equipment suitability is specifically required by other relevant sections of the Rules for such equipment or requested by ABS.

7.9.3 Documentation **(2025)**

For vessels subject to the SOLAS Convention, shipbuilders are to identify and document the vessel accelerations and motions periods to which machinery and equipment might be subjected. The expected accelerations and ship motion periods are to be within machinery and equipment manufacturer's requirements. The estimations are to consider vessel type, machinery or equipment location and expected service conditions.

7.9.4 Evaluation of Equipment Suitability **(2025)**

Machinery and equipment manufacturers are to submit evidence that their machinery or equipment can operate under the required static and dynamic conditions stated in 4-1-1/9 TABLE 7 and at least at the levels of shipboard accelerations as stated in 7.9.2 and/or specified in the relevant sections of the Rules. Documentation of satisfactory performance is to take the form of:

- Test reports showing operation under representative conditions, or
- Calculations or simulation using recognized computational techniques accompanied by detailed and relevant validation data, or
- Evidence of satisfactory service experience

7.9.5 Installation and Operation **(2025)**

Machinery and equipment manufacturers are to submit details of the requirements/recommendations for installation of the machinery and equipment on board necessary for satisfactory operation in service under the required static and dynamic conditions as described in 4-1-1/9 TABLE 7 and at least at the levels of shipboard accelerations as stated in 7.9.2 and/or specified in the relevant sections of the Rules.

Commentary:

Consideration should be given for positioning machinery in order to minimize the dynamic load on bearings due to ship motions.

End of Commentary

Shipbuilders are to submit details demonstrating that the installation of the machinery and equipment on board is in accordance with manufacturer’s requirements/recommendations.

7.11 Ambient Temperature **(2024)**

For vessels of unrestricted service, ambient temperature as indicated in TABLE 8 is to be considered in the selection and installation of machinery, equipment and components. For ships of restricted or special service, the ambient temperature appropriate for the specific service is to be considered.

TABLE 1
Certification Details - Prime Movers (1 July 2021)

	Prime Movers	ABS Approval Tier (1A-1-A4/1)	Rule Reference
Section 1: Internal Combustion Engines			
1.	Internal Combustion Engines ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel, or required by optional class notation	4/5	4-2-1/1.1, 4-2-1/3, 4-2-1/13.1 - 13.9, 4-2-1/13.11, 4-2-1/15
2.	Internal Combustion Engines < 100 kW (135 hp)	1	4-2-1/1.1
3.	Internal Combustion Engines ≥ 100 kW (135 hp), intended for services not essential for propulsion and aux. services for propulsion, maneuvering and safety of the vessel	1	4-2-1/1.1, 4-2-1/7
4.	Engines operating on natural gas ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel	4/5	4-2-1, 5C-8-1/1.1.3, 5C-8-A7, 5C-13-1/1.7, 5C-13-10, 5C-13-1/1.9
5.	Engines operating on low flashpoint fuels ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel	4/5	4-2-1, 5C-8-1/1.1.3, 5C-13-1/1.7, 5C-13-1/1.2, 5C-13-2/3, 5C-13-10, 5C-8-16/9
Section 2: Turbochargers			
6.	Turbochargers serving cylinder groups > 2500 kW (Category C)	4/5	4-2-2/1.1, 4-2-2/3, 4-2-2/5.7, 4-2-2/11.1 - 11.5, 4-2-2/11.7
7.	Turbochargers serving cylinder groups >1000 kW and ≤ 2500 kW (Category B)	3	4-2-2/5.7, 4-2-2/3,4-2-2/11.1 - 11.5, 4-2-2/11.7
8.	Turbochargers serving cylinder groups ≤ 1000 kW (Category A)	2	4-2-2/1.1, 4-2-2/11.7, 4-2-2/11.5
Section 3: Gas Turbines			
9.	Gas turbines ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel	5	4-2-3/1.1, 4-2-3/5.7, 4-2-3/13.1 - 13.5
10.	Gas turbines that are mass produced per 4-2-3/13.3.2(b)	4	4-2-3/5.7, 4-2-3/13.1 - 13.5
11.	Gas turbines < 100 kW (135 hp)	1	4-2-3/1.1
12.	Gas turbines ≥ 100 kW (135 hp), intended for services not essential for propulsion and aux. services for propulsion, maneuvering and safety of the vessel	1	4-2-3/1.1 , 4-2-3/7
13.	Gas Turbines operating on natural gas or other low flashpoint fuels ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel	4/5	4-2-3, 5C-8-16/8, 5C-8-A8/9.1, 5C-13-10/A1-9, 5C-8-1/1.1.4, 5C-13-10/5
Section 4: Steam Turbines			
14.	Steam turbines ≥ 100 kW (135 hp), intended for propulsion and aux. services essential for propulsion, maneuvering and safety of the vessel	5	4-2-4/1.1, 4-2-4/3, 4-2-4/13.1–13.5
15.	Steam turbines that are mass produced per 4-2-4/13.3.2(b)	4	4-2-4/1.1, 4-2-4/3, 4-2-4/13.1 - 13.5
16.	Steam turbines < 100 kW (135 hp)	1	4-2-4/1
17.	Steam turbines ≥ 100 kW (135 hp), intended for services not essential for propulsion and aux. services for propulsion, maneuvering and safety of the vessel	1	4-2-4/1.1 , 4-2-4/7

TABLE 2
Certification Details - Propulsion, Maneuvering and Mooring Machinery (2024)

	Propulsion, Maneuvering and Mooring Machinery	ABS Approval Tier (1A-1-A4/1)	Rule Reference
Section 1: Gears and Clutches			
1.	Gears and clutches ≥ 5590 kW (7500 hp)	5	4-3-1/9.7.1
2.	Gears and clutches ≥ 100 kW (135 hp)	4/5	4-3-1/1.1 , 4-3-1/9.7.2(c)
3.	Gears and clutches < 100 kW (135 hp)	1	4-3-1/9.7.2(d)
Section 2: Propulsion Shafting			
4.	Propulsion shafts, Coupling bolts	5	4-3-2/3.1 - 3.7, 4-3-2/3.7.2(b), 4-3-2/9, 4-3-2/5.19
5.	Cardan Shafts, Couplings	4/5	4-3-2/3.1 - 3.7, 4-3-2/3.7.2(b), 4-3-2/9, 4-3-2/5.21, 4-3-2/5.19
6.	Coupling bolts constructed to a recognized standard	1	N/A
Section 3: Propellers			
7.	Propellers, fixed and controllable pitch (Diameter > 60 imches)	5	4-3-3/7.3
8.	Propellers (Diameter ≤ 60 inches)	2	
9.	Contra Rotating Propellers	5	4-3-9
Section 4: Steering Gears			
10.	Steering Gears	5	4-3-4/19.1 - 19.7
Section 5: Thrusters, Waterjets			
11.	Propulsion Thrusters	4/5	4-3-5
12.	Propulsion Waterjets installed on vessels over 24 m (79 ft)	4/5	4-3-6
13.	Propulsion Waterjets installed on vessels 24 m (79 ft) and below	2	4-3-6
14.	Podded Propulsion Units	5	4-3-8 and 3-2-14/25
15.	Dynamic Positioning Thrusters with optional notation *DPS*	4/5	4-3-5/1.3 and 4-3-5/13, *DPS Guide*
16.	Maneuvering Thrusters with Optional Notations *PAS*, *APS*	4/5	4-3-5/1.3 and 4-3-5/13
Section 6: Anchoring and Mooring			
17.	Anchor Windlass	4/5	4-5-1/7
18.	Mooring Winches	1	4-5-1/1.3

TABLE 3
Certification Details - Electrical and Control Equipment (2025)

	Electrical and Control Equipment	ABS Approval Tier (1A-1-A4/1)	Rule Reference
1.	Generators and motors for essential services ≥ 100 kW (135 hp)	4/5	4-8-3/3 , 4-8-5/3.13.1(high voltage)
2.	Motors ≥ 100 kW (135 hp) for liquified gas cargo or vapor handling services.	4/5	5C-8-10/2.12 , 4-8-3/3.17
3.	*(2017)* Generators and motors for essential services < 100 kW (135 hp)	1	4-8-3/3.1
4.	Motors < 100 kW (135 hp) for liquified gas cargo or vapor handling services.	1	4-8-3/3, 5C-8-10
5.	Propulsion generators and motors ≥ 100 kW (135 hp)	5	4-8-3/3 , 4-8-5/5.17.5, 4-8-5/3.11.1 (high voltage)
6.	Switchboards (propulsion, main and emergency)	4/5	4-8-3/5.11.1 , 4-8-5/3.13.2 (high voltage)
7.	Motor controllers for essential services (See 4-8-1/7.3.3) ≥ 100 kW (135 hp) and for services indicated in 4-8-3/Table 7 ≥ 100 kW (135 hp)	4/5	4-8-3/5.11.1
8.	Motor controllers ≥ 100 kW (135 hp) for liquified gas cargo or vapor handling services.	4/5	5C-8-10/2.12
9.	Motor control centers including motor controller for essential services (See 4-8-1/7.3.3)) ≥ 100 kW (135 hp) and for services indicated in 4-8-3/15 TABLE 7 of aggregate load ≥ 100 kW (135 hp)	5	4-8-3/5.11.1
10.	Motor controllers for steering gear	5	4-8-3/5.11.1
11.	Motor control centers ≥ 100 kW (135 hp) for liquified gas cargo or vapor handling services.	4/5	4-8-3/5.11.1, 5C-8-10/2.12
12.	Battery charging and discharging units of 25 kW and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/5.9 or for emergency/transitional source of power.	4/5	4-8-3/5.11.1
13	Computer-based battery charging and discharging units of 25 kW and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/5.9, or for emergency/transitional source of power, or for services covered under optional notations, including battery chargers under 25 kW.	4/5	4-8-3/5.11.1, 4-9-9/Table 1
14.	Uninterruptible power system (UPS) units of 50 kVA and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/15 TABLE 7, or for emergency/transitional source of power.	4/5	4-8-3/5.11.1
15	Computer-based UPS controllers of 50 kVA and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/15 TABLE 7, or for emergency/transitional source of power systems, or for services covered under optional notations, including UPS units under 50 kVA	4/5	4-8-3/5.11.1, 4-9-9/Table 1
16.	Distribution boards associated with the charging or discharging of the battery system of 25 kW and over for emergency source and transitional source of power	4/5	4-8-3/5.11.1
17.	Distribution boards associated with the uninterruptible power system (UPS) units of 50 kVA and over used for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/15 TABLE 7 or for emergency/transitional source of power	4/5	4-8-3/5.11.1
18.	Power transformers for essential services and for emergency source of power and converters of low voltage	2	4-8-3/7
19.	Semiconductor converters used to control motor drives having a rated power of 100 kW and over intended for essential services or for services indicated in 4-8-3/15 TABLE 7.	4/5	4-8-3/8

Electrical and Control Equipment		ABS Approval Tier (1A-1-A4/1)	Rule Reference
20.	Non-sparking fans	2	4-8-3/11, 5C-8-12/1.7, 5C-9-12/1.8, 5C-13-13/3.3
21.	Plastic Cable Tray and Protective Casing	2	4-8-4/21.9.4, 4-8-4-A1
22.	Power transformers ≥ 100 kVA and converters for high voltage systems exceeding 1 kV, for essential or emergency source of power	4/5	4-8-5/3.7.5(e) , 4-8-3/8
23.	Cables	2	4-8-5/3.13.3 (high voltage), 4-8-3/9.17, 4-8-3/9.5
24.	Propulsion cables	4/5	4-8-5/5.17.11
25.	Circuit breakers & fuses	1	4-8-3/5.3.3, 4-8-3/5.3.4
26.	Circuit breakers with computer-based tripping units	3	4-8-3/5.3.3, 4-8-3/5.3.4, 4-9-9/ Table 1
27.	Certified safe equipment	2	4-8-3/13.1, 4-8-4/27.13
28.	Electronic Governors/ Governors	2	4-2-1/7.3.3.iii
29.	Cable penetration devices	2	4-8-1/5.3.1
30.	Semiconductor converters for propulsion	4/5	4-8-5/5.17.8
31.	Generator prime mover remote control system	4/5	4-9-9/1, 4-9-3/8, 4-9-9/13 for additional ACC, ACCU and ABCU requirements , 4-9-13, 4-9-14 (as applicable)
32.	Remote auxiliary machinery control system	4/5	4-9-9/1,4-9-3/8, 4-9-9/13 for additional ACC, ACCU and ABCU requirements, 4-9-13, 4-9-14 (as applicable)
33.	Centralized control and monitoring console for *ACC*, *ACCU* and *ABCU* notations	2	4-9-1/7.5, 4-1-1/1.9.1, 4-9-3/8, 4-9-9/1, 4-9-13, 4-9-14 (as applicable)
34.	Control, monitoring and safety system devices, including computers, programmable logic controllers, instrumentation (e.g., electrical/ electronic sensors, transmitters, actuators), etc., for *DPS*, *ACC* and *AC CU* notations and other computer-based systems of Categories II and III. (1)	4/5	4-9-3/8, 4-9-9/13.1, 4-6-2/9.11 (for instrumentation), 4-9-13, 4-9-14 (as applicable)
35.	Complete assembly or subassembly units	4/5	4-9-3/8, 4-9-9/13.1, 4-6-2/9.11 (for instrumentation), 4-9-13, 4-9-14 (as applicable)
36.	Steering control system and computer-based steering system	5	4-3-4/13.9, 4-9-3/8.3.7, 4-9-13, 4-9-14 (as applicable)
37.	Boiler control system (4-9-1/7.3)	5	4-4-1/11.5, 4-9-3/8, 4-9-13, 4-9-14 (as applicable)
38.	CPP control system	5	4-9-3/8 , 4-9-13, 4-9-14 (as applicable)
39.	Control, Safety and Automatic shutdown Systems for generators driven by Gas turbines using gas as fuel	4/5	5C-8-A8/15.1, 5C-13-10/ A1-15.1
40.	Control, Safety and Automatic shutdown Systems for generators driven by Engines using gas as fuel	4/5	4-2-1/13.7.4, 4-9-9, 5C-8-16/7.3, 5C-8-A7/5, 5C-8-A7/7.3.2, 5C-8-A7/3.7, 5C-13-15/7, 5C-13-15/11.5
41.	Cable Management System	4	6-4-3/13

Note:

1. Commercial off-the-shelf (COTS) computer-based system devices such as PLC's, I/O devices, transmitters, transducers, electrical/electronic sensors, etc., can be assigned Tier 2 or Tier 3 as applicable.

7 Definitionssential Services

7.3.3 Essential Services

TABLE 1
Primary Essential Services (2021)

(a)	Steering gears
(b)	Pumps for controllable pitch propellers
(c)	Scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines, turbines and shafting necessary for propulsion
(d)	Ventilation necessary to maintain propulsion
(e)	Forced draft fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services
(f)	Oil burning installations for steam plants on steam turbine vessels and for auxiliary boilers where steam is used for equipment supplying primary essential services
(g)	Fuel gas supply pumps, low duty gas compressor and other boil-off gas treatment facilities supporting boil-off gas usage as fuel to main propulsion or electric power generation machinery.
(h)	Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps, etc.
(i)	Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
(j)	Electric generators and associated power sources supplying primary essential equipment
(k)	Hydraulic pumps supplying primary essential equipment
(l)	Viscosity control equipment for heavy fuel oil
(m)	Control, monitoring and safety devices/systems of equipment for primary essential services.
(n)	Fire pumps and other fire extinguishing medium pumps.
(o)	Navigation lights, aids and signals.
(p)	Internal safety communication equipment.
(q)	Lighting system.

TABLE 2
Secondary Essential Services (2022)

(a)	Windlass
(b)	Fuel oil transfer pumps and fuel oil treatment equipment
(c)	Lubrication oil transfer pumps and lubrication oil treatment equipment
(d)	Pre-heaters for heavy fuel oil
(e)	Starting air and control air compressors
(f)	Bilge, ballast and heeling pumps
(g)	Ventilating fans for engine and boiler rooms
(h)	Services considered necessary to maintain dangerous spaces in a safe condition (inert gas system of an oil carrier, ventilation for Ro-Ro cargo spaces, etc.)

(i)	Methods used to comply with 5C-8-7/1 on liquefied gas carriers
(j)	Fire detection and alarm system
(k)	Electrical equipment for watertight and fire-tight closing appliances
(l)	Electric generators and associated power sources supplying secondary essential equipment
(m)	Hydraulic pumps supplying secondary essential equipment
(n)	Control, monitoring and safety systems for cargo containment systems
(o)	Control, monitoring and safety devices/systems of equipment for secondary essential services.
(p)	Ambient temperature control equipment required by 4-8-3/1.17.2
(q)	Watertight Doors (see Section 3-2-9, 3-2-15 and 3-2-16)

1 General (1 July 2022)

The requirements of this section apply to shipboard electrical power generation and distribution systems. High voltage systems and electric propulsion systems are subject additionally to the provisions of 4-8-5. For DC systems, unless specifically stated in this Section, and 4-8-5/7, see the ABS *Requirements for Direct Current (DC) Power Distribution Systems For Marine and Offshore Applications*, and IEC Publications 60092-201, 60092-202 and 60092-301.

3 Main Source of Electrical Power

3.1 Number and Capacity of Generators

3.1.1 General (2020)

The number and capacity of generating sets is to be sufficient under normal seagoing conditions with any one generator in reserve to carry:

- Those electrical loads for essential services and for minimum comfortable conditions of habitability, as defined in and , as applicable and
- The electrical loads related to the electric power critical notations listed in .

In addition, where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the vessel in conjunction with other machinery, as appropriate, from a dead ship condition within thirty minutes, as defined in 4-1-1/1.9.6. See also 3.1.3.

For vessels of 500 GT and above, where the main source of electrical power is necessary for propulsion and steering of the vessel, the system is to be so arranged so that, in the event of the loss of any one of the generators in service, the electrical supply to equipment necessary for propulsion and steering and to provide safety of the vessel will be maintained or restored in accordance with the provision in 3.11.2 or 3.11.3.

3.1.2 Consideration for Motor Starting Current

In selecting the capacity of a generating set, particular attention is to be given to the starting current of motors forming part of the system. With any one generator held in reserve as a standby, the remaining generator sets, operating in parallel and initially carrying the loads in 3.1.1, are to have sufficient capacity with respect to the largest idle essential motor on the vessel so that the motor can be started and the voltage drop occasioned by its starting current will not cause any already running motor to stall or control equipment to drop out. The limits of transient voltage variation under suddenly applied loads are to be in accordance with 4-8-3/3.13.2(c).

For vessels fitted with electric motor driven athwartship thrusters to assist maneuvering, the starting and running of this motor may be supported by all the installed generators, provided arrangements are made such that its starting is conditional upon the requisite generators being available and that it will not cause inadvertent load shedding.

3.1.3 Starting from Dead Ship Condition **(2019)**

In restoring the propulsion from a dead ship condition (see 4-1-1/1.9.6), no stored energy is to be assumed available for starting the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available to start the emergency generator at all times.

The emergency source of electrical power may be used to restore the propulsion, provided its capacity either alone or combined with other available sources of electrical power is sufficient to provide at the same time those services required to be supplied by 5.5.

The emergency source of electrical power and other means needed to restore the propulsion are to have a capacity such that the necessary propulsion starting energy is available within 30 minutes from a dead ship condition, as defined in 4-1-1/1.9.6. Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

For steam ships, the 30 minute time limit is to be taken as the time from a dead ship condition to light-off of the first boiler.

See also 3.11 and 3.13 below.

3.3 Power Supplied by Propulsion Generators

For vessels propelled by electric power and having two or more constant voltage propulsion generating sets, the vessel's service electric power may be derived from this source. See 4-8-5/5.5.1.

3.5 Generators Driven by Propulsion Machinery

3.5.1 Constant Speed Drive

A generator driven by propulsion machinery capable of operating continuously at a constant speed, e.g., those fitted with controllable-pitch propellers, may be considered one of the generators required by 3.1.1, provided that the arrangements stated in i) to iii) below are complied with:

i. The generator and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in and under all weather conditions during sailing or maneuvering and also while the vessel is stopped.
ii. The rated capacity of the generator and the generating systems is safeguarded during all operations given under *i*) and is such that the services required by can be maintained upon loss of any generator in service.
iii. An arrangement is made for starting a standby generator and connecting it to the switchboard, in accordance with .

3.5.2 Variable Speed Drive **(2020)**

A generator driven by propulsion machinery not capable of operating continuously at a constant speed may be used for normal operational and habitable conditions of the vessel, provided that the arrangements stated in i) to v) below are complied wit This type of generator will not be counted as one of the generators required by 3.1.1.

i. When the frequency variations at the main bus bar exceeds the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to comply with .

Permanent frequency variation:	±5.5%
Transient frequency variation:	±11% (5 sec)

ii. The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in and .
iii. Where load-shedding arrangements are provided, they are fitted in accordance with .
iv. Where the propulsion machinery is capable of being operated from the navigation bridge, means are provided or procedures are in place such that power supply to essential services are maintained during maneuvering conditions in order to avoid a blackout situation.

3.9 Location of Generators (2023)

The main switchboard is to be placed as near as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries, so that the integrity of the normal electrical power supply may be affected only by a fire, flooding or similar casualty in one space. An environmental enclosure for the main switchboard such as may be provided by a centralized control room situated within the main boundaries of the space, is not to be considered as separating the switchboard from the generators.

Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided there is access between the spaces.

The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads. Where essential services for steering and propulsion are supplied from these main switchboards and any transformers, converters and similar appliances constituting an essential part of electrical supply system are also to satisfy the foregoing.

3.11 System Arrangement

3.11.1 General (2020)

Load shedding of nonessential services and, where necessary, secondary essential services (see 4-8-1/7.3.3) or other arrangements, as may be necessary, are to be provided to protect the generators against sustained overload. See also 9.9.

3.11.2 Single Generator Operation (2024)

Where the electrical power is normally supplied by a single generator, provision is to be made upon loss of power for automatic starting and connecting to the main switchboard of a standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries in sequential operation, if necessary, to restore propulsion and steering for the safety of the vessel. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds after loss of the electrical power supply but in no case more than 45 seconds.

3.11.3 Multiple Generators Operation (2024)

Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, the system is to be so arranged that in the event of the loss of any one of the generators in service, the electrical supply to equipment necessary for propulsion and steering by the remaining generator(s) in service will be maintained for the safety of the vessel.

3.13 Main Switchboard (2020)

Where the main source of electrical power is necessary for propulsion of the vessel, the main bus bar is to be subdivided into at least two sections which are normally to be connected by circuit breakers or other approved means; so far as is practicable, the connection of generator sets and other duplicated equipment are to be equally divided between the sections.

If the arrangement is such that the main switchboard is divided into separate sections which are interconnected by cable, the cable is to be protected at each end against faults.

“Other approved means” can be achieved by:

Circuit breaker without tripping mechanism; or disconnecting link or switch by which bus bars can be split easily and safely. Bolted links, for example bolted busbar sections, are not accepted.

3.15 Other Sources for Main Power Supply **(2024)**

When the main source of electrical power is lithium-ion batteries that are charged by fuel cells or other alternative energy sources such as wind, solar etc., the following ABS publications are to be referred to and complied with, as applicable:

i. *Requirements for Fuel Cell Power Systems for Marine and Offshore Applications*
ii. *Requirements for Use of Lithium-ion Batteries in the Marine and Offshore Industries.*
iii. *Requirements for Hybrid Electric Power Systems for Marine and Offshore Installation*
iv. *Requirements for Wind Assisted Propulsion System Installation*
v. *Requirements for Use of Supercapcitors in the Marine and Offshore Industries.*

5 Emergency Source of Electrical Power

5.1 General

5.1.1 Basic Requirement

A self-contained emergency source of electrical power is to be provided so that in the event of the failure of the main source of electrical power, the emergency source of power will become available to supply power to services that are essential for safety in an emergency. Passenger vessels are subject to the requirements in 5C-7-5/13.5.

5.1.2 Scope of Provision

A self-contained emergency source of electrical power includes prime mover and its starting equipment, generator, fuel tank, emergency switchboard, associated transforming equipment, if any, transitional source of emergency power, if applicable, and emergency lighting switchboard and associated transformers, if applicable.

5.1.3 Requirements by the Governmental Authority

Attention is directed to the requirements of governmental authority of the country, whose flag the vessel flies, for emergency services and accumulator batteries required in various types of vessels.

5.5 Emergency Services

i. The electrical power available from the emergency source is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. Where the sum of the loads on the emergency generator switchboard exceeds the power available, an analysis demonstrating that the power required to operate the services simultaneously is to be produced. The analysis is to be submitted for review in support of the sizing of the emergency generator.
ii. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the services listed in for the period specified.

TABLE 1
Services to be Powered by an Emergency Source and by a Transitional Source (2024)

Service	Gross Tons	Duration (hours)				
		500 GT or over [1]		Under 500 GT		
	Electrical Plant's Capacity	---		75 kW or over [2]		Under 75 kW
	Emergency Power Consumers	Emergency Power	Transitional Power	Emergency Power	Transitional Power	Emergency Power [3]
	At every muster and embarkation station for survival craft, their launching appliance, over the sides for launching	3	0.5	2	0.5	2
	At the area of water into which the survival craft is to be launched	3	0.5	2	0.5	2
Emergency lighting	In all service and accommodation alleyways, stairways, and exits, personnel lift cars, and personnel lift trunks	18	0.5	6	0.5	6
	In the machinery spaces and main generating stations including their control positions	18	0.5	6	0.5	6
	In all control stations, machinery control rooms, and at each main and emergency switchboard	18	0.5	6	0.5	6
	At all storage positions for fireman's outfits	18	0.5	6	0.5	6
	At the steering gear	18	0.5	6	0.5	6
	At the emergency fire pump, the sprinkler pump, the emergency bilge pump, their starting positions	18	0.5	6	0.5	6
	In all cargo pump rooms	18	0.5	6	0.5	-
	Floodlight and perimeter lights on helicopter landing decks	18	0.5	6	0.5	-
Navigation lights	The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea	18	0.5	6	0.5	-
Commun-ication	Radio equipment as required by Chapter IV of SOLAS	18	1[9]	6[10]	0.5[10]	-
	All internal communication equipment as required in an emergency, see 11.5, 11.7	18	0.5	6	0.5	-
	Intermittent operation of daylight signaling lamp, ship's whistle, manually operated call points, all internal signals that are required in an emergency, see 11.7	18	0.5	6	0.5	-

Service	Gross Tons	Duration (hours)				
		500 GT or over [1]		Under 500 GT		
	Electrical Plant's Capacity	---		75 kW or over [2]		Under 75 kW
	Emergency Power Consumers	Emergency Power	Transitional Power	Emergency Power	Transitional Power	Emergency Power [3]
Navigation Aids	Navigational equipment required by Regulation V/19 and V/20 of SOLAS	18 [5]	-	-	-	-
Alarm Systems	Fire detection and alarm	18	0.5	6 [8]	0.5	-
	Gas detection and alarm system	18	0.5	6	0.5	-
Fire pumps	Emergency fire pump (see 4-7-3/1.5.3); one of the fire pumps required by 4-7-3/1.5.1 and fixed pressure water-spray system pump (see 4-7-2/1.2.1.iii.) if dependent upon the emergency generator for its source of power	18	-	-	-	-
Steering gear	Steering gears required to comply with 4-3-4/11.9	0.5 [6,7]	-	0.17 [7]	-	-
Navigation	Remote propulsion control and monitoring system for *ACC*, *ACCU* and *ABCU* notations, see 4-9-5/3.5 and 4-9-6/3.7	0.5	-	0.5	-	-
Other emergency services	Free-fall lifeboat secondary launching appliance, if not dependent on gravity, stored mechanical power or other manual means	0.5	-	0.5	-	-
	Power-operated watertight door, as required by 4-9-8/1.3.4	0.5	-	0.5	-	-

Notes:

1 See 4-8-2/5.5

2 See 5.11

3 See 5.21

4 See 4-8-5/9

5 Vessels less than 5,000 GT may be waived if approved by the Administration

6 Applicable for rudder stock diameter over 230 mm (9 in.)

7 10 minutes continuous operation on vessels of less than 10,000 GT

8 Where a fixed fire detection and fire alarm system is installed

9 Applies to ships 300 Gross Tonnage and over, 6 h on ships not provided with an emergency source of electrical power. The source of energy is to be independent of the propelling power of the ship and the ship's electrical system.

10 Applies to ships under 300 Gross Tonnage

For radio equipment, as required by SOLAS Chapter IV, Reg 13, a reserve source of power is to be provided that is in addition to the vessel's emergency source of power.

5.7 Vessels on Short Duration Voyages (2024)

In a vessel engaged regularly in voyages of short duration and an equivalent level of safety is assessed, a lesser period than the 18 hour period specified in 5.5 but not less than 12 hours may be accepted.

5.9 Power Source

Emergency source of electrical power may be a generator, an accumulator battery, or a combination of these.

5.9.1 Generator (2020)

Where the emergency source of electrical power is a generator, it is to be:

i. Driven by a prime mover with all necessary auxiliary systems independent from the main source of electrical power systems. The auxiliary systems, which may include fuel system, starting equipment, cooling system, ventilation and lubricating oil system, are to be installed as near as is practicable to the generator prime mover, preferably located in the same space as the generator prime mover unless the safe operation of the generator prime mover would thereby impaired.
ii. Started automatically upon failure of the main source of electrical power supply and automatically connected to the emergency switchboard supplying those services referred to in in not more than 45 seconds. Where the emergency generator is not provided with automatic starting, a transitional source of emergency electrical power, as specified in , is to be fitted.
iii. Provided with an adequate capacity of fuel with a flashpoint (closed cup test) of not less than 43°C (110°F) for the emergency generator prime mover. The use of fuel oil having a flashpoint of less than 60°C (140°F) but not less than 43°C (110°F) is to be subject to the provisions of .

Where it is intended to use fuel with a flash point of less than 60°C (140°F) then details of the precautions used to address the associated hazardous area issues are to be submitted to ABS for review.

5.13 Emergency Switchboard

5.13.4 Non-emergency Services and Circuits (2020)

The emergency generator may be used, exceptionally and for short periods, to supply non-emergency circuits during the blackout situation (see 4-1-1/1.9.7), dead ship condition (see 4-1-1/1.9.6), and routine testing (to check its proper operation, see 5.13.5) provided that measures are taken to safeguard the independent emergency operation under all circumstances. The generator is to be safeguarded against overload by automatically shedding such non-emergency services so that supply to the required emergency loads is always available.

For ready availability of the emergency source of electrical power, and to provide electrical power automatically to the emergency circuits, arrangements are to be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard.

For use of the emergency generator in port, see 5.17.

5.13.5 Arrangements for Periodic Testing

Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting system.

5.15 Starting Arrangements for Emergency Generator Sets

5.15.1 General

The emergency generator is to be capable of being readily started in their cold condition at a temperature of 0°C (32°F). If this is impracticable or if lower temperatures are likely to be encountered, heating arrangements are to be fitted.

5.15.2 Number of Starts

Each emergency generator arranged to be automatically started is to be equipped with starting devices with a stored energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion (i.e. not to be depleted beyond a level where starting by manual intervention is still possible) by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy is to be provided for an additional three starts within thirty minutes unless manual starting can be demonstrated to be effective.

5.15.3 Stored Energy for Starting **(2020)**

The stored energy for each starting system of the emergency generator set is to be maintained at all times, as follows:

i. Electrical and/or hydraulic starting systems are to be maintained from the emergency switchboard.

ii. Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard.

iii. All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

5.15.4 Manual Starting

Where automatic starting of the emergency generator in accordance with 5.9.1 is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective.

When manual starting is not practicable, the requirements of 5.15.2 and 5.15.3 above, are to be complied with except that starting may be manually initiated.

5.17 Use of Emergency Generator in Port (for Vessels 500 GT and Over)

Unless instructed otherwise by the Flag Administration, the emergency generator may be used during lay time in port for supplying power to the vessel, provided the following requirements are complied with.

5.17.2 System Arrangements

5.17.2(a) *Independence.*The power supply circuits, including control and monitoring circuits, for the use of anemergency generator in port are to be so arranged and protected that any electrical fault, except for theemergency generator and the emergency switchboard, will not affect the operation of the main and emergencyservices. **(2024)**

5.17.2(b) *Changeover arrangement.*Means are to be provided to readily change over to emergency operation. **(2024)**

5.17.2(c) *Overload prevention.*The generator is to be safeguarded against overload by automatically sheddingsuch other loads that the supply to the required emergency loads is always available. **(2024)**

5.17.3 Operational Instruction

Operational instructions, such as that on fuel oil tank level, harbor/seagoing mode changeover arrangements, etc. are to be provided on board. Before the vessel is underway all valves, switches, etc. are to be in the positions for the intended mode of operation of the emergency generator and the emergency switchboard. Such instructions are to be distinctly posted at the emergency generator room. Planned maintenance is to be carried out only while in port.

5.21 Vessels Less than 500 GT Having Electrical Plants of 75 kW and Above

5.21.1 General

This requirement is intended for vessels less than 500 GT having electrical plants of an aggregate capacity of 75 kW and above. The emergency source of electrical power is to be self-contained and readily available. 5.3, and 5.9 through 5.13 are also applicable. Where the source of electrical power is a battery, see 4-8-4/5 for the installation. For emergency lighting, a relay-controlled, battery-operated lantern is acceptable.

5.21.2 Capacity

The emergency source of electrical power is to be capable of supplying simultaneously the services for the period as specified in TABLE 1.

7 Distribution System

7.7 Cable Sizing **(2020)**

7.7.3 Generator Cable

Generator cable is to have a current carrying capacity of not less than the rated current or the rated continuous overload current of the generator.

9 System Protection

9.1 General

Each electrical system is to be protected against overload and short circuit by automatic protective devices, so that in the event of an overload or a short circuit the device will operate to isolate it from the systems:

- To maintain continuity of power supply to remaining essential circuits; and
- To minimize the possibility of fire hazards and damage to the electrical system.

These automatic protective devices are to protect each non-earthed phase conductors (e.g., multipole circuit breakers or fuses in each phase).

In addition, where possibility exists for generators to be overloaded, load-shedding arrangements are to be provided to safeguard continuity of supply to essential services.

The following are exceptions:

- Where it is impracticable to do so, such as engine starting battery circuits.
- Where, by design, the installation is incapable of developing overload, in which case, it may be protected against short circuit only.
- Steering circuits; see .

9.3 Protection Against Short Circuit

9.3.1 General

Protection against short circuit is to be provided for each non-earthed conductor (multipole protection) by means of circuit breakers, fuses or other protective devices.

9.11 Protection of Generators

9.11.1 Overload Protection (2020)

Generators are to be protected by circuit breakers providing long-time delay over-current protection not exceeding 115% of the full-load rating current of continuous-rated machines or the overload rating of special-rated machines. Alternatively generators of less than 25 kW not arranged for parallel operation may be protected by fuses.

9.11.2 Short Circuit Protection (2020)

Generators are to be protected for short circuit by circuit breakers provided with short-time delay trips. For coordination with feeder circuit breakers, the short-time delay trips are to be set at the lowest values of current and time which will coordinate with the trip settings of feeder circuit breakers. The current setting of the short time delay trip is to be less than the steady state short-circuit current of the generator.

Where two or more AC generators are arranged for parallel operation, each generator's circuit breaker is, in addition, to be provided with instantaneous trip set in excess of the maximum (asymmetrical) short-circuit contribution of the individual generator. (See 4-8-3/3.13.2(d)).

Alternative suitable protection, such as generator differential protection, which will trip the generator circuit breaker in the event of a fault in the generator or in the supply cable between the generator and its circuit breaker, would also be acceptable.

For generators of less than 200 kW driven by diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of the short-time delay trips if instantaneous trips and long-time overcurrent protection (see 9.11.1) are provided. When the short time delay trips are omitted, the thermal withstand capacity of the generator is to be greater than the steady state short-circuit current of the generator, until activation of the tripping system.

9.11.3 Thermal Damage Protection

Generator circuit breakers at the main and emergency switchboard are to have tripping characteristics and to be set such that they will open before the generator sustains thermal damages due to the fault current. See 9.7.

9.11.4 Reverse Power Protection

A reverse power protection device is to be provided for each generator arranged for parallel operation. The setting of the protective devices is to be in the range 2% to 6% of the rated power for turbines and in the range 8% to 15% of the rated power for diesel engines.

A setting of less than 8% of the rated power of diesel engines may be allowed with a suitable time delay recommended by the diesel engine manufacturer**.** A fall of 50% in the applied voltage is not to render the reverse power protection inoperative, although it may alter the setting to open the breaker within the above range.

9.11.5 Prime Mover Shutdown

The shutting down of the prime mover is to cause the tripping of the generator circuit breaker.

9.11.6 Undervoltage Protection

Generators arranged for parallel operation are to be provided with means to prevent the generator circuit breaker from closing if the generator is not generating, and to open the same when the generator voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

9.17 Protection of Motor Circuits

Overload and short-circuit protection is to be provided for each motor circuit in accordance with the following requirements.

9.17.1 Motor Branch Circuit Protection

9.17.1(a) General. **(2020)**

Motor branch circuits are to be protected with fuses or circuit breakers having both instantaneous and long-time delay trips. The setting is to be such that it will permit the passage of starting currents without tripping. Normally, the protective device is to be set in excess of the motor's full load current but not more than the limitations given in the table below. If that rating or setting is not available, the next higher available rating or setting may be used.

Type of Motor	Rating or Setting, % Motor Full-load Current
Squirrel-cage and synchronous full-voltage, reactor- or resistor-starting	250
Autotransformer starting	200
Wound rotor	150

When fuses are used to protect polyphase motor circuits, they are to be arranged to protect against single-phasing.

9.17.1(b) Short circuit protection only.

Where the motor branch circuit is protected with circuit breaker fitted with instantaneous trip only (e.g. 9.17.5), the motor controller is to have short circuit rating matching at least that of the circuit breaker instantaneous trip setting, and the motor overload protection (see 9.17.2) is to be arranged to open all conductors.

9.17.2 Motor Overload Protection

The overload protective devices of motors are to be compatible with the motor overload thermal characteristics, and are to be set at 100% of the motor rated current for continuous rated motor. If this is not practicable, the setting may be increased to, but in no case exceeding, 125% of the motor rated current. This overload protective device may also be considered the overload protection of the motor branch circuit cable.

For athwartship thrusters, a motor overload alarm in the wheelhouse is acceptable in lieu of the overload protection.

9.17.3 Undervoltage Protection

Undervoltage protection is to be provided for motors having power rating exceeding 0.5 kW (0.7 hp) to prevent undesired restarting upon restoration of the normal voltage, after a stoppage due to a low voltage condition or voltage failure condition.

9.17.4 Undervoltage Release **(2022)**

Undervoltage release is to be provided for the following motors unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions:

i. Primary essential services (see).

ii. Only those secondary essential services (see) necessary for safety, such as:

- Ventilating fans for engine and boiler rooms where their failure to restart may prevent the normal operation of the propulsion machinery (See Note 1 below)

  Note:

  1: Undervoltage protection is to be provided for ventilation fans for engine and boiler room, which are supplied by an emergency source of power for the purpose of removing smoke from the space after a fire has been extinguished.

iii. Where the design of the consumers listed in and are demonstrated to show that the operation of such consumers is not immediately essential to maintain the vessel's propulsion, steering and a minimum level of safety, undervoltage protection in lieu of undervoltage release may be acceptable.

Special attention is to be paid to the starting currents due to a group of motors with undervoltage release controllers being restarted automatically upon restoration of the normal voltage. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

9.17.5 Protection of Steering Gear Circuits

9.17.5(a) *AC motors*. The steering gear feeder is to be provided with short-circuit protection only, which is to be located at the main or emergency switchboard. However, overload protection may be permitted if it is set at a value not less than 200% of the full load current of the motor (or of all the loads on the feeder), and is to be arranged to permit the passage of the starting current.

9.17.5(b) *DC motors*. The feeder circuit breaker on the main switchboard is to be set to trip instantaneously between 300% and 375% of the rated full-load current of the steering-gear motor. The feeder circuit breaker on the emergency switchboard may be set to trip instantaneously between 200% and 375%.

1 General

1.1 Objective **(2024)**

1.1.3 Compliance **(2024)**

A vessel is considered to comply with the goals and functional requirements within the scope of classification when the prescriptive requirements are complied with or when an alternative arrangement has been approved. Refer to Part 1D, Chapter 2.

1.3 Standard

Electrical equipment is to be designed, constructed and tested to a national, international or other recognized standard and in accordance with requirements of this section.

1.5 Certification of Equipment

The electrical equipment indicated below are required to be certified by ABS for complying with the appropriate provisions of this section (see also 4-1-1/9 TABLE 3):

- Generators and motors of 100 kW (135 hp) and over intended for essential services (see definition in) or for services indicated in . See .
- Main, propulsion and emergency switchboards. See .
- Motor controllers of 100 kW (135 hp) and over intended for essential services or for services indicated in . See .
- Motor control centers with aggregate load of 100 kW (135 hp) and over intended for essential services or for services indicated in . See .
- Semiconductor converters used to control motor drives having a rated power of 100 kW(135 hp) and over intended for essential services or for services indicated in . See .
- Battery charging and discharging boards for emergency and transitional source of power. See .
- Uninterruptible power system (UPS) units of 50 kVA and over. See .
- Propulsion controls, propulsion semiconductors and propulsion cables. See and , and .

Other electrical equipment items are to be designed, constructed and tested in accordance with established industrial practices, manufacturer's specifications and applicable requirements in this Section. Acceptance will be based on manufacturer's documentation which is to be made available upon request and on satisfactory performance after installation. Mass produced items can, at the discretion of the manufacturers, be certified under the Type Approval Program, Appendix 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)* and 4-1-1/9 TABLE 3.

1.7 Materials and Design

Electrical equipment is to be constructed of durable, flame-retardant, moisture resistant materials, which are not subject to deterioration in the marine environment and at the temperatures to which it is likely to be exposed.

Electrical equipment is to be designed such that current-carrying parts with potential to earth are protected against accidental contact.

1.9 Voltage and Frequency Variations

The electrical characteristics of electrical equipment supplied from the main or emergency systems, other than battery supplies, are to be capable of being operated satisfactorily under normally occurring variations in voltage and frequency. Unless otherwise specified in national or international standards, the following variations from the rated value are to be assumed:

Voltage and Frequency Variations for AC Distribution Systems		
Quantity in Operation	Permanent Variation	Transient Variation (Recovery Time)
Frequency	±5%	±10% (5 s)
Voltage	+6%, -10%	±20% (1.5 s)

Voltage Variations for DC Distribution Systems (such as systems supplied by DC generators or rectifiers)	
Parameters	Variations
Voltage Tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (AC r.m.s over steady DC voltage)	10%

Voltage Variations for Battery Systems	
Type of System	Variations
Components connected to the battery during charging (see note)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%

Note: Different voltage variations as determined by the charging/discharging characteristics, including the ripple voltage from the charging device, are to be considered.

Any special system, such as electronic circuits, whose function cannot operate satisfactorily within the limits shown in the above tables, is not to be supplied directly from the system but by alternative means, such as through a stabilized supply.

For generators, see 4-8-3/3.13.1(a), 4-8-3/3.13.1(b) and 4-8-3/3.13.2.

1.11 Enclosures

1.11.1 General

Electrical equipment is to have a degree of enclosure for protection against the intrusion of foreign objects and liquids appropriate for the location in which it is installed. The minimum degree of protection is to be in accordance with 4-8-3/15 TABLE 2.

For the purpose of defining protection levels used in 4-8-3/15 TABLE 2, the following conventions apply. The degree of protection by an enclosure with respect to the intrusion of foreign particles and water is defined by the designation 'IP' followed by two digits: the first digit signifies the protection degree against particles, and the second digit signifies the protection degree against water. For complete details, see 4-8-3/15 TABLE 1A and 4-8-3/15 TABLE 1B. These designations are identical to that specified in IEC Publication 60529. For high voltage equipment see 4-8-5/3 TABLE 1.

1.11.2 Equipment in Areas Affected by Local Fixed Pressure Water-Spraying or Local Water-mist Fire Extinguishing Systems in Machinery Spaces

Electrical and electronic equipment within areas affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing Systems are to be suitable for use in the affected area. See 4-8-3/1.11.2 FIGURE 1.

Where enclosures have a degree of protection lower than IP44, evidence of suitability for use in these areas is to be submitted to ABS taking into account:

i. The actual Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing system being used and its installation arrangements, and
ii. The equipment design and layout (e.g., position of inlet ventilation openings, filters, baffles, etc.) to prevent or restrict the ingress of water mist/spray into the equipment. The cooling airflow for the equipment is to be maintained.

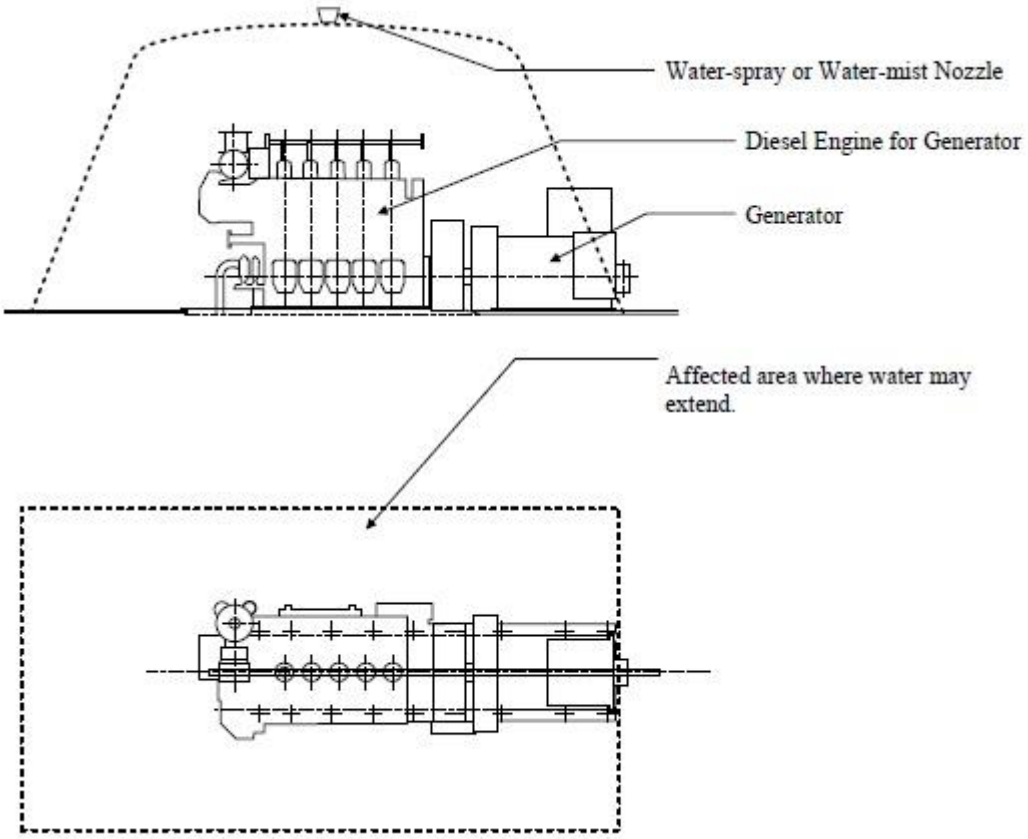
Notes:

Additional precautions may be required to be taken with respect to:

a. Tracking as the result of water entering the equipment
b. Potential damage as the result of residual salts from sea water systems
c. High voltage installations
d. Personnel protection against electric shock

Equipment may require maintenance after being subjected to water mist/spray.

FIGURE 1
Example of Area Affected by Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System in Machinery Spaces



1.13 Accessibility

Electrical equipment is to be designed and arranged with a view to provide accessibility to parts requiring inspection or adjustment.

1.15 Insulation

1.15.1 Insulation Material (2024)

Insulating materials are to be classified by their maximum continuous operating temperatures in accordance with the following table:

Class	Maximum Continuous Temperature	
	°C	°F
E	120	248
B	130	266
F	155	311
H	180	356

Materials or combination of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180°C (356°F) will also be considered. In this regard, supporting background information, reports, tests conducted, etc. ascertaining their suitability for the intended application and operating temperature are to be submitted for review.

1.15.2 Insulated Handrails or Handles **(2024)**

Insulated handrails or handles are to be provided for the equipment which are required to be operated safely during motion or inclination of the vessel. This include the main and emergency switchboards, motor control centers, distribution boards for essential and emergency services, as well as deck mounted electrical equipment necessary for specific Class notations (such as refrigerated cargo notation, dynamic positioning system, etc.). See also 4-8-3/5.5.3, 4-8-3/8.5.5.

Commentary:

Handrails or handles are required on the front of equipment only, unless normal operation is expected at the rear or sides of the equipment.

End of Commentray

1.17 Ambient Temperatures

1.17.1 General

For purposes of rating of equipment, a maximum ambient temperature of 45°C (113°F) is to be applied.

Where ambient temperatures in excess of 45°C (113°F) are expected, the rating of equipment is to be based on the actual maximum ambient air temperature.

The use of lower ambient temperatures can be considered provided the total rated temperature of the equipment is not exceeded and where the lower values can be demonstrated. The use of a value for ambient temperature less than 40°C (104°F) is only permitted in spaces that are environmentally controlled.

1.17.2 Reduced Ambient Temperature for Electrical Equipment in Environmentally Controlled Spaces

1.17.2(a) Environmentally-controlled Spaces.

Where electrical equipment is installed within environmentally-controlled spaces, the ambient temperature for which the equipment is to be rated can be reduced from 45°C and maintained at a value not less than 35°C, provided:

i. The equipment is not to be used for emergency services.
ii. Temperature control is achieved by at least two independent cooling systems so arranged that in the event of loss of one cooling system for any reason, the remaining system(s) is capable of satisfactorily maintaining the design temperature. The cooling equipment is to be rated for a 45°C ambient temperature.
iii. The equipment is to be able to initially start to work safely at a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved.
iv. Audible and visual alarms are provided, at a continually-manned control station, to indicate any malfunction of the cooling systems.

1.17.2(b) Rating of Cables.

In accepting a lesser ambient temperature than 45°C, it is to be ensured that electrical cables for their entire length are rated for the maximum ambient temperature to which they are exposed along their length.

1.17.2(c) Ambient Temperature Control Equipment.

The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as asecondary essential service, in accordance with 4-8-1/7.3, and the capability of cooling is to be witnessed by the Surveyor at sea trial.

3 Rotating Electrical Machines (2024)

3.1 Application (2024)

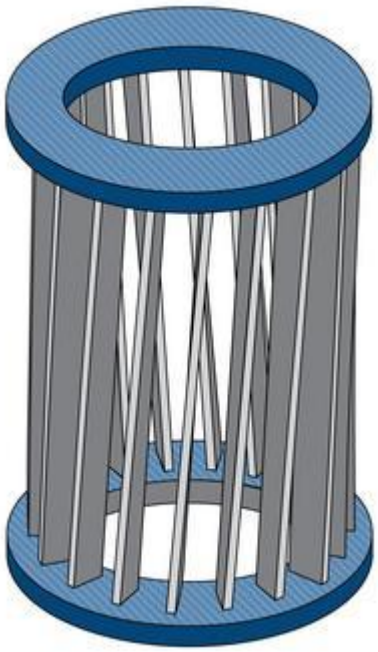
All generators and motors of 100 kW (135 hp) and over intended for essential services (see 4-8-1/7.3.3) or for services indicated in 4-8-3/15 TABLE 7 are to be designed, constructed and tested in accordance with the requirements of 4-8-3/3.

Furthermore, their design and construction are to withstand all loads (e.g., mechanical, electrical, thermal, cyclic, etc.) that would be imposed during the intended operation.

For squirrel cage electric motors serving essential services, special attention is also to be given to the method of attachment of the rotor bars to the rotor so that the overall operational integrity of the motor will not be affected during service. The common arrangement is with the shorting ring in full contact, via brazing or welding, with the ends of the rotor bars. A less common arrangement is with the shorting ring only in partial contact with the ends of the rotor bars. For these less common arrangements, calculations, analyses, tests and/or operational service history data are to be provided in this regard substantiating the design and construction of the rotating machine for its intended application and service. See 4-8-3/Figure 2.

All other rotating electrical machines are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests for rotating electrical machines less than 100 kW (135 hp) for essential services or for services indicated in 4-8-3/15 TABLE 7 are to include at least the tests described in 4-8-3/3.15.2 through 4-8-3/3.15.11, regardless of the standard of construction. The test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance after installation.

FIGURE 2
Example of Rotor Bar and Short Ring (2024)



3.3 Definitions

3.3.1 Periodic Duty Rating

The periodic duty rating of a rotating machine is the rated kW load at which the machine can operate repeatedly, for specified period (N) at the rated load followed by a specified period (R) of rest and de-energized state, without exceeding the temperature rise given in 4-8-3/15 TABLE 4; where N+R = 10 minutes, and cyclic duty factor is given by N/(N+R) %.

3.3.2 Short Time Rating

The short time rating of a rotating electrical machine is the rated kW load at which the machine can operate for a specified time period without exceeding the temperature rise given in 4-8-3/15 TABLE 4. A rest and de-energized period sufficient to re-establish the machine temperature to within 2°C (3.6°F) of the coolant prior to the next operation is to be allowed. At the beginning of the measurement the temperature of the machine is to be within 5°C (9°F) of the coolant.

3.3.3 Non-periodic Duty Rating **(2024)**

A rating at which the machine is operated continuously or intermittently with varying load and speed within the permissible operating range. The load and speed variations include the overloads applied frequently, which may greatly exceed the full load rating of the machine.

3.3.4 Continuous Rating

The continuous rating of a rotating electrical machine is the rated kW load at which the machine can continuously operate without exceeding the steady state temperature rise given in 4-8-3/15 TABLE 4.

3.5 Rating

Generators are to be of continuous rating. Motors are to be of continuous rating unless utilized on an application which definitely imposes an intermittent duty on the motor.

For maximum ambient temperatures to be used when rating rotating machines, see 4-8-3/1.17.

To satisfy the requirements of 4-8-3/3.1, the required power output of gas turbine prime movers for ship's service generator sets is to be based on the maximum expected inlet air temperature.

3.7 Overload and Over-current Capability **(1 July 2019)**

Overload and over-current capabilities for AC and DC generators and motors are to be in accordance with IEC Publication 60034-1. For convenience, the following requirements for AC generators and motors are provided.

3.7.1 AC Generators

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds. The test is to be performed in conjunction with the short circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

3.7.2 AC Motors

3.7.2(a) Over-current capacity.

Three phase induction motors having rated output not exceeding 315 kW (422 hp) and rated voltage not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three phase induction motors having rated outputs above 315 kW (422 hp) the over-current capacity is to be in accordance with the manufacturer's specification. The test can be performed at a reduced speed.

3.7.2(b) Overload capacity for induction motors.

Three phase induction motors, regardless of duty, are to be capable of withstanding for 15 seconds without stalling, or abrupt change in speed, an excess torque of 60% above the rated torque; the voltage and frequency being maintained at the rated values. For windlass motors, see 4-5-1/5.1.3.

3.7.2(c) Overload capacity for synchronous motors.

Three phase synchronous motors, regardless of duty, are to be capable of withstanding an excess torque as specified below for 15 seconds without falling out of synchronism; the excitation being maintained at the value corresponding to the rated load:

- Synchronous (wound rotor) induction motors: 35% excess torque.
- Synchronous (cylindrical rotor) motors: 35% excess torque.
- Synchronous (salient pole) motors: 50% excess torque.

Synchronous motors fitted with automatic excitation are to meet the same excess torque values with the excitation equipment operating under normal conditions.

3.9 Short Circuit Capability

Short circuit capabilities of generators are to be in accordance with IEC Publication 60034-1. Under short circuit conditions, generators are to be capable of withstanding the mechanical and thermal stresses induced by short circuit current of at least three times the full load current for at least 2 seconds.

3.11 Construction

3.11.1 Shafting

3.11.1(a) Rotors of non-integrated auxiliary machinery. **(2026)**

The design of the following specified rotating shafts and components, when not integral with the propulsion shafting, are to comply with the following:

• Rotor shaft:	4-2-4/5.3.1 and 4-2-4/5.3.2
• Hollow shaft:	4-3-2/5.3
• Key	4-3-2/5.7 and 4-2-4/5.3.2
• Keyless Fittin	4-3-2/5.19.4
• Coupling flanges and bolts	4-3-2/5.19

3.11.1(b) Rotors of integrated auxiliary machinery. **(1 July 2021)**

The shaft diameters of the shaft motors and shaft generators, which are an integral part of the line shafting, are to be evaluated per 4-3-1/5.9.1, 4-3-1/5.9.7.i., and 4-3-1/5.9.7.ii., for maximum torsional moment (steady and vibratory) acting within the operating speeds, instead of torsional moment at rated speed.

The shaft diameter of the motors and generators, that are an integral part of the line shafting, are to also be designed per 4-3-2/5 and are to be evaluated based on engineering analyses per 4-3-2/1.1.

The following components intended for propulsion installations are to be tested in the presence of a Surveyor per 4-3-2/3: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings. Major castings or built-up parts such as frames, spiders and end shields are to be surface inspected and the welding is to be in accordance with the requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

3.11.2 Shaft Circulating Current

Means are to be provided to prevent circulating currents from passing between the journals and the bearings, where the design and arrangement of the machine is such that damaging current may be expected, due to the unbalance of magnetic fields. Where such protection is required, a warning plate is to be provided in a visible, stationary location cautioning against the removal of such protection.

3.11.3 Lubrication

Rotating machine's shaft bearings are to have the required lubrication at all rated operating conditions, and with the vessel inclined as specified in 4-1-1/7.9. Where forced lubrication is employed, generators are to be fitted with means to shut down their prime movers automatically upon failure of the generator's lubricating system. Each self-lubricating sleeve bearing is to be fitted with a means for visual indication of oil level.

3.11.4 Cooling

Where water cooling is used, the cooler is to be so arranged to avoid entry of water into the machine, whether through leakage or condensation in the heat exchanger.

3.11.5 Moisture Condensation Prevention

All generators, and each propulsion motor, are to be provided with a means to prevent moisture condensation in the machine when idle.

Motors, rated 50kW and over, used for essential services and located in damp spaces or exposed to weather are to be provided with a means to prevent moisture condensation in the machine when idle.

3.11.6 Stator Temperature Detection

AC propulsion generators and motors rated above 500 kW (670 hp) are to be provided with means of obtaining the temperatures at each phase of the stationary windings.

3.11.7 Enclosure and Terminal Box

Cable terminal boxes are to be fitted with means to secure the cables. Enclosures of rotating machines including the cable terminal boxes are to be such as to eliminate mechanical injury and the risk of damage from water, oil and shipboard atmosphere. The minimum degree of protection is to be in accordance with 4-8-3/15 TABLE 2.

Terminals are to be provided at an accessible position and protected against mechanical damage and accidental contact for earthing, short-circuit or touching. Terminal leads are to be secured to the frame and the designation of each terminal lead are to be clearly marked. Terminal leads are to be terminated securely with a vibration resistant means of termination. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

3.11.8 Nameplate Data **(1 July 2020)**

Nameplates of corrosion-resistant material are to be provided and are to indicate at least the following, as applicable (for AC generating sets, see 4-8-3/3.19.4):

The manufacturer's serial number	The manufacturer's name
(or identification mark)	The year of manufacture
Type of machine	Degree of protection by IP code
Rating	The rated output
The rated voltage	The rated current
The rated speed	The class of insulation
The rated ambient temperature	Number of phase
The rated frequency	The rated power factor
Type of winding connections	Rated exciter voltage
Rated exciter current	

3.13 Generator Control

3.13.1 Operating Governors

An operating governor is to be fitted to each prime mover driving a main or emergency generator and is to be capable of automatically maintaining the speed within the following limits.

3.13.1(a) Steam or gas turbine prime movers: **(1 July 2025)**

i. The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:
   - Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off;

     In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency can be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by or , is not activated.
   - Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state.

   In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds.

ii. The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

iii. For gas turbines driving emergency generators, the requirements of and above are to be met. However, for purpose of , where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used.

3.13.1(b) Diesel engine prime mover: **(1 July 2025)**

i. The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:
   - Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off;

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency can be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by , is not activated.

- Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds. Considerations can be given to alternative method of load application as provided in for electrical systems fitted with power management systems and sequential starting arrangements.

ii. The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

iii. For emergency generators, the requirements of and above are to be met. However, for purpose of , where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used

3.13.2 Automatic Voltage Regulation System

The following requirements are for AC generators. For DC generators, refer to IEC Publications 60092-202 and -301.

3.13.2(a) General.

An automatic voltage regulator is to be fitted for each generator. Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machines being controlled.

3.13.2(b) Variation from rated voltage - steady state.

The automatic voltage regulator is to be capable of maintaining the voltage under steady conditions within ± 2.5% of the rated voltage for all loads between zero and rated load at rated power factor, taking the governor characteristics of generator prime movers into account. These limits may be increased to ±3.5% for generators for emergency services.

3.13.2(c) Variation from rated voltage - transient. **(2026)**

Momentary voltage variations are to be within the range of –15% to +20% of the rated voltage, and the voltage is to be restored to within ±3% of the rated voltage in not more than 1.5 seconds. For emergency generator, these values may be increased to ±4% in not more than 5 seconds respectively when:

- A load equals to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and
- A load equal to the above is suddenly thrown off.

Subject to ABS approval, such voltage regulation during transient conditions can be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

Consideration may be given to performing the test required by 4-8-3/3.15.4 according to precise information concerning the maximum values of the sudden loads instead of the values indicated above, provided precise information is available. The precise information concerning the maximum values of the sudden loads is to be based on the power management system arrangements and starting arrangements provided for the electrical system.

3.13.2(d) Short circuit condition.

Under short-circuit conditions, the excitation system is to be capable of maintaining a steady-state short-circuit current of not less than three times its rated full load current for 2 seconds or for such magnitude and duration as required to properly actuate the electrical protective devices. See 4-8-3/3.9.

In order to provide sufficient information for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The

decrement curve need not be based on physical testing. The manufacturer's simulation model for the generator and the voltage regulator can be used where this has been validated through the previous type test on the same model.

3.13.3 Parallel Operation

3.13.3(a) General.

When it is intended that two or more generators be operated in parallel, means are to be provided to divide the reactive power equally between the generators in proportion to the generator capacity.

3.13.3(b) Reactive load sharing.

The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the smallest generator, whichever is the less.

3.13.3(c) kW load sharing.

In the range between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than ±15% of the rated output kW of the largest generator, or 25% of the rated output kW of the individual generator, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate load with each generator carrying its proportionate share.

3.14 Permanent Magnet Shaft Generators on Single Screw Vessels **(1 July 2022)**

3.14.1 General **(2025)**

In addition to any applicable requirements under 4-8-3/3.1 to 4-8-3/3.17, permanent magnet generators installed in line with propulsion shaft on single screw vessels, and in cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, are to be capable to maintain propulsion under a faulty condition, in accordance with the following requirements:

i. The internal phase to phase short circuit is to be protected by circuit breakers or fuses at both in the neutral side and the converter side of each winding. These protective devises may be installed externally to the machine.
ii. Earth fault protection is to be provided, opening two circuit breakers at each side of the winding in case of earth fault.
iii. The stator winding is to be vacuum impregnated and fitted with form-wound windings.
iv. The manufacturer of the form wound windings is to have a quality system and be certified in accordance with and of the ABS *Rules for Conditions of Classification (Part 1A)* or ISO 9001 (or equivalent) and have a quality control plan for the production and testing of the windings.
v. The winding heads are to have a physical separation of at least 5 mm. Also, the two ends of the windings, including the wiring between the form-wound windings and the terminals, are to run with a physical separation between all phases from the winding heads to the terminals. There is to be physical separation of arc proof material between the neutral side terminals and the converter side terminals.
vi. When conditions allow a repair to be performed, it is to be possible to bring the air gap flux to zero, or to prevent the permanent magnets from rotating by mechanical means and complete a repair procedure within three hours. It is to be possible to ensure a standstill of the shaft during this procedure, if necessary. It is to be possible to reverse the procedure (e.g., physically reconnect the rotor) in order to bring the machine mechanically back to working conditions without dismantling the shaft. An instruction manual for the repair procedure is to be provided on board.
vii. Generators with water cooling, either fitted with heat exchangers or jacket water cooled, are to have water-leakage detection and drain holes. For generators with two winding systems that rely on common cooling systems, means are to be provided to isolate the cooling systems individually. In addition, provision is to be made for an alternative supply of cooling water.
viii. Means for stopping the shaft after any internal fault are to be provided, even under the event of wind milling. A risk study is to also to be submitted as per 4-8-1/5.5.1.

ix. The shipbuilder is to inform the vessel's owner of the particular arrangement and provide the appropriate operational information that will include the following:

a. An inter-turn short circuit fault in the permanent magnet shaft generator will necessitate the need to stop propulsion for three hours, for the crew to disconnect the rotor hub from the main shaft.
b. In cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, propulsion can be continued. The procedure to disconnect the rotor hub from the propulsion shaft will need to be performed as soon as navigational and operational parameters allow. Also, the permanent magnet shaft generator will be assumed to require overhaul

3.14.2 Prototype Design

The acceptance of the arrangement and equipment covered by 4-8-3/3.14.1, is based on successful verification that the propulsion can be maintained, in cases where the navigational or operational needs of the vessel do not allow the propulsion to be stopped, under worst case failure of the generator as defined by the required risk assessment as per 4-8-1/5.5.1. Accordingly, with regards to the interturn fault, the following are required:

i. FEM simulation, or similar, and calculation of an interturn fault as per .
ii. Prototype testing as per .

3.15 Testing

3.15.1 Machines to be Tested and Test Schedule

3.15.1(a) Machines of 100 kW and Over. **(1 July 2022)**

Each design of generator and motor of 100 kW (135 hp) and over, intended for essential services (see 4-8-1/7.3.3), or for services indicated in 4-8-3/15 TABLE 7, is to be assessed by testing in accordance with the "type tests" schedule indicated in 4-8-3/15 TABLE 3. Each subsequent production unit of an accepted design is to be tested in accordance with the "routine tests" schedule indicated also in 4-8-3/15 TABLE 3.

Permanent magnet shaft generators on single screw vessels, as per 4-8-3/3.14, are to comply with the requirements of this section.

3.15.1(b) Machines Below 100 kW.

All rotating machines of less than 100 kW intended for essential services or for services indicated in 4-8-1/7.3.3, or for services indicated in 4-8-3/15 TABLE 7, are to be tested in accordance with 4-8-3/15 TABLE 3 (item 2 through item 10 and item 12). The tests are to be carried out by the manufacturer whose certificate of tests is acceptable and is to be submitted upon request from ABS.

3.15.1(c) Other Machines.

For machines not intended for essential services or for services indicated in 4-8-3/15 TABLE 7, the tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

3.15.1(d) Special Testing Arrangements.

In cases where all of the required tests are not carried out at the plant of the manufacturer, the Surveyor is to be notified and arrangements are to be made so that the remaining tests will be witnessed.

3.15.2 Insulation Resistance Measurement

The resistance is to be measured before the commencement of the testing and after completion of the testing for all circuits. Circuits or groups of circuits of different voltages above earth are to be tested separately.

Immediately after the high voltage tests, the insulation resistance is to be measured using a direct current insulation tester between:

i. all current carrying parts connected together and earth;
ii. all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible, an approved method of calculation is to be used:

Rated Voltagem, U_n (V)	Minimum Test Voltage (V)	Minimum Insulation Resistance (MΩ)
$U_n \le 250$	$2U_n$	1
$250 < U_n \le 1000$	500	1
$1000 < U_n \le 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \le 15000$	5000	$U_n/1000 + 1$

3.15.3 Winding Resistance Measurement

The resistance of the machine winding is to be measured and recorded, using an appropriate bridge method or voltage and current method.

3.15.4 Verification of Voltage Regulation System

Tests are to be conducted on generators to verify that the automatic voltage regulation system is capable of achieving the performance described in 4-8-3/3.13.2

3.15.5 Rated Load Test and Temperature Rise Measurements **(1 July 2023)**

The temperature rises are to be measured after running at the output, voltage, frequency and duty for which the machine is rated in accordance with the testing methods specified in IEC 60034-1 or a national, international or other recognized standard. The limits of temperature rise are to be as specified in 4-8-3/15 TABLE 4.

For rotating electrical machines covered by IEC 60034-1, when they can not be tested at rated conditions, an indirect testing to determine the temperature rise in accordance with IEC 60034-29 can be carried out by agreement between the manufacture and the purchaser. Simulation tests specified in IEEE Standard 115 for temperature rise measurements can also be accepted for induction motors and synchronous generators.

3.15.6 Overload and Over-current Tests **(1 July 2019)**

Tests are to be conducted on generators and motors to demonstrate that their overload and over-current capabilities are as described in 4-8-3/3.7.

3.15.7 Short Circuit Capability Tests

Tests are to be conducted on AC generators to demonstrate that the generator and its automatic voltage regulation system are capable of sustaining without damage, under steady-state short-circuit condition, a current of three times the rated current for 2 seconds. See 4-8-3/3.9 and 4-8-3/3.13.2(d).

3.15.8 Overspeed Test **(2019)**

AC generators and, where specified and agree upon between purchaser and manufacturer, AC motors are to withstand without damage a test run at 1.2 times the rated speed for at least 2 minutes. This test is not applicable to squirrel cage motors.

Where specified and agreed upon between purchaser and manufacturer, DC generators and motors are to withstand a test run without damage for the following overspeed tests for at least 2 minutes:

Item	DC Machine Type	Overspeed Requirements
1	Generators	1.2 times the rated speed
2	Shunt-wounded and separately excited motors	1.2 times the highest rated speed, or 1.15 times the corresponding no-load speed, whichever is the greater
3	Compound-wounded motors having speed regulation of 35% or less	1.2 times the higher rated speed, or 1.15 times the corresponding no-load speed, whichever is the greater but not exceeding 1.5 times the highest rated speed
4	Compound-wounded motors having speed regulation greater than 35% and series-wounded motors	The manufacturer is to assign a maximum safe operating speed which is to be marked on the rating plate. The overspeed for these motors is to be 1.1 times the maximum safe operating speed.
5	Permanent magnet excited motors	Overspeed as specified in item 2 unless the motor has a series winding and, in such a case, they are to withstand the overspeeds specified in items 3 or 4 as appropriate

3.15.9 Dielectric Strength Test

The dielectric strength of all rotating machines is to be tested with all parts assembled and in a condition equivalent to normal working condition. The following requirements apply to those machines other than high voltage systems covered by 4-8-5/3.13.1. The test voltage is to be applied between the windings under test and the frame of the machine, with the windings not under test and the core connected to the frame.

The test voltage is to be a voltage of sinusoidal wave form and a frequency of 25 Hz to 60 Hz. It is to be applied continuously for 60 seconds. The standard test voltage for all rotating machines is twice the rated voltage plus 1000 V, with a minimum of 1500 V, except for machine parts specified in the table below:

Machine Part	Test Voltage (rms)
Field windings of synchronous generators, synchronous motors and synchronous condensers:	
a) For all machines except that in b)	a) Ten times the rated field voltage with a minimum of 1500 V and a maximum of 3500 V
b) For motors started with field winding connected across resistance of more than ten times of the field winding resistance	b) 1000 V + twice the maximum value of the voltage with a minimum of 1500 V
Phase-wound rotors of induction motors:	
a) For non-reversing motors or motors reversible from standstill only	a) 1000 V + twice the open-circuit standstill secondary voltage
b) For motors reversible by reversing the primary supply while running	b) 1000 V + four times the open-circuit standstill secondary voltage

Where temperature rise test is to be performed, such as when performing type tests, the dielectric strength test is to be carried out immediately after this test.

Test voltage for other machines are to be in accordance with IEC Publication 60034-1, Table 16.

3.15.10 Running Balance Test **(1 July 2023)**

Motors are to be operated at no load and at rated speed while being supplied with a rated voltage and frequency; and in the case of a generator, driven by a suitable means and excited to give rated terminal voltage. The vibration of the machine and operation of the bearing lubrication system, where applicable, are to be checked and found satisfactory. Vibration measurements are to be taken and results are to be verified to be within acceptable limits in accordance with a national, international or other recognized standard.

3.15.11 Bearings

Upon completion of tests in 4-8-3/3.15.10, machines having sleeve bearings are to be opened to establish that the shaft is properly seated in the bearings.

3.15.12 Type Tests for Permanent Magnet Shaft Generators **(1 July 2022)**

A type test to demonstrate the effects of an interturn fault current is required for permanent magnet shaft generators of single screw vessels. A mock-up model of one slot can be accepted to demonstrate the effects of an interturn fault current. Prior to insertion in the slot model, a fault between two windings is introduced to the model. The calculated interturn fault current (from simulation and calculation as per 4-8-3/3.14.2.i)) is fed into the mock-up model. In this way, the effects of the fault current on all materials can be demonstrated.

The expected results for the test are:

- Local overheating of the faulty area.
- Insulation breaks.
- Leads to an earth fault.

The simulated fault and resulting temperature rise are not to be detrimental to the insulation of any other part adjacent to the fault.

3.17 Certification **(1 July 2023)**

Each generator and motor of 100 kW (135 hp) and over intended for essential services (see 4-8-1/7.3.3), or for services indicated in 4-8-3/15 TABLE 7 is to be certified based on design review and type and routine tests performed in accordance with 4-8-3/15 TABLE 3 in the presence of a Surveyor.

At the option of the manufacturer, each machine design or type may be maintained on record as design-assessed product in accordance with the provisions of 1A-1-A3/5.1 of the ABS *Rules for Conditions of Classification (Part 1A)*. In which case, each production unit of the type may be certified based only on routine test carried out to the satisfaction of a Surveyor at the manufacturer’s facilities.

Shafting material to be used for propulsion application, material tests are to be tested in the presence of a Surveyor in accordance with the provisions of 4-8-3/3.11. Shafting material to be used for non-propulsion application, will be accepted on the basis of the manufacturer's certified material test reports and a satisfactory surface inspection and hardness check witnessed by the Surveyor upon request .

Further, at the option of the manufacturer, the quality assurance system of the manufacturing facilities may also be assessed in accordance with 1A-1-A3/5.5 of the ABS *Rules for Conditions of Classification (Part 1A)*. In which case, and along with approval of the design, the machine can be deemed type approved, and each production unit may be certified based on an audit, by a Surveyor, of the quality records maintained by the manufacturer. The machine may be posted on the ABS website, http://www.eagle.org/typeapproval.

3.19 AC Generating Sets **(1 July 2020)**

3.19.1 General

Notwithstanding the requirements in 4-2-1 and 4-8-3, the provisions of this subsection are applicable to AC generating sets driven by reciprocating internal combustion engines irrespective of their types (i.e. diesel engine, dual fuel engine, gas-fuel engine), except for those sets consisting of a propulsion engine which also drives power take off (PTO) generator(s).

3.19.2 Torsional vibration levels

The generating set is to show torsional vibration levels which are compatible with the allowable limits for the alternator, shafts, coupling and damper. The coupling selection for the generating set is to take into account the stresses and torques imposed on it by the torsional vibration of the system.

Torsional vibration calculations are to be submitted to ABS for approval when the engine rated power is 110 kW or above.

3.19.3 Rated power **(2024)**

The rated power is to be determined in accordance with the actual use of the generator set.

3.19.4 Rating plate

The alternator manufacturer or the entity responsible of assembling the generating set is to install a rating plate marked with at least the following information:

i. the generating set manufacturer’s name or mark;
ii. the set serial number;
iii. the set date of manufacture (month/year);
iv. the rated power (both in kW and KVA) with one of the prefixes COP, PRP (or, only for emergency Generating sets, LTP) as defined in ISO 8528-1;
v. the rated power factor;
vi. the set rated frequency (Hz);
vii. the set rated voltage (V);
viii. the set rated current (A);
ix. the mass (kg)

5 *Switchboards*, *Motor Controllers*, etc.

5.1 Application **(1 July 2021)**

Main and emergency switchboards, power and lighting distribution boards, motor control centers and motor controllers, and battery charging and discharging boards are to be designed, constructed and tested in accordance with the provisions of this Subsection.

Low-voltage switchboards should meet the requirements of UL 891 or IEC 61439-1 for dead-front switchboards or IEEE Std C37.20.1, UL 1558, or IEC 61439-1 for low-voltage, metal-enclosed power circuit breaker switchgear. Other alterative recognized standards will be specially considered.

5.3 Construction, Assembly and Components

5.3.1 Enclosures **(1 July 2021)**

Enclosures and assemblies are to be constructed of steel or other suitable incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electro-magnetic and thermal stresses which may be encountered under both normal and short circuit fault conditions.

Enclosures are to be of the closed type. The degree of the protection is to be in accordance with 4-8-3/15 TABLE 2.

All wearing parts are to be accessible for inspection and be readily renewable. Equipment manufacturer is to identify the wearing parts, and this is to be agreed upon by ABS.

Arrangement of bus bars, connection bars and switchboard wiring are to be such that accessibility is provided for cable connections. Equipment manufacturer in conjunction with the system integrator (shipyard) is to provide equipment arrangement drawing and details of the cable connections to verify accessibility for maintenance and overhauls.

5.3.2 Bus Bars

5.3.2(a) General.

Bus bars are to be copper; bus bars of other materials will require special consideration, such as aluminum bar covered by a properly bonded layer copper. Bus bars are to be sized and arranged such that the temperature rise will not affect the normal operation of electrical devices mounted in the switchboard. The design maximum ambient temperature is to be in accordance with 4-8-3/1.17.

5.3.2(b) Bracing of bus bars.

Bus bars and circuit breakers are to be mounted, braced and located so as to withstand thermal effects and magnetic forces resulting from the maximum prospective short circuit current.

5.3.2(c) Bolted connections.

Bolted bus bar connections are to be suitably treated (e.g., silver plating) to avoid deterioration of electrical conductivity over time. Nuts are to be fitted with means to prevent loosening.

5.3.2(d) Cable connections.

Cable connections are to be made by the use of crimp lugs or equivalent. Soldered connections are not to be used for connecting or terminating any cable of 2.5 mm^2 or greater. Soldered connections, where used, are to have a solder contact length at least 1.5 times the diameter of the conductor.

5.3.2(e) Bus Bar Connections. **(1 July 2021)**

Demonstration of proper alignment, fastening, connecting, and torque of the bus bar connections are to be witnessed by the attending Surveyor.

5.3.2(f) Clearance and creepage.

Minimum clearances and creepage distances between live parts of different potential, i.e., between phases and between phase and the ground, are to be in accordance with the following table.

Rated Insulation Voltage U_n (V)	*Minimum Clearance (mm)*	*Minimum Creepage Distance (mm)*
$U_n \le 250$	15	20
$251 < U_n \le 690$	20	25
$690 < U_n \le 1000$	25	35

5.3.2(g) Alternative.

Alternatively, reduced creepage and clearance distances can be used provided:

i. The equipment is not installed in ‘Machinery Spaces of Category A’ or in areas affected by a Local Fixed Pressure Water-spraying or Local Water-mist Fire Extinguishing System.
ii. The minimum clearance distance is not to be less than 8 mm
iii. The minimum creepage distance is not to be less than 16 mm
iv. The equipment complies with IEC 61439-1
v. In applying IEC 61439-1, the equipment is considered to be:
    - Of overvoltage Category III,
    - Installed in an environment of pollution degree 3,
    - Having insulating material of type IIIa, and
    - Installed in inhomogeneous field conditions
vi. The temperature dependent criteria in IEC 61439-1 are derated to meet the ambient temperatures found on marine installations. Refer to .
vii. The equipment is subject to an impulse voltage test with test voltage values shown in the Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

Rated Operational Voltage V	Rated Impulse Withstand Test Voltage kV
50	0.8
100	1.5
150	2.5
300	4

Rated Operational Voltage V	Rated Impulse Withstand Test Voltage kV
600	6
1000	8

5.3.3 Circuit Breakers

5.3.3(a) Compliance with a standard. **(2024)**

Circuit breakers are to be designed, constructed and tested to IEC Publication 60947-2 or other recognized standard. The certificates of tests are to be submitted upon request by ABS. Circuit breakers of the thermal type are to be calibrated for an ambient-air temperature, as provided in 4-8-3/1.17.

Commentary:

Where thermal-type breakers are mounted within enclosures, should be considered that the temperature within the enclosure may exceed the specified ambient temperature.

End of Commentary

5.3.3(b) Short circuit capacity.

Circuit breakers are to have sufficient breaking and making capacities as specified in 4-8-2/9.3.

5.3.3(c) Removable mounting.

Circuit breakers are to be mounted or arranged in such a manner that the breakers can be removed from the front of the switchboard without first de-energizing the bus bars to which the breakers connect. Draw-out or plug-in type circuit breakers are acceptable for this purpose. Alternatively, an isolation switch can be fitted upstream (line or supply side) of the breaker. Consideration will be given to arrangements where portions can be isolated to allow circuit breaker removal, provided that this will not interrupt services for propulsion and safety of the vessel.

5.3.4 Fuses

Fuses are to be designed, constructed and tested in accordance with IEC Publication 60269 or other recognized standard. The certificates of tests are to be submitted upon request from ABS.

The requirements of 4-8-3/5.3.3(b) and 4-8-3/5.3.3(c) are to be complied with. Where disconnecting means are fitted they are to be on the line or supply side. Where voltage to earth or between poles does not exceed 50V DC or 50V AC rms, fuses may be provided without switches.

All fuses, except for instrument and control circuits are to be mounted on or accessible from the front of switchboard.

5.3.5 Disconnecting Device

The rating of the disconnecting devices is to be equal to or be higher than the voltage and current ratings of connected load. The device is to have indicator for its open or closed position.

5.3.6 Internal Wiring

5.3.6(a) *Wires*.

Internal instrumentation and control wiring is to be of the stranded type and is to have flame-retarding insulation. They are to be in compliance with a recognized standard.

5.3.6(b) Protection.

Internal instrumentation and control wiring is to be protected by fuse or circuit breaker with the following exception:

- Generator voltage regulator circuits;

- Generator circuit breaker tripping control circuits; and
- Secondary circuit of current transformer.

These circuits, however, except that of the current transformer, are to be fitted with short circuit protection.

5.3.6(c) Terminals.

Terminals or terminal rows for systems of different voltages are to be clearly separated from each other. The rated voltage is to be clearly indicated at least once for each group of terminals which have been separated from the terminals with other voltage ratings. Terminals with different voltage ratings, each not exceeding 50 V DC or 50 V AC can be grouped together. Each terminal is to have a nameplate indicating the circuit designation.

5.3.7 Circuit Identification

Identification plates for feeders and branch circuits are to be provided and are to indicate the circuit designation and the rating or settings of the fuse or circuit breaker of the circuit.

5.5 Main and Emergency *Switchboards*

In addition to the foregoing requirements, main and emergency switchboards are to be complied with the following requirements.

5.5.1 Bus Bars

Generator bus bars are to be designed to meet the maximum generator rating based on ambient temperature of 45°C (113°F). Main bus bars are to be sized to the combined rated generator current that can flow through. Distribution bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all loads they supply, or the combined current of the generators that can supply to that part of the bus, whichever is less. When a distribution bus bar supplies to one unit or one group of units in simultaneous operation, it is to be designed for full load.

5.5.2 Subdivision of Bus Bars

Refer to 4-8-2/3.13 for requirements for the division of main bus bars.

5.5.3 Hand Rails

Insulated handrail or insulated handles are to be provided for each front panel of the switchboard. Where access to the rear is required, insulated handrails or insulated handles are to be fitted to the rear of the switchboard also.

5.5.4 Instrumentation

Equipment and instrumentation are to be provided in accordance with 4-8-3/15 TABLE 5. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They are to be mounted on the centralized control console if the main switchboard is located in the centralized control station.

5.5.5 Door Latching **(2024)**

Hinged doors which are to be opened for operation, maintenance or similar purposes are to be provided with a latching or locking facility to keep the door open during normal movement of the vessel.

5.7 *Motor Controllers*

In addition to the applicable requirements in 4-8-3/5.3, motor controllers are to comply with the following.

5.7.1 Overload and Under-voltage Protection

Overload protection and under-voltage protection where provided in the motor controllers are to be in accordance with 4-8-2/9.17.2 and 4-8-2/9.17.3.

5.7.2 Disconnecting Means

A circuit-disconnecting device is to be provided for each branch circuit of motor rated 0.5 kW or above so that the motor and the controller can be isolated from the power supply for maintenance purposes. However, for pre-assembled or skid-mounted units having two or more motors (e.g., fuel oil blender), a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6 A. The circuit-disconnecting device is to be operable externally. See also 4-8-4/9.3.

Where the controlgear is mounted on or adjacent to a main or auxiliary distribution switchboard, a disconnecting switch in the switchboard can be used for this purpose in accordance with 4-8-4/9.3.2. Otherwise, a disconnecting switch within the controlgear enclosure or a separate enclosed disconnecting switch is to be provided.

5.7.3 Resistor for Control Apparatus

Resistors are to be protected against corrosion either by rust-proofing or embedding in a protective material. Where fitted, the enclosure is to be well-ventilated and so arranged that other electrical equipment and wiring within will not be exposed to a temperature in excess of that for which they are designed.

5.7.4 Auto-starters

Alternating-current (AC) motor manual auto-starters with self-contained auto-transformers are to be provided with switches of the quick-make-and-break type, and the starter is to be arranged so that it will be impossible to throw to the running position without having first thrown to the starting position. Switches are to be preferably of the contactor or air-break-type.

5.9 Battery Systems and Uninterruptible Power Systems (UPS) **(1 July 2025)**

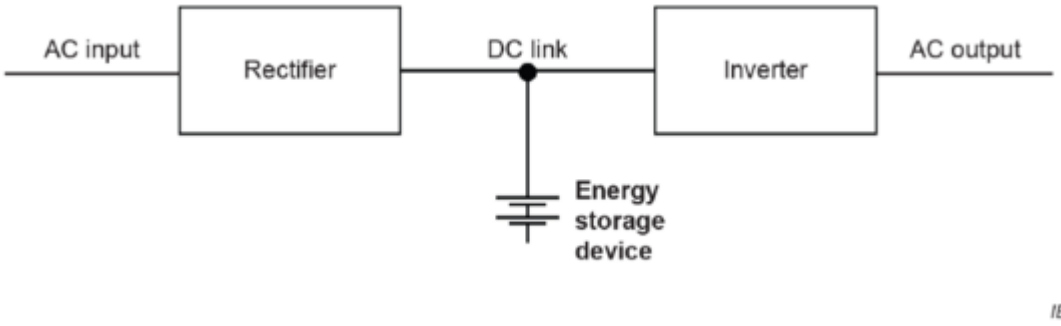
In addition to the applicable requirements in 4-8-3/5.3, equipment for main, emergency and transitional sources of power is to comply with the following. Such equipment would include:

- Battery charging and discharging units of 25 kW and over and the associated distribution boards.
- Uninterruptible power supply (UPS) units of 50 kVA and over and the associated distribution boards.

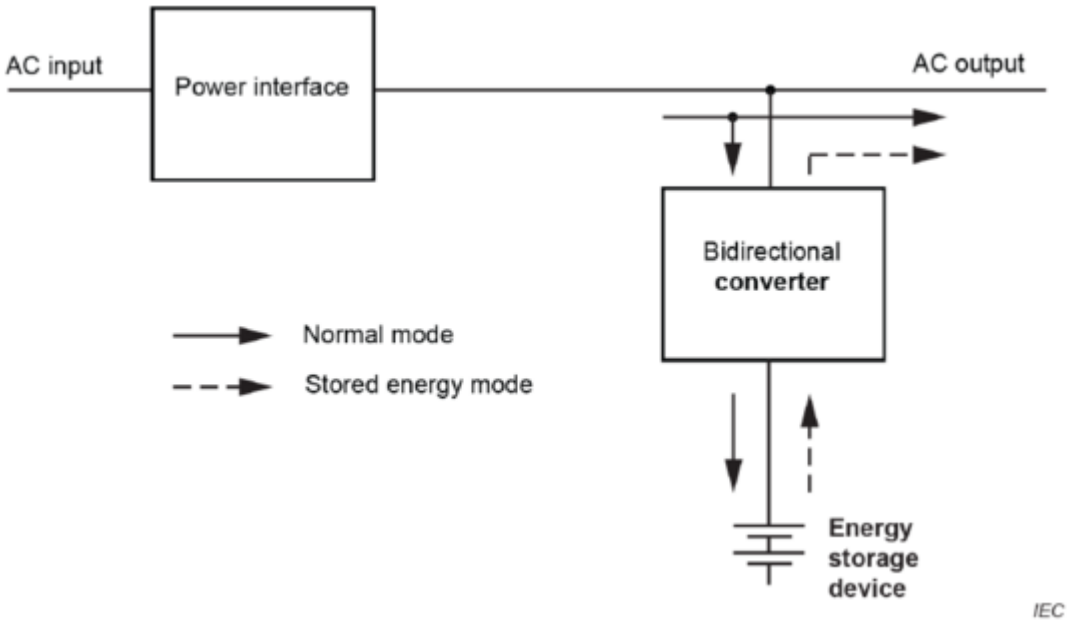
5.9.1 Definitions **(1 July 2025)**

Uninterruptible Power System (UPS). A combination of converters, switches and energy storage devices (such as batteries), constituting a power system for maintaining continuity of load power in case of AC input power failure (IEC 62040-3).

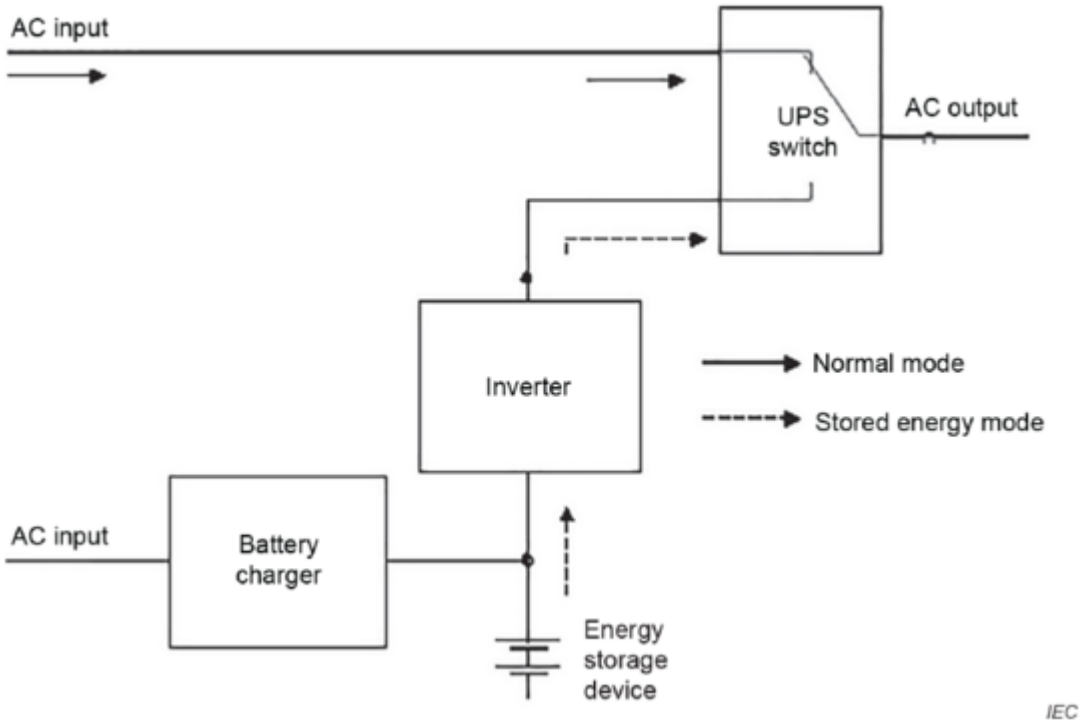
Double Conversion Topology. A UPS topology comprises an AC to DC converter, generally a rectifier, and a DC to AC converter, generally an inverter. When the AC input power is out of UPS pre-set tolerances, the UPS enters stored energy mode (refer to Annex B to IEC 62040-3).



Line Interactive Topology. A UPS topology comprises bidirectional AC to DC power conversion, generally through a bidirectional converter and an AC power interface. When AC input power voltage or frequency is out of UPS pre-set tolerances, the UPS runs in stored energy mode (Refer to Annex B to IEC 62040-3).



Standby Topology. A UPS topology comprises a battery charger, a DC to AC converter, generally a unidirectional inverter and a UPS switch. When the AC input power is out of UPS pre-set tolerances, the UPS operates in stored energy mode (Refer to Annex B to IEC 62040-3).



DC UPS Unit. A UPS unit where the output is in DC (direct current).

Energy Storage Device. A system consisting of a single or multiple devices designed to provide power to the UPS inverter/converter (IEC 62040-3).

AC Input Power Failure. Variation in the AC input power which could cause the UPS to operate in stored energy mode (IEC 62040-3).

Bidirectional Converter. Converter which has the functions of both a rectifier and an inverter, and which can reverse the flow of power from AC to DC and vice-versa (IEC 62040-3).

5.9.2 Battery Charging Rate

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80% capacity in not more than 10 hours. See also 4-8-3/5.9.6(c).

5.9.3 Reversal of Charging Current

An acceptable means, such as reverse current protection, for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery, is to be fitted.

5.9.4 Design and Construction

5.9.4(a) Construction.

Battery charger units and uninterruptible power system (UPS) units are to be constructed in accordance with the IEC 62040 Series, or an acceptable and relevant national or international standard

5.9.4(b) Operation.

The operation of the UPS is not to depend upon external services

5.9.4(c) Type. **(1 July 2025)**

The configuration and topology of UPS unit employed is to be appropriate to the power supply requirements of the connected load equipment.

5.9.4(d) Continuity of Supply. **(1 July 2025)**

When external bypass is provided, a bypass transfer switch is to be arranged to protect the load against power disturbances or interruption arising from inrush or fault current (refer to Annex C to IEC 62040-3). For battery charger units and DC UPS units, see 4-8-2/3.7.3. A UPS with an integral Maintenance Bypass Switch allowing for battery replacement or repair of the inverter converter is acceptable as an alternative to an external bypass.

5.9.4(e) Monitoring and Alarming. **(1 July 2025)**

The battery charger unit or uninterruptible power system (UPS) unit is to be monitored and audible and visual alarm is to be given in continuously manned station(s) for the following.

- Power supply failure (voltage and frequency) to the connected load
- Earth fault
- Operation of battery protective device
- When the battery is being discharged
- When the bypass is in operation in case an external bypass is provided. When changeover occurs, for battery charger units and DC UPS units required to comply with ; and
- Any other fault and abnormal conditions of the UPS unit, as applicable.

5.9.5 Location

5.9.5(a) Location.

The UPS unit is to be suitably located for use in an emergency. The UPS unit is to be located as near as practical to the equipment being supplied, provided the arrangements comply with all other Rules, such as 4-8-4/5, 4-8-4/7 and 4-8-4/9 for location of electrical equipment.

5.9.5(b) Ventilation.

UPS units utilizing valve regulated sealed batteries can be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of 4-8-4/5.3 and 4-8-4/5.5. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, calculations are to be submitted in accordance with 4-8-4/5.5 to establish the gas emission performance of the valve regulated batteries compared to the standard lead acid batteries. Arrangements are to be provided to allow any possible gas emission to be led to the weather, unless the gas emission performance of the valve regulated batteries does not exceed that of standard lead acid batteries connected to a charging device of 0.2 kW.

5.9.5(c) Battery Installation.

For battery installation arrangements, see 4-8-4/5.

5.9.6 Performance

5.9.6(a) Duration.

The output power is to be maintained for the duration required for the connected equipment as stated in 4-8-2/5.5 for emergency services and 4-8-2/5.11 of transitional source of power, as applicable.

5.9.6(b) Battery Capacity.

No additional circuits are to be connected to the battery charger unit or UPS unit without verification that the batteries have adequate capacity. The battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in 4-8-3/5.9.6(a).

5.9.6(c) Recharging.

On restoration of the input power, the rating of the charging facilities are to be sufficient to recharge the batteries while maintaining the output supply to the load equipment. See also 4-8-3/5.9.2.

5.9.7 Testing and Survey

5.9.7(a) Surveys.

Equipment units are to be surveyed during manufacturing and testing in accordance with 4-8-3/5.11.

5.9.7(b) Testing.

Appropriate testing is to be carried out to demonstrate that the battery charger units and uninterruptible power system (UPS) units are suitable for the intended environment. This is expected to include as a minimum the following tests:

- Functionality, including operation of alarms;
- Temperature rise;
- Ventilation rate;
- Battery capacity

5.9.7(c) Test upon power input failure.

Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

5.11 Testing and Certification

5.11.1 Certification

5.11.1(a) Essential and emergency services and services indicated in 4-8-3/15 TABLE 7. **(1 July 2021)**

Switchboards and associated motor control centers and distribution board, motor controllers of 100 kW and over, battery charger units of 25 kW and over, uninterruptible power system (UPS) units of 50 KVA and over, and distribution boards [associated with the charging and discharging of the battery system or unnterruptible power system (UPS)], where required for essential services (see 4-8-1/7.3.3), and services indicated in 4-8-3/15 TABLE

7, transitional source of power (see 4-8-2/5.11) and for distribution of emergency source of power (see 4-8-2/5), are to be inspected by, tested in the presence of and certified by the Surveyor, preferably at the plant of the manufacturer.

Switchboards are to be tested in accordance with the standards applied during design and construction (refer to 4-8-3/5.1). The prototype and routine tests are to be witnessed by ABS Surveyor.

Small distribution boards required for similar services, but not forming a part of the switchboards or the battery charging and discharging boards referred to above, such as lighting distribution boards, are to be treated as in 4-8-3/5.11.1(b). See also application of Type Approval Program in 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)* and 4-1-1/3.5 through 4-1-1/3.7.

5.11.1(b) Other services.

Switchboards, distribution boards, motor controllers, etc., where required for services other than those in 4-8-3/5.11.1(a), are to be tested by the manufacturers. Test certificates are to be submitted upon request by ABS.

5.11.2 Insulation Resistance Measurement

The insulation resistance between current-carrying parts and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 V before and after the dielectric strength tests. The insulation resistance measurement after the dielectric strength tests is to be carried out before components which have been disconnected for the dielectric tests are reconnected, and the insulation resistance is not to be less than 1 megohm (MΩ).

5.11.3 Dielectric Strength Test **(2025)**

The dielectric strength of the insulation is to be tested for 60 seconds by an AC voltage applied, in accordance with the voltage values given in the following table, between

- Each electric circuit, and
- All other electric circuits and metal parts earthed.

Rated Voltage U_n (V)	AC Test Voltage rms (V)
$U_n \le 12$	250
$12 < U_n \le 60$	500/1000 (see note)
$60 < U_n \le 300$	1500
$300 < U_n \le 690$	1890
$690 < U_n \le 800$	2000
$800 < U_n \le 1000$	2200
$1000 < U_n \le 1500$	2700

Note:

For power circuits $12 < U_n \le 60$, the test voltage is 1000. For control circuits, the test voltage is 500.

The test voltage at the moment of application is not to exceed 50% of the values given in the above table. It is to be increased steadily within a few seconds to the required test voltage and maintained for 60 seconds. Test voltage is to have a sinusoidal waveform and a frequency between 45 Hz and 60 Hz. Certain devices such as potential transformers having inherently lower insulation strength are to be disconnected during the test.

Equipment and apparatus produced in large quantities for which the standard test voltage is 2500 V or less may be tested for one second with a test voltage 20% higher than the 60-second test voltage.

5.11.4 Operational Tests **(1 July 2021)**

Operational tests are to be carried out including but not limited to the testing of protective devices (over current, under-voltage, and preferential trippings, etc.), electrical interlocks, synchronization of generators, earth detection, alarms.

With the UPS unit initially switched off and with no external power supply to the UPS itself, it is to be demonstrated that the UPS can be switched on to supply the load.

7 Transformers

7.3 Transformers for Essential Services

7.3.4 Prevention of the Accumulation of Moisture

TABLE 5
Equipment and Instrumentation for Switchboards

Instrumentation and Equipment		Alternating-current (AC) Switchboard	Direct-current (DC) Switchboard
1.	Indicator light	An indicator light for each generator, connected between generator and circuit breaker.(3)	An indicator light for each generator, connected between generator and circuit breaker.
2.	Generator Disconnect	A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses, except the earth lead.(1)	A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators equalizer poles may be provided on the circuit breaker. For 3-wire generators, the circuit breakers are to protect against a short circuit on the equalizer buses.(1)
3.	Insulation Monitor and Alarm	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values.(3) (5)	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values.(3)
4.	Ammeter	An ammeter for each generator with a selector switch to read the current of each phase.(3)	An ammeter for each 2-wire generator. For each 3-wire generator an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current.
5.	Voltmeter	A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus.(3)	A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator, a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage, positive to negative, and bus voltage positive to negative, positive to neutral, and neutral to negative. Where permanent provisions for shore connections are fitted, one voltmeter switch to provide also for reading shore-connection voltage, positive to negative
6.	Space heater indicator light	Where electric heaters are provided for generators, a heater indicator light is to be fitted for each generator.	Where electric heaters are provided for generators, a heater indicator light is to be fitted for each generator.
7.	Synchroscope or Lamps	A synchroscope or synchronizing lamps with selector switch for paralleling in any combination.(3)	Not applicable
8.	Prime mover Speed Control	Control for prime mover speed for paralleling.(3)	Not applicable
9.	Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator.(3)	Not applicable

Instrumentation and Equipment		Alternating-current (AC) Switchboard	Direct-current (DC) Switchboard
10.	Frequency Meter	A frequency meter with selector switch to connect to any generator.(3)	Not applicable
11.	Field Switch	A double-pole field switch with discharge clips and resistor for each generator.(2)	Not applicable
12.	Voltage Regulator	A voltage regulator.(3)	Not applicable
13.	Stator Winding Temperature Indicator	For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel.(3)(4)	For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel.(3)(4)

Notes:

1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.

2 For generators with variable voltage exciters or rotary rectifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch and the discharge resistor and may be omitted.

3 Where vessels have centralized control systems in accordance with Part 4, Chapter 9 and the generators can be paralleled from the centralized control station, and the switchboard is located in the centralized control station, this equipment may be mounted on the control console. See 4-8-3/5.5.4.

4 For high voltage systems, see also 4-8-5/3.7.3(c).

5 For high voltage systems, see 4-8-5/3.3.2.

TABLE 7
Additional Services Requiring Electrical Equipment to be Designed, Constructedand Tested to the Requirements in Section 4-8-3
[See 4-8-1/5.5, 4-8-3/1.5, 4-8-3/3.1, 4-8-3/3.15.1, 4-8-3/3.17 and 4-8-3/5.11.1]

(a)	Equipment necessary for specific class notations (Such as refrigerated cargo notations, dynamic positioning systems, etc.)
(b)	Cargo Pump Motors (oil carriers, gas carriers, chemical carriers, liquefied gas carriers, etc.)
(c)	Motors for hydraulic power unit for hydraulically driven cargo pump motors
(d)	High duty gas compressors on liquefied gas carriers

1 Application (2024)

The provisions of this Section apply to (a) high voltage systems; (b) electric propulsion systems; and (c) three-wire dual-voltage DC systems; and (d) electric plants of less than 75 kW; (e) energy storage systems. Unless stated otherwise, the applicable requirements of 4-8-4 are also to be complied with.

1.1 Objective (2024)

1.1.1 Goals

The electrical systems addressed in this Section are to be designed, constructed, operated, and maintained to:

Goal No.	Goal
PROP 1	Provide sufficient thrust/power to move or maneuver the vessel when required
PROP 2	Provide redundancy and/or reliability to maintain propulsion
POW 2	Provide power to enable the machinery/equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel.
POW 3	Enable *all electrical services necessary for maintaining the vessel in normal operational and habitable conditions to be available without recourse to the emergency source of power*.
POW 4	Enable all *electrical services* required *for safety* to be available during *emergency conditions*.
POW 5	Enable supply/power for essential services to be restored after malfunction
FIR 1	*Prevent the occurrence of fire and explosion.*
SAFE 1-1	Minimize danger to persons on board, the vessel, and surrounding equipment / installations from hazards associated with machinery and systems.
MGMT 5-1	Design and construct vessel, machinery, and electrical systems to facilitate safe access, ease of inspection, survey, and maintenance.
AUTO 1	Perform its functions as intended and in a safe manner
AUTO 2	Indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance
AUTO 3	Have an alternative means to enable safe operation in the event of an emergency or failure of remote control.

The goals in the cross-referenced Rules are also to be met.

1.1.2 Functional Requirements

In order to achieve the above-stated goals, the design, construction, and maintenance of the systems and equipment to which this Section applies are to be in accordance with the following functional requirements:

Functional Requirement No.	Functional Requirements
Propulsion, Maneuvering, Station Keeping (PROP)	
PROP-FR1	Have suitable arrangements such that the integrity/continuity of supplies to services required for propulsion and steering as well as the safety of the ship is maintained.
PROP-FR2	Provide redundancy for electrical equipment forming part of the electric propulsion drive train such that a single failure will not completely disable the propulsion of the vessel
PROP-FR3	Provide means to activate the propulsion control to avoid maloperation of equipment
PROP-FR4	Provide means for controlling the prime mover speed at the control assembly for safe operation
PROP-FR5	Opening of the control system assemblies or compartments is not to cause inadvertent or automatic loss of propulsion
PROP-FR6	The design of propulsion control system is to prevent a dangerous situation due to a control failure
PROP-FR7	Provide protection measures to prevent voltage variations and over speeding of the propulsion system due to regenerative power
PROP-FR8	Provide overspeed protection for propulsion motors to avoid loss of propulsion
Power Generation and Distribution (POW)	
POW-FR1	Provide winding connection methods for high voltage transformers to achieve redundancy of power supply upon a single failure
POW-FR2	The capacity of the main source of power is to be such that in the event of any one power source being stopped it will still be possible to supply services necessary to provide normal operational conditions of propulsion and safety

Functional Requirement No.	Functional Requirements
POW-FR3	Provide protection against overload, short circuit, earth-fault and overvoltage conditions and other hazards to prevent damage to equipment and maintain continuity of power to remaining circuits
POW-FR4	Provide means of storing energy for the safe operation of high voltage circuit breakers and switches
POW-FR5	Provide measures to protect equipment from internal damages
POW-FR6	Provide means to distribute loads such that blackouts are avoided, and power is always maintained to essential services and propulsion loads
POW-FR7	Provide protection again loss of excitation to avoid dangerous operation
POW-FR8	To withstand all loads that would be imposed during the intended operation
POW-FR9	Provide means to shutdown the propulsion machinery in case of emergency operation.
POW-FR10	Provide means to regulate transformer output voltage to achieve necessary performance characteristics of the converter unit in which the transformer is used
POW-FR11	Circuit disconnecting devices are to be constructed to withstand vibration or shock encountered during normal marine environmental conditions and avoid deterioration
POW-FR12	Circuit disconnecting devices used for generators and motors are to be designed to operate at full load conditions and are to be constructed to prevent flammability due to any damage.
POW-FR13	Provide method to absorb the excessive regenerated energy.
POW-FR14	Provide a power source independent of the main source of power to support emergency services for the applicable duration
POW-FR15	Provide instrumentation to control generator(s) for safe operation.
Fire Safety (FIR)	
FIR-FR1	Provide fire-extinguishing systems for effective containment and extinction of fire in electrical equipment.
Safety of Personnel (SAFE)	
SAFE-FR1	Provide conditions for the safe use of hull return and earthing systems
SAFE-FR2	Provide means to monitor and alarm the earth fault in the high voltage electric power systems
SAFE-FR3	Provide protection to prevent accidental contact with live parts of the assembly.
SAFE-FR4	Provide an external insulation enclosure for switchgear and control gear assemblies for protection of the equipment from electric hazards
SAFE-FR5	Provide locking arrangements for circuit protection devices to keep the position.
SAFE-FR6	Provide means of protection for persons operating the switchgear and control gear assemblies in the event of internal arc.
SAFE-FR7	Provide enclosure with suitable degree of protection against ingress of foreign objects and liquids based on location and personnel accessibility of installation
SAFE-FR8	Provide measures to prevent hazards and injuries due to high voltage cable penetrations in the accommodation spaces.
SAFE-FR9	Provide segregation for high voltage cables and equipment to avoid potential electric hazard and injuries
SAFE-FR10	Provide means of effective electrical bonding to earth for safe operation of high voltage cables
SAFE-FR11	Provide working space for high voltage equipment to prevent potential severe injuries to personnel performing maintenance activities
SAFE-FR12	Provide measures to avoid exposure of high voltage equipment to damaging environments
SAFE-FR13	HV electrical system is to be designed such that the crew can safely isolate any damaged distribution equipment and switch to alternative supplies without the need to open the HV equipment.
SAFE-FR14	Provide safety measures and alarms to detect and to protect from the earth leakage in AC and DC systems
SAFE-FR15	Provide enclosed ventilation or other means of protection for electric rotating machine to prevent personal injury or entrance of foreign matter
SAFE-FR16	Provide safety design for water-air cooler to prevent the water leakage.
SAFE-FR17	Provide lightning protection methods on nonmetallic mast for protection against electrical shock
SAFE-FR18	Provide neutral earthing methods of three-wire dual-voltage direct-current systems at the generator switchboards for protection against electrical shock

Functional Requirement No.	Functional Requirements
SAFE-FR19	High voltage equipment is to be able to withstand the marine environment and maximum or lower ambient temperature without any deterioration
SAFE-FR20	Navigation lighting system is to be provided with safety measures and alarms to alert the crew of any failures of the navigation lights
SAFE-FR21	Provide protection for DC propulsion circuits to avoid a damaging flashover
Safety Management (MGMT)	
MGMT-FR1	Provide accessibility to all the parts of the equipment requiring inspection or adjustment or replacement
MGMT-FR2	Provide means of disconnecting the electrical equipment from power source for maintenance
MGMT-FR3	Cables are to be constructed to withstand marine environment and support connected loads and their overload protection
MGMT-FR4	Provide means to seal the propulsion cables to prevent from admission of moisture or air
MGMT-FR5	To determine the authorizations required for each operation or task involving high voltage equipment and for access to the equipment location.
MGMT-FR6	To identify the tools and PPE for HV equipment inspection, calibration and maintenance
MGMT-FR7	Electrical equipment installations are to be well supported and provided with adequate clearance for ease of operation and maintenance
MGMT-FR8	Provide suitable marking for high voltage cables, equipment and spaces containing them for ready identification of danger.
MGMT-FR9	Provide means to prevent moisture condensation in the machine when idle.
Automation: Control, Monitoring and Safety Systems (AUTO)	
AUTO-FR1	Provide safety measures and alarms to protect the electrical distribution system from harmonics
AUTO-FR2	Provide means to monitor internal temperatures of the equipment and alarm when the normal operating temperatures are exceeded to prevent damage to the equipment
AUTO-FR3	Provide means to prevent reversal of generator rotation upon failure of the driving power of its prime mover
AUTO-FR4	Interlock arrangements are to be provided for propulsion control levers to avoid improper operation
AUTO-FR5	All critical parameters for power generation, distribution equipment are to be monitored and protections are to be provided to avoid damage to equipment and onboard personnel
AUTO-FR6	The control station is to be provided with means to monitor the parameters and status of propulsion system for normal operation of propulsion machinery
AUTO-FR7	Provide means to control the prime mover speed within the preset range under all operating conditions
AUTO-FR8	Provide measures to safeguard the reduction gear against lubrication supply failure.

The functional requirements covered in the cross-referenced Rules are also to be met.

3 High Voltage Systems

3.5 Circuit Protection

3.5.1 Protection of Generator

Protection against phase-to-phase fault in the cables connecting the generators to the switchboard and against inter-winding faults within the generator is to be provided. This is to trip the generator circuit breaker and automatically de-excite the generator. In distribution systems with a low impedance earthed neutral, phase to earth faults are to be likewise treated.

3.7 Equipment Design

3.7.3 Rotating Machines

3.7.3(a) *Protection* . Refer to 4-8-5/3 TABLE 1 for ingress protection (IP) requirements. **(2019)**

3.7.3(b) *Windings*. Generator stator windings are to have all phase ends brought out for the installation of the differential protection. **(2019)**

3.7.3(c) *Temperature Detectors*. Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage. **(2019)**

3.7.3(d) *Space Heater*. Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle. **(2019)**

3.7.6 Cables

3.7.6(a) *Standards*. Cables are to be constructed to IEC Publication 60092-353, 60092-354, or other recognized standard. See also 4-8-3/9. **(2019)**

TABLE 1
High Voltage Equipment Locations and Minimum Degree of Protection

Example of Location	Condition of Location	Switchboards, Distribution Boards, Motor Control Centers and Controllers	Generators	Motors	Transformers, Converters	Junction/ Connection Boxes
Dry control rooms Authorized Personnel Only	Danger of touching live parts only	IP32	N/A	N/A	IP23	IP44
Dry control rooms		IP42	N/A	N/A	IP44	IP44
Control rooms Authorized Personnel Only	Danger of dripping liquid and/or moderate mechanical damage	IP32	N/A	N/A	IP23	IP44
Control Rooms		IP42	N/A	N/A	IP44	IP44
Above floor plates in machinery spaces Authorized Personnel Only (1)		IP32	IP23	IP23	IP23	IP44
Above floor plates in machinery spaces		IP42	IP23	IP43	IP44	IP44
Emergency machinery rooms Authorized Personnel Only		IP32	IP23	IP23	IP23	IP44
Emergency machinery rooms		IP42	IP23	IP43	IP44	IP44
Below floor plates in machinery spaces Authorized Personnel Only	Increased danger of liquid and/or mechanical damage	N/A	N/A	*	*	IP44
Below floor plates in machinery spaces		N/A	N/A	*	N/A	IP44
Ballast pump roomsAuthorized Personnel Only	Increased danger of liquid and mechanical damage	IP44	N/A	IP44	IP44	IP44
Ballast pump rooms		IP44	N/A	IP44	IP44	IP44

Example of Location	Condition of Location	Switchboards, Distribution Boards, Motor Control Centers and Controllers	Generators	Motors	Transformers, Converters	Junction/ Connection Boxes
Holds for general cargo	Danger of liquid spray presence of cargo dust, serious mechanical damage, and/or aggressive fumes	*	*	*	*	IP55
Open decks (2)	Not exposed to seas	N/A	IP56	IP56	IP56	IP56
Open decks (2)	Exposed to seas	N/A	N/A	*	*	*

" * " indicates that equipment in excess of 1000 V is not normally permitted in these locations

Notes:

1. See where the equipment is located within areas affected by local fixed pressure water-spraying or water-mist fire extinguishing systems
2. For High Voltage Shore Connections (HVSC) see the requirements in Part 6, Chapter 4.
3. Where the IP rating of the high voltage electrical equipment has been selected on the basis that it is only accessible to authorized personnel, the entrance doors to the spaces in which such equipment is located, are to be marked accordingly.

3.13 Tests

3.13.1 Rotating Machine Tests

Each design of HV generator and motor is to be assessed by testing in accordance with the “type tests” schedule indicated in 4-8-3/15 TABLE 3. Each subsequent production unit of and accepted design is to be tested in accordance with the “routine tests” schedule also indicated in 4-8-3/15 TABLE 3.

3.13.1(a) *Inter-turn Insulation test*. In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with IEC Publication 60034-15 is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

3.13.1(b) Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:

i. All current carrying parts connected together and earth
ii. All current carrying parts of different polarity or phase where both the ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible then an approved method of calculation is to be used.

Rated Voltage, U_n (V)	Minimum Test Voltage (V)	Minimum Insulation Resistance (MΩ)
$1000 < U_n \leq 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \leq 15000$	5000	$U_n/1000 + 1$

3.13.2 Switchgear Tests

A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies with test voltages shown in the Table below. The test procedure is to be in accordance with IEC Publication 62271-200 Section 7/ *Routine Test*.

Rated Voltage (kV)	Rated Power Frequency Withstand Voltage (kV)
3.6	10
7.2	20
12	28
15	38

Where intermediate values of switchgear rated voltages are used, the next higher power frequency withstand test voltage is to be used.

3.13.3 Cable Test after Installation

A voltage withstand test is to be carried out on each completed cable and its accessories before a new high voltage installation, including additions to an existing installation, is put into service.

An insulation resistance test is to be carried out prior to the voltage withstand test being conducted.

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TABLE 2
Factory Testing Schedule for Generators and Motors ≥ 100 kW (135 hp) [8, 9] [See 6-1-7/19.1 and 6-1-7/19.3]

Tests	AC Generators		AC Motors		DC Machines	
	Type Test (1)	Routine Test (2)	Type Test (1)	Routine Test (2)	Type Test (1)	Routine Test (2)
1. isual inspection	X	X	X	X	X	X
2. Insulation resistance measureme	X	X	X	X	X	X
3. Winding resistance measuremen	X	X	X	X	X	X
4. erification of voltage regulation system.	X	X (3)	–	–	–	–
5. Rated load test and temperature rise measuremen	X	–	X	–	X	–
6. Overload/over-current tes	X	X (4)	X	X (4)	X	X (4)
7. erification of steady short circuit condition. (5)	X	–	–	–	–	–
8. Over-speed tes	X	X	X (6)	X (6)	X (6)	X (6)
9. Dielectric strength tes	X	X	X	X	X	X
10. Running balance te (7)	X	X	X	X	X	X
11. erification of degree of protection.	X	–	X	–	X	–
12. Bearing check after te	X	X	X	X	X	X
13. Air gap measurement.	X	X	–	–	X	X
14. Commutation che	–	–	–	–	X	–

Notes:

1 Type tests apply to prototype machines or to at least the first of a batch of machines. After type test, generator components, randomly selected at the discretion of the Surveyor, are to be presented for inspection.

2 Machines to be routine tested are to have reference to the machine of the same type that has passed a type test. Reports of routine tested machines are to contain manufacturers' serial numbers of the type tested machines and the test results.

3 Only functional test of voltage regulator system.

4 Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.

5 Verification at steady short circuit condition applies to synchronous generators only.

6 Where so specified and agreed upon between purchaser and manufacturer. Not required for squirrel cage motors.

7 Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearings, or with incomplete set of bearings.

8 The tests in 6-1-7/Table 2 are to be documented. The documentation is to include information on make, type, serial number, insulation class, all technical data necessary for the application of the machine, as well as the results of the required tests.

9 The result of type tests, and the serial number of the type tested machine, are to be specified in the documentation of test results for routine tests.

TABLE 3
Dielectric Strength Test for Rotating Machines [See 6-1-7/5.7]

Item	Machine or Part	Test Voltage (AC rms)
1	Insulated windings of rotated machines having rated output less than 1 kVA, and of rated voltage less than 100 V with the exception of those in items 4 to 8.	500 V + twice the rated voltage.
2	Insulated windings of rotating machines having rated output less than 10,000 kVA with the exception of those in items 1 and 4 to 8 (See Note 1).	1,000 V + twice the rated voltage with minimum of 1,500 V (See Note 2).

Item		Machine or Part	Test Voltage (AC rms)
3		Insulated windings of rotating machines having rated output 10,000 kVA or more, and of rated voltage (see Note 1) up to 24,000 V with the exception of those in items 4 8 (see Note 2).	1,000 V + twice the rated voltage.
4		Separately-excited field windings of DC machines.	1,000 V + twice the maximum rated circuit voltage with minimum of 1,500 V (See Note 1).
5		Field windings of synchronous generators and synchronous motors.	
	a)	Field windings of synchronous generators	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	b)	When the machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of winding.	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	c)	When the machine will be started either with: - the field winding connected across resistance or more than ten times the field winding resistance, or - the field windings on open circuit or without a field dividing switch.	1,000 V + twice the maximum value of the voltage with a minimum of 1,500 V - between the terminals of the field winding, or - between the terminals of any section for a sectionalized field winding, which will be occurred under the specified starting conditions (see Note 3).
6		Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g., if intended for rheostatic starting)	
	a)	For non-reversing motors or motors reversible from standstill only.	1,000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage applied to the primary windings.
	b)	For motors to be reversed or braked by reversing the primary supply while the motor is running.	1,000 V + four times the open-circuit standstill secondary voltage as defined in item 6.a. above.
7		Exciters (except as listed below) *Exception 1*—Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field winding during starting *Exception 2*—Separately excited field windings of exciters (see Item 4 above).	As for windings to which they are connected. 1,000 V + twice the rated exciter voltage with a minimum of 1,500 V.
8		Assembled group of machines and apparatus.	A repetition of the tests in items 1 to 7 above is to be avoided if possible. But, if a test on an assembled group of several pieces of new apparatus, each one is made, the test voltage to be applied to such assembled group is to be 80% of the lowest test voltage appropriate for any part of the group (see Note 4).

Notes:

1 For two-phase windings having one terminal in common, the rated voltage for the purpose of calculating the test voltage is to be taken as 1.4 times the voltage of each separate phase.

2 High-voltage tests on machines having graded insulation is to be subject to special consideration.

3 The voltage, which is occurred between the terminals of field windings or sections thereof under the specified starting conditions, may be measured at any convenient reduced supply voltage. The voltage so measured is to be increased in the ratio of the specified starting supply voltage to the test supply voltage.

4 For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

TABLE 4
Limits of Temperature Rise for Air-Cooled Rotating Machines
[See 6-1-7/5.9.1]

Ambient Temperature = 45°C

Item No.		Part of Machine	Temperature Measuring Method	Limit of Temperature Rise, °C for Class of Insulation				
				A	E	B	F	H
1	a)	AC windings of machines having rated output of 5,000 kW (or kVA) or more	Resistance	55	—	75	95	120
			Embedded temp. detector	60	—	80	100	125
	b)	AC windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA)	Resistance	55	70	75	100	120
			Embedded temp. detector.	60	—	85	105	125
	c)	AC windings of machines having rated outputs of 200 kW (or kVA) or less (1)	Resistance	55	70	75	100	120
2		Windings of armatures having commutators	Thermometer	45	60	65	80	100
			Resistance	55	70	75	100	120
3		Field windings of AC and DC machines having DC excitation, other than those in item 4	Thermometer	45	60	65	80	100
			Resistance	55	70	75	100	120
4	a)	Field winding of synchronous machines with cylindrical rotors having DC excitation winding embedded in slots, except synchronous induction motors	Resistance	—	—	85	105	130
	b)	Stationary field windings of AC machines having more than one layer	Thermometer	45	60	65	80	100
			Resistance	55	70	75	100	120
			Embedded temp. detector.	—	—	85	105	130
	c)	Low resistance field winding of AC and DC machines and compensating windings of DC machines having more than one layer	Thermometer	55	70	75	95	120
			Resistance	55	70	75	95	120
	d)	Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single layer compensating windings of DC machines (2)	Thermometer	60	75	85	105	130
			Resistance	60	75	85	105	130
5		Permanently short-circuited windings	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it.					
6		Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)						
7		Commutators, slip-rings and their brushes and brushing	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it. Additionally, the temperature is not to exceed that at which the combination of brush grade and commutator/ slip-ring materials can handle the current over the entire operating range.					

Notes:

1 With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes A, E, B or F, the limits of temperature rise given for the resistance method may be increased by 5°C.

2 Also includes multiple layer windings provided that the under layers are each in contact with the circulating coolant.

TABLE 5
Nameplates

a. Rotating Machines [See 6-1-7/5.11.9]

The manufacturer's name
The manufacturer's serial number (or identification mark)
The year of manufacture
Type of Machine (Generator or motor, etc.)
Degree of protection enclosures (by IP code)
Class of rating or duty type
The rated output
The rated voltage
The rated current and type of current (AC or DC)
The rated speed (r.p.m.) or speed range
The class of insulation or permissible temperature rise
The ambient temperature
Number of phase (for AC machines)
The rated frequency (for AC machines)
Power factor (for AC machines)
Type of winding (for DC machines)
Exciter voltage (for synchronous machines or DC machines with separate excitation)
Exciter current at rating (for synchronous machines or DC machines with separate excitation)
Open-circuit voltage between slip-rings and the slip-ring current for rated conditions (for wounded-rotor induction machines)

b. Accumulator Battery [See 6-1-7/7.3.3]

The manufacturer's name
The type designation
The rated voltage
The ampere-hour rating at a specific rate of discharge
The specific gravity of the electrolyte
(in the case of a lead-acid battery, the specific gravity when the battery is fully charged).

c. Transformer [See 6-1-7/11.5.3]

The manufacturer's name
The manufacturer's serial number (or identification mark)
The year of manufacture
The number of phases
The rated power
The rated frequency
The rated voltage in primary and secondary sides
The rated current in primary and secondary sides
The class of insulation or permissible temperature rise
The ambient temperature

d. Semiconductor Converter [See 6-1-7/13.5.4]

The manufacturer's name
The identification number of the equipment

TABLE 6
Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers, and Controllers [See 6-1-7/19.5, 6-1-7/19.7 and 6-1-7/19.9]

1 Insulation resistance measurements in accordance with 6-1-7/9.3.
2 Dielectric strength test in accordance with 6-1-7/9.5 and the Table below.
3 Protective device tripping test, such as overcurrent tripping, emergency tripping, preferential tripping, etc.
4 Inspection of the assembly, including inspection of wiring and, if necessary, electrical operation test.

Standard Test Voltage for Dielectric Strength Test

Rated Insulation Voltage	Dielectric Test Voltage AC rms
Up to and including 12 V	250 V
over 12 V to 60 V inclusive	500 V
over 60 V to 300 V inclusive	2000 V
over 300 V to 690 V inclusive	2500 V
over 690 V to 800 V inclusive	3000 V
over 800 V to 1000 V inclusive	3500 V
over 1000 V to 1500 V inclusive*	3500 V
Note: *For Direct-current (DC) only	

TABLE 7
Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers, Motor Control Centers and Controllers (1) [See 6-1-7/9.9.6]

Rated insulation voltage (V)	Minimum clearances mm (in.)	Minimum creepage distances mm (in.)
Up to 250	15 ($^{19}/_{32}$)	20 ($^{25}/_{32}$)

Rated insulation voltage (V)	Minimum clearances mm (in.)	Minimum creepage distances mm (in.)
From 251 to 690	20 ($^{25}/_{32}$)	25 (1)
Above 690	25 (1)	35 ($1^{3}/_{8}$)

Notes:

1 The values in this table apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts, including earthing.

2 For 1 kV to 15 kV systems, see 4-3-5/1.1.3.

TABLE 8
Equipment and Instrumentation for Switchboard [See 6-1-7/9.13.4]

Instrumentation and Equipment		Alternating-current (AC) Switchboard	Direct-current (DC) Switchboard
1.	Pilot Lamp	A pilot lamp for each generator connected between generator and circuit breaker. See Note 3.	A pilot lamp for each generator connected between generator and circuit breaker.
2.	Generator Disconnect	A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses, except the earth lead. See Note 1.	A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators, equalizer poles may be provided on the circuit breaker. For 3-wire generators, the circuit breakers are to protect against a short circuit on the equalizer buses. See Note 1.
3.	Field Rheostat	A field rheostat for each generator and each exciter. See Note 2.	A field rheostat for each generator. See Note 2.
4.	Insulation Monitor and Alarm	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. See Note 3 and 5.	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. For 3-wire generators, see 4-3-5/5.3. See Note 3.
5.	Ammeter	An ammeter for each generator with a selector switch to read the current of each phase. See Note 3.	An ammeter for each 2-wire generator. For each 3-wire generator, an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current.
6.	Voltmeter	A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus. See Note 3.	A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator, a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage, positive to negative, positive to neutral, and neutral to negative. Where permanent provisions for shore connections are fitted, one voltmeter switch to provide also for reading shore-connection voltage, positive to negative.
7.	Space Heater Pilot Lamp	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.
8.	Synchroscope or Lamps	A synchroscope or synchronizing lamps with selector switch for paralleling in any combination. See Note 3.	Not applicable.

Instrumentation and Equipment		Alternating-current (AC) Switchboard	Direct-current (DC) Switchboard
9.	Prime mover Speed Control	Control for prime mover speed for paralleling. See Note 3.	Not applicable.
10.	Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. See Note 3.	Not applicable.
11.	Frequency Meter	A frequency meter with selector switch to connect to any generator. See Note 3.	Not applicable.
12.	Field Switch	A double-pole field switch with discharge clips and resistor for each generator. See Note 2.	Not applicable.
13.	Voltage Regulator	A voltage regulator. See Note 3.	Not applicable.
14.	Stator Winding Temperature Indicator	For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 4.	For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 4.

Notes:

1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.

2 For generators with variable voltage exciters or rotary amplifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch, the discharge resistor and generator field rheostat may be omitted.

3 Where units have centralized control systems in accordance with Part 4, Chapter 9 of the ABS *Marine Vessel Rules* and the generators can be paralleled from the centralized control station, and the switchboard is located in the centralized control station, this equipment may be mounted on the control console. See 6-1-7/9.13.4.

4 For high voltage systems, see also 6-1-7/15.3.1(c).

5 For high voltage systems, see 4-3-5/1.3.5.

1 High Voltage Systems

1.9 Equipment Installation and Arrangement

1.9.4 High Voltage Shore Connection **(2023)**

Where arrangements are made for the supply of electricity at high voltage from onshore and designed to allow the shipboard generators to be shut down while in port, the requirements given in Part 6, Chapter 4 of the *Marine Vessel Rules* are to be complied with.

1.11 Machinery and Equipment

1.11.1 Rotating Machines

1.11.1(a) *Protection.* Refer to 4-6-5/1 TABLE 1 for ingress protection (IP) requirements.

1.11.1(b) *Windings.* Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

1.11.1(c) *Temperature Detectors.* Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against over-voltage.

1.11.1(d) *Space Heater.* Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

1.11.1(e) *Tests.* Each design of HV generator and motor is to be assessed by testing in accordance with the “type tests – schedule indicated in 4-6-4/13.7 TABLE 1. Each subsequent production unit of and accepted design is to be tested in accordance with the “routine tests – schedule also indicated in 4-6-4/13.7 TABLE 1.

i. *Inter-turn Insulation Test.* In addition to the tests normally required for rotating machinery, a high frequency, high voltage test, in accordance with IEC Publication 60034-15, is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

ii. Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:

   a. All current carrying parts connected together and earth

   b. All current carrying parts of different polarity or phase where both the ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible then an approved method of calculation is to be used.

Rated Voltage U_n (V)	Minimum Test Voltage (V)	Minimum Insulation Resistance (MΩ)
$1000 < U_n \leq 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \leq 15000$	5000	$U_n/1000 + 1$

21 Special Requirements for Non-metallic Craft

21.17 Equipment Earthing **(2023)**

All electrical enclosures, fittings, and similar equipment are to be permanently earthed to the generator frame and engine bedplate or to the nearest earth point with equipment earthing conductors that are at least as large as the conductors supplying the equipment.

For essential services, supplementary protective equipotential bonding is to be provided for installations in locations where particular risk may exist due to unintentional simultaneous access to exposed-conductive-parts of fixed equipment and extraneous-conductive parts.

On non-essential services where the voltage between simultaneously accessible conductive parts exceeds 50 VAC or 120 VDC an automatic disconnection protective device with sensitivity of 30 mA maximum for final circuits and an operating time not exceeding 40 ms is to be fitted.

Notes:

1. An automatic disconnection protective device can be a residual current device (RCD) or a device with similar characteristics.
2. Simultaneously accessible means equipment within arm’s reach. See IEC 61140 Par 5.2.5.
3. Equipotential bonding is essentially an electric connection that keeps the potential of several exposed and extraneous conducting elements close to same. An earthed equipotential zone is where exposed conductive parts and extraneous conducting parts have nearly the same potential by bonding. The intent is to ensure that the potential difference between accessible exposed conductive parts does not occur under fault conditions.