TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Part E

Chapter 105 - Electric

2015

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction is on or after 01st of January 2015.

If there is a difference between the rules in English and in Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version. Once downloaded, this document will become UNCONTROLLED. Please check the website below for the valid version.

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Chapter 105 – Electric

Section 5 - Low-Voltage Switchgear Assemblies

Section 6 - Power Electronics

Section 7 - Power Equipment

Section 8 - Medium-Voltage Installations

Section 9 - Control, Monitoring and Ship's Safety Systems

SECTION 1

GENERAL REQUIREMENTS AND INSTRUCTIONS

A. Scope

1. These Rules for Classification and Construction apply to electrical and electronic equipment on naval ships which is relevant for these ships as platform for military tasks and which is defined in these rules. Special requirements for weapon systems should be defined in the building specification.

2. References to other rules and regulations

2.1 Where the requirements for electrical equipment and facilities are not laid down in these Rules, decisions shall be made, wherever necessary, regarding the use of other applicable regulations and standards. These include e.g. IEC publications, especially all IEC 60092 publications.

2.2 Further rules and guidelines stipulated in the Construction Rules as well as international standards have to be considered, if applicable.

2.3 The provisions of the "International Convention for the Safety of Life at Sea **(SOLAS)"** are taken into account in these Rules, insofar as these can be applied to naval surface ships.

2.4 For NATO ships, or if required in the building specification, the NATO Standardization Agreement (STANAG) shall be observed.

2.5 Where necessary, the relevant national regulations and special provisions in the building specification shall be observed in addition to these Construction Rules, insofar as they do not conflict with any safety regulations of these Construction Rules.

2.6 Requirements given in other chapters shall also be given due consideration, if they are pertinent to the design of the electrical installation.

3. Design

Electrical installations must be designed so that:

3.1 The maintaining of normal operational and habitable conditions provided on board, as well as the operation of all equipment needed for the primary duties of the ship, will be ensured without recourse to the second power station or the emergency source of electrical power,

3.2 The operation of the equipment required for safety will be ensured under various emergency conditions,

3.3 The safety of crew and ship from electrical hazards will be ensured,

3.4 A high reliability will be provided through simple and clearly understandable operating sequences and through the use of type-tested products where these are prescribed in these Rules and in the building specification,

3.5 A high combat survivability will be safe guarded through decentralization of the generating and distributing arrangements as well as redundancies, both in the construction and in the functions, especially for essential equipment,

3.6 If in a class of naval ships, originally planned to be identical, deviations become necessary, TL shall be duly informed and changes properly documented.

4. Equivalence

4.1 Naval ships deviating from the TL Rules in their type, equipment or in some of their parts may be classed, provided that their structures or equipment are found to be equivalent to the TL requirements for the respective Class.

4.2 In this respect, **TL** can accept alternative design, arrangements and calculation/analyses (FE, FMEA, etc.) which are suitable to satisfy the intent of the respective **TL** requirements and to achieve the equivalent safety level.

B. Definitions

1. Power supply installations

The power supply installations comprise all installations for the generation, conversion, storage and distribution of electrical energy.

1.1 **Power station** is the grouping of generators, switchboard, auxiliary machinery etc. to form an independent functional unit as part of the main source of electrical power.

1.2 **Propulsion plant** is the grouping together of the turbines, engines, gears, generators, electrical propeller motors etc. that are needed for the ship's propulsion, with the associated ancillary equipment, to form an independent function unit of the propulsion system with regard to one propeller.

1.3 Electrical distribution

1.3.1 Main groups are distribution switchboards

that are fed alternatively from at least two power station switchboards.

1.3.2 Groups are distribution switchboards which are only fed from either a main group or from a power station switchboard.

1.3.3 Subgroups are distribution switchboards which are only fed from a group.

1.4 Main electrical power supply

The main source of electrical power ensures unrestricted ship operation under all operational conditions, even after failure of any generator or power station.

1.5 Auxiliary power supply

The auxiliary power supply consists of flexible and transportable cables with plug-and-socket connections which, in the event of damage to permanently installed cable connections, can be used to supply selected emergency consumers from the main group or the power station.

1.6 Emergency electrical power supply

On ships which have a main electrical power supply with reduced requirements for combat survivability (e.g. only 1 power station), an independent emergency power supply must be provided to feed the emergency consumers in the event of failure of the main electrical power supply (reference is made to B.5., E.2., Section 2, A.1.5, A.1.6, A.2. and B.4., Section 3, C., Section 4, B. and I.7., Section 5, C.3., Section 11, B.6. and to Section 16, D.4.2.2).

1.7 Uninterruptible power supply (UPS)

The uninterruptible power supply safeguards the operation of equipment that is relevant to safety, if the main electrical power supply should fail, as specified under Section 3, D.

2. Essential equipment

2.1 Principal requirements

Essential equipment is required to ensure continuity of the following functions:

- The propulsion, manoeuvrability, navigation and safety of the ship
- The safety of the crew
- All equipment, machinery and appliances needed to an unrestricted extent for the primary duty of the ship
- All equipment, machinery and appliances needed for the flooding control, fire fighting and NBC defence

These requirements apply for both the power supply and control functions.

Essential equipment is subdivided into:

- Primary essential equipment
- Secondary essential equipment

2.2 Primary essential equipment

Primary essential equipment is that required to be operative at all times to maintain the maneuverability of the ship as regards propulsion and steering, and that required directly for the primary duty of the ship.

It comprises e.g.:

- Steering gear
- CP propeller installation
- Charging air blowers, fuel feeder pumps, fuel booster pumps, lubricating oil pumps and fresh cooling water pumps for main and auxiliary engines and turbines, as far as required for propulsion
- Condensate pumps, feed water pumps, boiler water circulating pumps, forced draught fans, burner equipment for auxiliary steam boilers for the operation of primary essential equipment
- Azimuth drives as sole propulsion and steering

equipment, included their lubricating oil and cooling water pumps

- Electrical main propulsion plants
- Generators supplying primary essential equipment
- Hydraulic pumps for primary essential equipment
- Viscosity control equipment
- Control, monitoring and safety devices/systems for primary essential equipment
- Navigational appliances and navigational systems
- Internal and external communication equipment
- Weapon systems (effectors and sensors)
- Tactical command system

2.3 Secondary essential equipment

Secondary essential equipment is required for the safety of the ship and the crew, and is such equipment which can briefly be taken out of service without the propulsion, steering and equipment, needed for the primary duty of the ship, being unacceptably impaired.

It comprises e.g.:

- Anchor windlasses and capstans
- Azimuth thrusters, if they are auxiliary equipment
- Fuel oil transfer pumps and fuel oil treatment equipment
- Lubrication oil transfer pumps and lubrication oil treatment equipment
- Starting-air and control-air compressors
- Bilge, ballast and heel-compensating installations
- Fuel injection valve cooling pump and seawater pump
- Fire pumps and other fire fighting equipment
- Ventilation fans for engine and boiler rooms
- Ventilation fans for hazardous areas
- Navigation lights and navy-specific signal lights
- Fire detection and alarm systems
- Main lighting system
- Bulkhead door closing equipment, shell closures, bow and stern ramps
- Auxiliary and main engine starting installations
- Generators supplying secondary essential equipment, but only if this equipment is not supplied by generators as described under 2.2
- Hydraulic pumps for secondary essential equipment
- Control, monitoring and safety devices/systems for secondary essential equipment
- Parts of the shipboard aircraft installations
- NBC fans
- NBC passage heaters
- Decontamination equipment
- Magnetic self-protection (degaussing)

3. Non-Essential Equipment

Non-essential equipment is that whose temporary disconnection does not impair propulsion and steerability of the ship, both in combat conditions and during wartime cruising, and does not endanger the safety of crew, ship and machinery.

4. Direct consumers

Direct consumers are consumers or equipment with a large power requirement that are connected directly to the power stations.

5. Emergency consumers

Emergency consumers are mandatory consumers which, after breakdown of the main energy supply, must be fed by the emergency electrical power supply, see 1.6.

6. Electrical Network

6.1 General

For the electrical networks of ships within NATO, or when stipulated in the building specification, the definitions set out in STANAG 1008 shall apply.

6.2 Isolated electrical network

This term refers to a system in which a conductor or the neutral is not connected to the ship's hull in normal operation. If it is earthed via measuring or protective devices with a very high impedance, the system is likewise deemed to be isolated.

6.3 Electrical network with earthed neutral

This is a system in which the neutral is connected to the ship's hull in normal operation.

7. Rated Voltage of an Electrical Network

The rated voltage U_N (RMS value) of a system is a characteristic system parameter to which specific characteristics of the connected facilities and the limit and test values of the system and of the facilities are referred.

8. Safety Voltage

Safety voltage is a protection measure and consists of a circuit with rated voltage not exceeding 50 V AC, operated un-earthed and isolated safely from supply circuits exceeding 50 V.

9. Low-Voltage Systems

These are systems operating with rated voltages of more than 50 V up to 1000 V inclusive and with rated frequencies of 50 Hz up to 400 Hz, or direct-current systems where the maximum instantaneous value of the voltage under rated operating conditions does not exceed 1500 V.

10. Medium-voltage systems

These are systems operating with rated voltages of more than 1 kV and up to 17,5 kV inclusive and with rated frequencies of 50 Hz or 60 Hz, or direct-current systems, with the maximum instantaneous value of the voltage under rated operating conditions over 1500 V.

11. Machinery spaces

Machinery spaces are, in general, spaces in which machines and equipment are installed and which are accessible only to authorized persons (e.g. engine rooms).

11.1 Wet operating spaces

Wet operating spaces are spaces in which facilities may be exposed to moisture (e.g. main engine rooms).

11.2 Dry operating spaces

Dry operating spaces are spaces in which no moisture normally occurs (e.g. engine control rooms, operation command centres).

11.3 Locked electrical spaces

Locked electrical spaces are spaces which are provided with lockable doors and are intended solely for the installation of electrical equipment such as switchgear, transformers etc. They have to be constructed as dry spaces.

11.4 Machinery spaces category A

Machinery spaces are spaces which contain internal combustion engines used for the main propulsion or other purposes and having a total power output of at least 375 kW, or which contain an oil-fired boiler or an oil-treatment plant. The trunks to such spaces are included.

12. Hazardous areas

12.1 Scope

Hazardous areas are areas in which an explosive atmosphere in dangerous quantity (a dangerous explosive atmosphere) is liable to occur owing to local and operating conditions.

Hazardous areas are divided into zones depending on the probability that a dangerous explosive atmosphere may occur.

12.2 Subdivision into zones

Zone 0 Comprises areas in which a dangerous explosive atmosphere is present either permanently or for long periods

Zone 1 Comprises areas in which a dangerous explosive atmosphere is liable to occur occasionally

Zone 2 Comprises areas in which a dangerous explosive atmosphere is liable to occur only rarely, and then only for a brief period (extended hazardous areas)

13. Areas potentially endangered by explosive materials

Areas potentially endangered by explosive materials are differentiated as follows:

13.1 Ammunition handling rooms

In these rooms, explosive materials are exposed during work on the ammunition, e.g. in

- Fuse testing rooms
- Mine and torpedo servicing rooms

13.2 Ammunition storage rooms

Ammunition storage rooms are areas in which ammunition is stored for longer than 12 hours and which are equipped with water spraying systems.

Note

Ammunition storage rooms do not include:

- *Ammunition staging rooms in which the ammunition is stored for less than 12 hours and which are not equipped with a sprinkler system.*
- *Ammunition magazines and lockers as well as rooms in which they are located.*

14. Flame-retardation of individual cables

Single cables and single wires are considered to be flame-retardant if they meet the test requirements of IEC publication 60332-1 regarding flame propagation.

15. Flame-retardation of cable bunches

Cable bunches and wire bunches are considered flame-retardant if they are flame retardant as single cables and, laid bundled, meet the requirements of IEC publication 60332-3, category A/F, with regard to flame propagation.

16. Fire-resistant cables

Fire-resistant cables are those which under the influence of flames demonstrate function-sustaining characteristics for a certain time (e.g. 3 h) and meet the IEC publication 60331 test requirements.

17. Cable bundles

Arrangement of two or more cables laid parallel and directly contiguous.

18. Systems

Systems contain all equipment necessary for monitoring, control and safety, including the input and output devices. Systems cover defined functions including behaviour under varying operating conditions, cycles and running.

19. Protective devices

Protective devices detect actual values, activate alarms in the event of limit-value infringement, and prevent machinery and equipment from being endangered. They automatically initiate curative measures or call for appropriate ones.

20. Safety devices

Safety devices detect critical limit-value infringements and prevent any immediate danger to persons, ship or machinery.

21. Safety systems

Combination of several safety devices and/or protection devices into one functional unit.

22. Alarms

An alarm gives optical and acoustical warning of abnormal operating conditions.

23. Power electronics

All equipment and arrangements for generation, transformation, switching and control of electrical power by the use of semi-conductor components.

24. Equipment of power electronics

All equipment which directly effect the flow of electrical energy consist of the functional wired semiconductor elements together with their protection and cooling devices, the semi-conductor transformers or inductors and the switchgear in the main circuits.

C. Documents for Approval

1. General requirements

1.1 The drawings and documents to be submitted for approval must comply with a recognized standard and must be complete, well-organized and consistent in themselves.

1.2 The drawings of switchgear and control systems shall be accompanied by parts lists indicating the manufacturers and characteristics of the electrical components, circuit diagrams, together with descriptions where these constitute a necessary aid to understanding.

The drawings and documents must make clear that the requirements set out in this Chapter have been complied with.

1.3 Any non-standard symbol used shall be explained in a key.

1.4 All documents shall be marked with the project designation (hull number) and the shipyard.

1.5 The drawings and documents listed under 2 shall be submitted at least in triplicate for examination at a sufficiently early date to ensure that they are approved and available to the surveyor at the beginning of manufacture or installation of the electrical equipment.

1.6 TL reserve the right to demand additional documentation if that submitted is insufficient for an assessment of the installation.

1.7 All documentation shall be submitted in English or Turkish language.

2. List of documents to be submitted

2.1 Forms

2.1.1 Form F 141: Description of electrical equipment

2.1.2 Form F 184: Copies of the certificate of conformity for explosion-protected equipment

2.2 Power system

2.2.1 Electrical equipment, power generation and distribution (overview diagram)

2.2.2 Generators, UPS equipment, converters, mains power supply units

2.2.3 Spaces with explosion hazards, with specification on the equipment installed there

2.2.4 Short-circuit calculation if a total generator output is larger than 500 kVA

2.2.5 Electrical power balance (main networks and sub-networks)

2.2.6 Power station switchboards (circuit diagrams, plans of the busbar systems, pictorial drawing and parts list)

2.2.7 Emergency switchboard (circuit diagrams, plans of the busbar systems, pictorial drawings and parts list)

2.2.8 Main groups, subgroups, groups (circuit diagram, pictorial drawing and parts list)

2.2.9 Groups for the lighting, with specification of the circuits and rooms supplied

2.2.10 Incoming feeders for weapons, sensors and tactical command systems

2.2.11 Concept to avoid radiation hazards

2.2.12 Switchgear, monitoring and control for refrigeration plant

2.2.13 Main cable ways for different voltage systems

2.2.14 Bulkhead/deck penetrations

2.2.15 Cable layout, list

2.3 Manoeuvring systems

2.3.1 Steering gear, control and monitoring system

2.3.2 Rudder propeller and lateral thruster systems

2.3.3 CP propeller installation

2.3.4 Dynamic positioning system, where applicable.

2.4 Lighting

2.4.1 Arrangement of the lighting fixtures and socket outlets of all main, reserve auxiliary, emergency and special lighting installations

2.4.2 Documentation on light fittings and socket used

2.5 Starting, control and monitoring equipment

2.5.1 Engine monitoring installation

2.5.2 Engine safety facilities / safety systems

2.5.3 Main and auxiliary engines starting installations

2.5.4 Controls and regulators for essential equipment / propulsion plants

2.6 Ship safety systems

2.6.1 General alarm system (quarter bill)

2.6.2 Position and navigation lights, signaling lights switchboard

2.6.3 Drawings/general arrangement plan (side view and top view of the ship, with key) for the navigation lights and navy-specific signaling lights and signal control, with details on their arrangement

2.6.4 Fire detection system

2.6.5 CO_2 alarm system

2.6.6 Watertight door control system and indicators

2.6.7 Fire door control system and indicators

2.6.8 Control and monitoring of shell doors, doors to the open deck

2.6.9 Emergency shutdown facilities

2.6.10 Tank level indicators, alarms, shutdown facilities

2.6.11 Gas and NBC (nuclear-biological chemical) detection systems

2.7 Control stations

2.7.1 Machinery Control Centre (MCC) consoles

2.7.2 Damage Control Centre (DCC) and stations for damage control groups

2.7.3 Auxiliary control positions.

2.8 Communication equipment

2.8.1 Public address system

2.8.2 Essential inter communication systems

2.9 Computer systems

2.9.1 Specification including hardware documentation (as relevant for classification)

2.9.2 Software quality plan

2.9.3 Concept of the power supply (main and emergency electrical power supply, UPS etc.)

2.9.4 Functional description as well as plans showing the functional interrelationships, interfaces to other systems and spatial arrangement of the hardware

2.9.5 Instructions for operating and commissioning

2.9.6 Further documents that may be necessary, depending on the requirement class of the system or the corresponding deployment

2.9.7 The software version at the time of delivery shall be documented.

2.10 Electrical propulsion plants

2.10.1 Propulsion motors

2.10.2 Converters

2.10.3 Control, regulation, monitoring

2.10.4 FMEA (Failure Mode and Effect Analysis) for electrical propulsion systems

2.10.5 Converter transformers

2.10.6 Propulsion switchgear

2.10.7 Functional description

2.11 Tests and trials

Test and trial schedules must be compiled for the power generation and power distribution, control and regulation systems, monitoring and safety installations, lighting system and also for the communication systems and other consumers, to cover the following test steps:

2.11.1 Tests in the manufacturer's factory of components and installations (FAT).

2.11.2 Installation and integration tests of components, installations and systems on board at the harbour (HAT).

2.11.3 Functional and load tests of systems on board during the sea trials (SAT).

3. Modifications and Extensions

Major modifications to the electrical installations of ships under construction or in service are subject to approval. The relevant documents shall be submitted in ample time prior to the execution of the work.

D. Documents for Delivery to be Kept Aboard

When the ship is commissioned or following major modifications and extensions of the electrical equipment, at least the documents subject to approval, specified in C. and showing the final arrangement of the electrical equipment, shall be supplied on board. The documents must be marked with the project designation (hull number) and the name of the yard, and the date of preparation of the documents.

E. Ambient Conditions

1. General Operating Conditions

1.1 The selection, layout and arrangement of the ship's structure and all shipboard machinery shall be such as to ensure faultless continuous operation under defined standard ambient conditions.

More stringent requirements must be observed for Class Notation **AC1** (see Chapter 101 - Classification and Surveys, Section 2, C.).

For the Class Notation **ACS** variable requirements for

unusual types and/or tasks of naval ships can be discussed case by case, but shall not be less than the standard requirements.

Components in the machinery spaces or in other spaces which comply with the conditions for the Notation **AC1** or **ACS** must be approved by TL.

1.2 Inclinations and movements of the ship

The design conditions for static and dynamic inclinations of a naval ship have to be assumed independently from each other. The standard requirements and the requirements for Class Notation **AC1** are defined in Table 1.1.

The effects of elastic deformation of the ship's hull on the machinery installation have to be considered.

1.3 Environmental conditions

The standard requirements and the requirements for Class Notation **AC** 1 are defined in Table 1.2.

2. Vibrations

2.1 General

2.1.1 Electrical machinery and appliances are normally subjected to vibration stresses. On principle their design, construction and installation must consider these stresses.

The faultless long-term operation of individual components shall not be impaired by vibration stresses.

2.1.2 Where an electrical machine or device generates vibrations when in operation, the intensity of the vibration shall not exceed defined limits.

The purpose is to protect the vibration exciter themselves, and the connected assemblies, peripheral equipment and hull components, from excessive vibration stresses liable to cause premature failures or malfunctions.

2.1.4 The following provisions relate to vibrations in the 2-300 Hz frequency range. They are to be applied in analogous manner to higher-frequency vibrations.

2.1.5 On principle investigation of vibration shall be carried out over the whole load and speed range of the vibration exciter.

2.2 Assessment

2.2.1 Assessment is based on the criteria laid down in Chapter 104 - Propulsion Plants, Section 1, D.2.

2.2.2 Assessment of the vibration loads on electrical machines and equipment is based on the areas defined in Fig. 1.1 and Table 1.3. It concerns vibrations which are introduced from the environment into electrical machines and equipment as well as vibrations generated from these components themselves.

2.2.3 The limits indicated Fig. 1.1 and Table 1.3 correspond to Fig. 1.1 and Table 1.3 in Chapter -104 Propulsion Plants, Section 1, D.2, with the difference that in Chapter 105 the vibration velocity is substituted by the vibration amplitude.

For the assignment of a vibration value to a particular area on principle the synthesis value, not an individual harmonic component, is relevant.

2.2.4 Electrical machines and equipment for use on board of ships must be designed at least for a vibration load corresponding to area A. With the agreement of TL, a lower endurance limit may be permitted in exceptional cases. In such cases, suitable countermeasures (vibration damping, etc.) must be taken to compensate for the increased sensitivity.

2.2.5 If an electrical machine or equipment generates mechanical vibrations when in service (e.g. be cause it is out of balance), the vibration amplitude measured on the machine or the equipment on board shall not be outside area A. For this evaluation, reference is made only to the self-generated vibration components. Area A may only be utilized if the loading of all components, with due allowance for local excess vibration, does not impair reliable long-term operation.

Table 1.1 Design conditions for ship inclinations and movements

Type of movement	Type of inclination and affected equipment	Design conditions	
		Standard requirements	Notation AC1
Static condition	**Inclination athwartships: (1)**		
	Main and auxiliary machinery	15°	25°
	Other installations **(2)**	22,5°	25°
	No uncontrolled switches or functional changes	45°	45°
	Ship's structure	acc. to stability requirements	acc. to stability requirements
	Inclinations fore and aft: (1)		
	Main and auxiliary machinery	5°	5°
	Other installations **(2)**	10°	10°
	Ship's structure	acc. to stability requirements	acc. to stability requirements
Dynamic condition	**Rolling:**		
	Main and auxiliary machinery	22,5°	30°
	Other installations **(2)**	22,5°	30°
	Pitching:		
	Main and auxiliary machinery	7,5°	10°
	Other installations **(2)**	10°	10°
	Accelerations:		
	Vertical (pitch and heave)	a_z [g] **(3)**	pitch: 32 °/s **(2)** heave: 1,0 g
	Transverse (roll, yaw and sway)	a_y[g] **(3)**	roll: 48 °/s **(2)** yaw: 2 °/s **(2)** sway: a_y **(3)** [g]
	Longitudinal (surge)	a_x[g] **(3)**	a_x **(4)** [g]
	Combined acceleration	acceleration ellipse **(3)**	direct calculation

(1) *Athwart ships and fore and aft inclinations may occur simultaneously*

(2) *Ship's safety equipment, switch gear and electric/electronic equipment*

(3) *Defined in Chapter 102 - Hull Structures and Ship Equipment, Section 5, B.*

(4) *To be defined by direct calculation*

2.2.6 In positions exposed to particularly severe stresses, electrical machines and appliances may be loaded outside area A. In this case the user has to inform the manufacturer about the operational requirements and the machines or the equipment shall be designed appropriately.

2.2.7 Electrical appliances and equipment operating in positions where they are exposed to severe vibration loads (e.g. in the immediate vicinity of reciprocating machines, and in steering gear compartments) must be designed for these severe vibration loads. The limit of area C shall, however, not be exceeded. Lower design parameters can be accepted subject to proof of lower vibration loading in service.

Table 1.3 Numerical definition of the area boundaries shown in Fig. 1.1

Area	A	C
ŝ [mm]	< 1	< 1
v [mm/s]	< 20	< 63
v_{eff} [mm/s]	< 14	< 45
â [9,81 m/s 2]	< 0,7	< 4

ŝ vibration displacement amplitude

v vibration velocity amplitude

v_{eff} effective value of vibration velocity

â vibration acceleration amplitude

2.3 Permissible alternating torque, see Chapter 104 - Propulsion Plants, Section 8, F.

Table 1.2 Design environmental conditions

Environmental area	Parametersx	Design conditions	
		Standard requirements	Notation AC1
Outside the ship/air	Temperature	-25 °C to +45 °C **(1)**	-30 °C to +55 °C **(1)**
	Temperature (partially open spaces)	-	-10 °C to +50 °C **(1)**
	Atmospheric pressure	1000 mbar	900 to 1100 mbar
	Max. relative humidity	60 % **(2)**	100 %
	Salt content	1 mg/m^3	1 mg/m^3
		withstand salt-laden spray	withstand salt-laden spray
	Dust/sand	to be considered	filters to be provided
	Wind velocity (systems in operation)	43 kn **(3)**	90 kn
	Wind velocity (systems out of operation)	86 kn **(3)**	100 kn
Outside the ship/ seawater	Temperature **(4)**	-2 °C to +32 °C	-2°C to +35°C
	Density acc. to salt content	1,025 t/m^3	1,025 t/m^3
	Flooding	withstand temporarily	withstand temporarily
Outside the ship/ icing of surface	Icing on ship's surfaces up to 20 m above waterline	see Chapter 1, Section 2, B.3.4	see Chapter 1, Section 2, B.3.4
Outside the ship/ navigation in ice	Ice class **B**	drift ice in mouth of rivers and coastal regions	drift ice in mouth of rivers and coastal regions
Entrance to the ship/ for design of	Air temperature	-15°C to +35°C	-15°C to +35°C
	Max. heat content of the air	100 kJ/kg	100 kJ/kg
	Seawater temperature	-2 °C to +32 °C	-2°C to +35°C
Inside the ship/ all spaces **(5)**	Air temperature	0 °C to +45 °C	0 °C to +45 °C
	Atmospheric pressure	1000 mbar	1000 mbar
	Max. relative humidity	up to 100 % (+45 C°)	100 %
	Salt content	1 mg/m^3	1 mg/m^3
	Oil vapour	withstand	withstand
	Condensation	to be considered	to be considered
Inside the ship/ air-conditioned areas	Air temperature	0 °C to +40 °C	0 °C to +40 °C
	Max. relative humidity	80%	100 %
	Recommended ideal climate for manned computer spaces	-	air temperature +20 °C to +22 °C at 60% rel. humidity
Inside the ship/ in electrical devices with	Air temperature	0 °C to +55 °C	0 °C to +55 °C
	Max. relative humidity	100 %	100 %

(1) *Higher temperatures due to radiation and absorption heat have to be considered*

(2) *100 % for layout of electrical installations*

(3) *For lifting devices according to TL Rules Chapter 50 - Guidelines for the Construction and Survey of Lifting Appliances, Section 2*

(4) *TL may approve lower limit water temperatures for ships operating only in special geographical areas*

(5) *For recommended climatic conditions in the ship's spaces see also Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 11, F.*

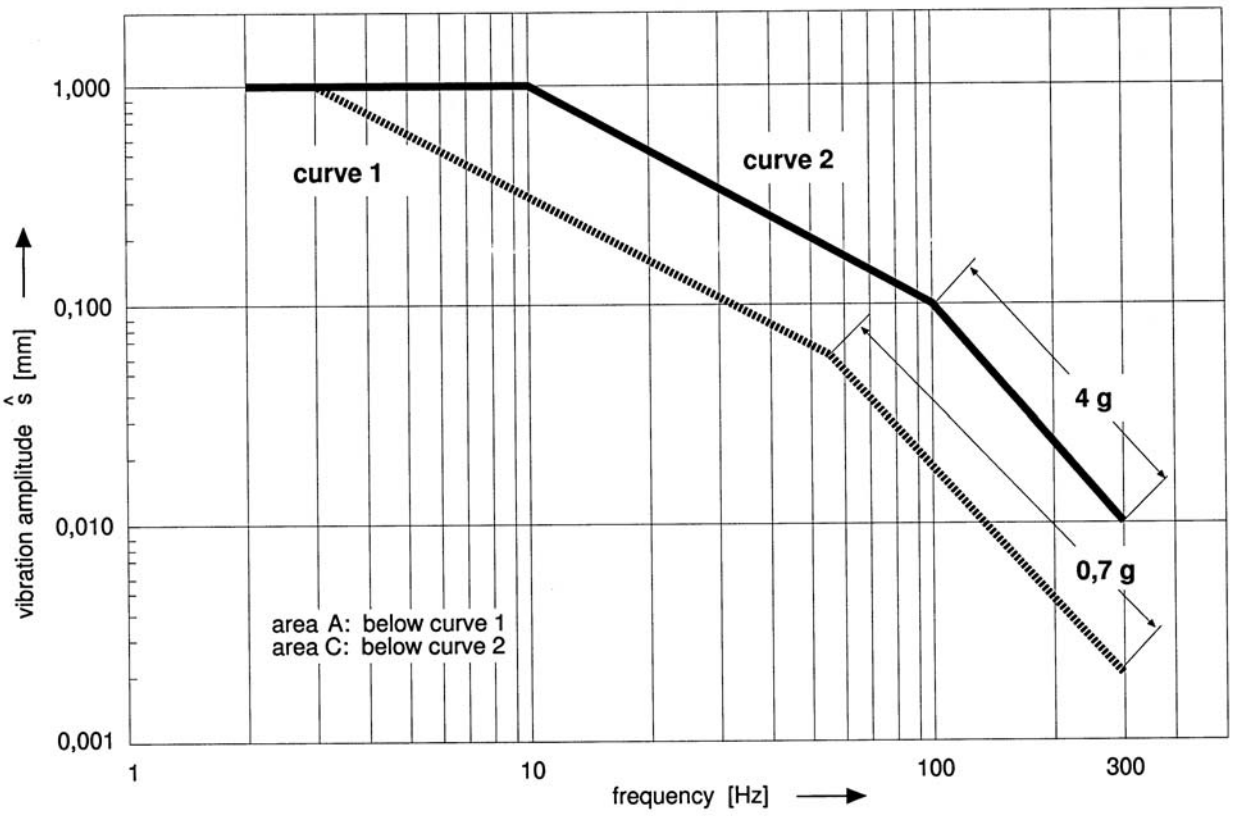


Fig. 1.1 Areas for the assessment of vibration loads

2.4 Proofs

2.4.1 A vibration test in accordance with TL Rules is deemed to constitute proof. The test (limit A respectively C) must conform to the operational requirements.

2.4.2 Other forms of proof (e.g. calculations) may be accepted upon agreement with TL.

2.5 Measurements

Where such measures are justified, TL reserves the right to demand that measurements be performed under operating or similar conditions. This applies both to proof of the vibration level and to the assessment of the self-generated exciter spectrum.

3. Environmental categories of products

Products are classified according to their environmental categories as shown in Table 1.4. Reference is made in the type approval certificates.

F. Operating Conditions

1. Voltage and frequency variations

1.1 For tolerances regarding voltages and frequencies on ships within NATO, or if stipulated in the building specification, the requirements of STANAG 1008 shall be observed.

1.2 For all other ships, the following requirements shall be observed:

1.2.1 All electrical equipment must be so designed that it works faultlessly during the voltage and frequency variations occurring in the normal operation. The variations indicated in Table 1.5 shall be used as a basis.

Table 1.4 Environmental conditions/environmental categories

Environmental Category	Environmental conditions						Comments
	Closed Area			Open Deck Area			
	Temperature	Relative humudity	Vibrations	Temperature	Relative humudity	Vibration	
A	0 °C to + 45 °C	to 100 %	0,7 g (curve 1)				For general applications, except category B, C, D, F, G, H.
B	0 °C to + 45 °C	to 100 %	4 g (curve 2)				For application at a higher level of vibration strain, e.g. in steering gear compartment
C	0 °C to + 55 °C	to 100 %	0,7 g (curve 1)				For application at a higher degree of heat, e.g. for equipment to be mounted in consoles, housings.
D	0 °C to + 55 °C	to 100 %	4 g (curve 2)				For application at a higher degree of heat and a higher level of vibrations strain, e.g. for equipment to be mounted on combustion engines and compressors.
E	0 °C to + 40 °C	to 80 %	0,7 g (curve 1)				For use in air-conditioned areas. With **TL**'s special consent only.
F				– 25 °C to + 45 °C	to 100 %	0,7 g (curve 1)	For application when additional influences of salt mist and temporary inundation are to be expected.
G				– 25 °C to + 45 °C	to 100 %	2,3 g	For use on masts, with the additional influence of salt mist.
H	In accordance with manufacturer's specifications						The provisions contained in the certificates shall be observed.

1.2.2 If, in direct-current systems supplied by storage batteries and static converters, the permissible limits are exceeded, the faultless function of all electrical devices must be ensured.

2. Mains quality

2.1 For ships within NATO, or if stipulated in the building specification, the mains quality of the electrical power supply must comply with the requirements of

2.2 STANAG 1008.

2.3 For all other ships, the following requirements shall be observed:

2.2.1 In systems without substantial static converter load and supplied by synchronous generators, the total voltage harmonic distortion shall not exceed 5%.

2.2.2 In systems fed by static converters, and systems in which the static converter load predominates, the limit values indicated in Fig. 1.2 apply for single harmonics as continuous values. The total harmonic distortion shall not exceed 8 %.

Table 1.5 Voltage- and frequency variations

	Parameter	Variations	
		continuous	transient
General	Frequency Voltage	±5% +6%-10 %	±10% (5 s) ±20% (1,5 s)
Storage batteries and static converters	Voltage	± 20 % **(1)**	
(1) *See 1.2.*			

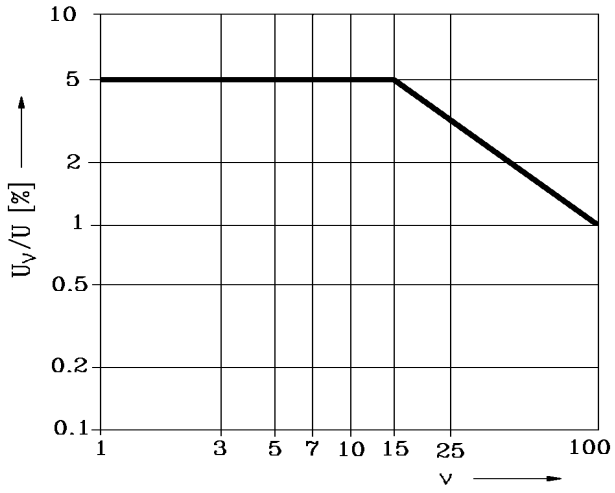


Fig. 1.2 Limit values for the single harmonics in the supply voltage. U_v is the RMS value of the v-th order harmonic voltage

2.2.3 If in particular cases (e.g. electrical propulsion plant systems) the above-mentioned limits are exceeded, the faultless function of all electrical devices must be secured.

G. Power Supply Systems

1. Low-Voltage Systems

1.1 General requirements

For the operation of electrical installations, the voltage systems mentioned below are recommended.

All main networks and sub-networks shall have all-pole insulation, without system earthing. Control circuits and other locally bounded circuits are excepted from this requirement. The maximum permissible rated mains voltages are given in Table 1.6.

1.2 Main networks (primary networks)

1.2.1 Three-phase systems (AC)

Rated generator voltage:	450 V line-to-line
Rated consumer voltage:	440 V line-to-line
Number of phases:	3
Number of conductors:	3
Rated frequency:	60 Hz

1.2.2 Direct-current systems (DC)

Rated generator voltage:	225 V
Rated consumer voltage:	220 V
Number of conductors:	2

1.3 Sub-networks (secondary networks)

Alternating current	(AC)
Rated output voltage:	120 V, 240 V, 450 V
Rated consumer voltage:	115 V, 230 V, 440 V
Number of phases:	2
Number of conductors:	2
Rated frequency:	60 Hz or 400 Hz

2. Medium-voltage systems

See Section 8.

H. Visual and Acoustical Signalling Devices

1. The colours used for visual signalling devices shall conform to Table 1.7.

2. The use of monochrome screens is permissible, provided that clear recognition of the signals is guaranteed.

3. Reference is made to **IMO** Resolution A.830 (19) "Code on Alarms and Indicators", 1995.

Table 1.6 Maximum permitted rated mains voltages

17 500 V	For permanently installed power plants
500 V	**a)** For permanently installed power and control circuits; **b)** For devices with plug-and-socket connections which are earthed either via their mounting or through a protective earth conductor; **c)** The power supply to systems requiring special electric shock-prevention measures, shall be provided via earth-leakage circuit breaker ≤ 30 mA (not applicable to essential equipment).
250 V	**a)** For installations and devices, as laid down in items a) to c) for 500 V, see above; **b)** For permanently installed lighting systems, **c)** For permanently installed control, monitoring and ships safety systems; **d)** For devices supplied via plug-and-socket and requiring special electric shock-prevention measures, the power supply is to take place via a protective isolating transformer, or the device must be double-insulated.
50 V Safety voltage	For portable devices for working in confined spaces where special electric shock-prevention measures are required

I. Materials and Insulation

1. General Requirements

1.1 The materials used for electrical machines, switchgear and other equipment must be resistant to sea air containing moisture and salt, seawater and oil vapours. They shall not be hygroscopic, and must be flame-retardant and self-extinguishing.

1.2 The evidence of flame-retardation must be according to IEC publication 60092-101 or other equivalent standards.

1.3 The usage of halogen-free materials is recommended. Insulation materials and sheath materials for permanently installed cables and switchboard conductors shall be halogen-free; see Section 12.

Cable ducts and covers for contact protection in switchgear installations shall be made of halogen-free material; see Section 5.

1.4 Units of standard industrial type may be used in areas not liable to be affected by salty sea air, subject to appropriate proof of suitability.

1.5 Materials with a high tracking resistance shall be used as supports for live parts.

2. Air and Creep Age Distances

2.1 The air and creepage distances for essential equipment shall be dimensioned as appropriate in accordance with IEC publication 60664-1 on the basis of the following values for

- Rating operating voltage U_e
- Overvoltage category III
- Fouling grade 3
- Insulation material group IIIa.

Table 1.7 Colour code for signalling devices

Colour	Meaning	Explanation
Red	Danger or alarm	Warning of danger or a situation which requires immediate action
Yellow	Caution	Change or impending change of conditions
Green	Safety (normal operating and normal working conditions)	Indication of a safe situation
Blue	Instruction / information (specific meaning assigned according to the need in the case considered (e.g. operational readiness))	Blue may be given meaning which is not covered by the three above colours: red, yellow and green
White	No specific meaning assigned (neutral)	General information, e.g. for confirmation

2.2 Smaller clearances and creepage distances may be accepted, provided a reduced level of contamination is proved (degree of protection).

2.3 For the air and creepage distances of main busbars in power station switchboards, main groups, and emergency and propulsion switchboards, see Section 5.

J. Protective Measures

1. Protection Against Foreign Bodies and Water

1.1 The protection of electrical equipment against foreign bodies and water must be appropriate to the particular place of installation. The minimum degrees of protection for low-voltage switchgear are listed in Table 1.5. The degree of protection of the equipment in its installed state must also be ensured during operation. Covers fitted at the place of installation are also regarded as a means of protection.

1.2 Exceptions to the provisions

The exceptions **t**o the provisions are summarised in Table 1.8.

1.2.1 At such installation places where temporary flooding has to be assumed for an undamaged ship (e.g. drain wells), the minimum degree of protection required for all electrical equipment is IP 56.

1.2.2 Flood pump motors shall always be constructed with the degree of protection IP 67.

1.2.3 For medium-voltage equipment, see Section 8.

1.2.4 The minimum degree of protection for the terminal boxes of machines in wet operating spaces is IP 44.

1.3 If water-spray systems are used as fire-extinguishing systems, the degree of protection of electrical equipment shall be given due consideration.

2. Protection Against Electric Shock

2.1 Protection against direct contact

Protection against direct contact comprises all the measures taken to protect persons against the dangers arising from contact with the live parts of electrical facilities. Live parts are conductors and conductive parts of facilities which in normal operating condition are under voltage.

2.1.1 Electrical facilities must be so designed that, when they are used properly, persons cannot touch or come dangerously close to live parts. For exceptions, see 2.1.2 and 2.1.3.

2.1.2 In locked electrical service spaces, protection against direct contact is already maintained by the mode of installation. Insulated handrails are to be fitted near live parts.

Table 1.8 Minimum degrees of protection against foreign bodies and water (as per IEC 529)

Equipment / Location	Generators, motors, transformers	Switchgear, Electronic equipment and recording devices	Communications equipment, display and input units, signaling equipment, switches, power sockets, junction boxes and control elements	Heating appliances heaters and cooking equipment	Lighting fittings
Locked dry electrical service rooms	IP 00	IP 00	IP20	IP20	IP20
Dry spaces, service rooms dry control rooms, accommodation	IP20	IP20	IP20	IP20	IP20
Wheelhouse, radio room, control stations	IP22	IP22	IP22	IP22	IP22
Wet spaces (e.g. machinery spaces, bow thruster room), ventilation ducts (internal), pantries, provision rooms, store rooms	IP22	IP22	IP44 **(1)**	IP22	IP22
Machinery spaces below floor (bilge), separator and pump rooms, refrigerated rooms, galleys, laundries, bathrooms and shower rooms	IP44	IP44	IP55 **(1)**	IP44	IP34
Pipe tunnels, ventilation trunks (to open deck), cargo holds	IP55	IP55	IP55 **(1)**	IP55	IP55
Zones hazardous by explosives	IP55	-	IP55 **(1) (2)**	-	IP55
Zones with explosion hazard	See J.3.				
Open decks	IP56	IP56	IP56	IP56	IP55

Notes:

(1) *Degree of protection for the measuring chamber of smoke detectors IP 42*

(2) *Degrees of protection for the equipment in intrinsically safe circuits (Ex)i : IP 22*

2.1.3 In systems using safety extra-low voltage, protection against direct contact may be dispensed with.

2.2 Protection against indirect contact

Electrical facilities must be constructed in such a way that persons are protected against dangerous contact voltages in the event of an insulation failure. For this purpose, the construction of the facilities must incorporate one of the following protective measures:

2.2.1 Protective earthing, see 2.3.

2.2.2 Protective insulation (double insulation)

2.2.3 Electrical facilities operated at very low voltages causing no danger, even in case of a fault

2.2.4 In cases where special precautions against electric shock become necessary (e.g. test switch boards), additional usage of residual current protective devices ≤ 30 mA (but not for essential equipment).

2.3 Protective earthing

2.3.1 Touchable conductive parts of equipment which are normally not live, but which may present a dangerous contact voltage in the event of a fault, shall be connected (earthed) to the ship's hull. Where such earthing is not effective by fastening or mounting, protective earthing conductors are to be used. For the earthing of cable shielding, armouring and braids, see Section 12.

2.3.2 The earth and protective earthing conductor on ships with a metallic hull shall be the welded hull itself.

2.3.3 All connections to protective earthing conductors and earth shall be made with care via clean contact surfaces so that they are electrically conductive and vibration-proof, and must be located at points where they are accessible and can easily be checked.

Connections of protective earthing conductors shall be protected against corrosion.

2.3.4 The protective conductors and earthing conductors must be made of copper. Where strips of stainless steel are prescribed for reasons of electro magnetic compatibility (EMC), the separated protective conductor can be dispensed with, provided that the stainless steel strips are of equivalent construction and dimensions.

2.3.5 For the helicopter earthing rod, an earthing possibility must be provided on the open deck.

The connection facility for the earthing rod must be easily accessible and located within the landing circle, or within a radius of 5 m from the point where persons or goods are transferred to or from the helicopter. It must be so constructed that a reliable and highly conductive connection to the earthing point is ensured. It must be possible to connect and disconnect the earthing rod without tools.

In the event of high tensile forces, the connection must be released without any damage to the earthing facility.

2.4 Protective earthing conductors

2.4.1 General requirements

The following points must be noted with regard to the use of earthing conductors:

2.4.1.1 An additional cable or an additional wire with a green/yellow coded core must be provided as an earthing conductor, or the connection cable must contain a green/yellow coded core. Cable braids and armouring shall not be used as earthing conductors.

2.4.1.2 A conductor normally carrying current shall not be used simultaneously as an earthing conductor, nor may it be connected with the latter to the ship's hull. The green/yellow coded core shall not be used as a current-carrying conductor.

2.4.1.3 If electrical equipment is mounted in an insulated manner (e.g. on rubber-metal vibration dampers, dished washers), then they shall be earthed by flexible cables, wires or stranded copper straps of adequate length and cross-section.

2.4.1.4 The cross-section of the earthing conductor shall at least conform to the values indicated in Table 1.9.

2.4.1.5 Steel structures and aluminium structures installed on insulated mountings must be connected to the ship's hull by special conductors at several points. The connections must have a high electrical conductivity and shall be corrosion-resistant. The minimum cross-section is 50 mm^2 per conductor.

2.5 Additional measures for protective earthing on ships with hulls of non-conductive materials

2.5.1 On these ships, a common protective earthing system shall be provided for all voltage systems. It must be connected to the earthing terminal by at least two contact points. Lighting protection electrodes must be routed separately.

On ships with a non-metallic hull, an earthing plate fastened near the keel and on the outer shell in the ship's longitudinal direction shall be used as the earth electrode.

2.5.2 As a material for this earthing plate, the alloy CuSn8F45 is recommended, with a thickness of 3 mm.

Its dimensions should not be less than the following minimum values:

Area 5 m^2
Width 250 mm

2.5.3 Along the whole length of the earthing plate, at spacings of about 2 m, slits with a width of 3 mm and a length of 130 mm shall be provided on the side facing away from the keel.

Note
Reduction of eddy currents is to be expected by these measures.

2.5.4 If structures such as foundations, frames, bulkheads, girders, walls etc. on these ships are electrically conductive, they must be so connected with each other and with the earthing electrode that no dangerous difference in potential can arise between the above-mentioned structural components.

3. Explosion Protection

Hazardous areas and areas potentially endangered by explosive material shall be marked as such at their access points.

Table 1.9 Cross-sections for earthing conductors

<table>
<tr><th rowspan="2">Cross-section of outer conductor
[mm^2]</th><th colspan="3">Minimum cross-section of earthing conductor</th></tr>
<tr><th>in insulated cables
[mm^2]</th><th>separately laid
[mm^2]</th><th>flexible cables and wires
[mm^2]</th></tr>
<tr><td>0,5 to 4</td><td>equal to cross-section of outer conductor</td><td>equal to cross-section of outer conductor but not less than 1.5 for stranded and 4 for solid earth conductor</td><td rowspan="2">equal to cross-section of outer conductor</td></tr>
<tr><td>>4 to 16</td><td>equal to cross-section of outer conductor</td><td rowspan="3">equal to half the cross-section of outer conductor but not less than 4</td></tr>
<tr><td>>16 to 35</td><td>16</td><td rowspan="2">equal to cross-section of outer conductor but not less than 16</td></tr>
<tr><td>>35 to < 120</td><td>equal to half the cross-section of outer conductor</td></tr>
<tr><td>≥ 120</td><td>70</td><td>70</td><td></td></tr>
</table>

3.1 Hazardous areas

In hazardous areas, only the electrical equipment necessary for operation should be installed.

3.1.1 Hazardous areas, Zone 0

3.1.1.1 These areas include for instance the insides of tanks and piping containing a combustible liquid with a flash point ≤ 60 °C, or inflammable gases.

3.1.1.2 For electrical installations in these areas, the only permissible equipment that may be fitted is:

- Intrinsically safe circuits Ex ia
- Equipment specially approved for use in this zone by a recognized test organization

3.1.2 Hazardous areas, Zone 1

3.1.2.1 These areas include e.g.:

- Paint rooms
- Storage battery rooms (see Section 2)
- Areas with machinery, tanks or piping for fuels with a flash point below 60 °C, or inflammable gases
- Ventilation trunks

3.1.2.2 Areas subject to explosion hazard also include tanks, vessels, heaters, pipelines etc. for liquids or fuels with a flash point over 60 °C, if these liquids are heated to a temperature higher than 10 °C below their flash point.

3.1.2.3 Electrical equipment shall not be installed or operated in areas subject to explosion hazard, with the exception of explosion-protected equipment of a type suitable for shipboard use. Items of electrical equipment are deemed to be explosion-protected if they are manufactured to a recognized standard, such as IEC 60079 publication or EN 50014 - 50020, and if they have been tested and approved by a recognized testing authority. Any notes and restrictions mentioned on the approval certificates must be observed.

The following types of explosion-protected equipment are permissible:

- intrinsic safety Ex i
- flameproof enclosure Ex d
- pressurized Ex p
- increased safety Ex e
- special type of protection Exs
- oil immersion Ex o
- encapsulation Ex m
- sand-filled Ex q

3.1.2.4 Cables in hazardous areas Zone 0 and 1

- must be armoured or screened

or

- run inside a metal tube.

3.1.3 Extended hazardous areas, Zone 2

3.1.3.1 These areas include e.g.:

- Areas directly adjoining Zone 1 lacking gastight separation from one another
- Closed helicopter hangars and closed stowage places for other vehicles containing fuel in their tanks with a flash point < 60 °C

3.1.3.2 For equipment in these areas, protective measures shall be taken which, depending on the type and purpose of the facility, could comprise e.g.:

- Use of explosion-protected facilities in accordance with 3.1.1.2 and 3.1.2.3

or

- Use of facilities with type Ex n protection

or

- Use of facilities which in operation do not cause any sparks, and the surfaces of which that are accessible to the open air do not attain any unacceptable temperatures

or

- Facilities which are overpressure-encapsulated in a simplified way or are fumetight-encapsulated (minimum protection type IP 55) and whose surfaces do not attain any unacceptable temperatures

- Cables shall be so laid, that they are protected.

3.2 Electrical equipment in paint rooms and other spaces with a similar hazard potential

3.2.1 In these rooms (Zone 1) and in ventilation ducts supplying and exhausting these areas, electrical equipment must be of a certified safe type and comply at least with IIB, T3. Switches, protective devices and motor switchgear for electrical equipment in these areas must be of the all-pole switching type and shall preferably be fitted in the safe area.

3.2.2 On the open deck within a radius of 1 m (Zone 2) around natural ventilation openings (inlets and outlets) or within a radius of 3 m around forced-ventilation outlets (Zone 2), the requirements of 3.1.3 must be fulfilled. Care must be taken to avoid exceeding temperature class T 3 or 200 °C.

3.2.3 Enclosed areas with access to paint rooms may be counted as safe areas under the following conditions; if

- The access door to the room is watertight and fitted with self-closing devices and without arresting devices

- The area is ventilated from a safe area by an independent natural ventilation system

- Warning labels are fixed to the outside of the access door, drawing attention to the combustible liquids in this room.

3.3 Pipe tunnels

All equipment and devices in pipe tunnels containing fuel lines or adjoining fuel tanks must be permanently installed, irrespective of the flash point of the fuels. Where pipe tunnels directly adjoin tanks containing combustible liquids with a flash point below 60 °C, or where pipes inside these tunnels convey combustible liquids with a flash point below 60 °C, all the equipment and devices must be certified as being explosion-protected in accordance with 3.1.2 (zone 1).

3.4 Areas potentially endangered by explosive materials

3.4.1 General requirements

In areas potentially endangered by explosive materials, only the electrical equipment necessary for operation should be installed.

Both normal and explosion-protected electrical equipment can be used when the surface temperature cannot exceed 120 °C, irrespective of the ambient temperature.

3.4.2 Degree of protection

The degree of protection for electrical equipment must not be less than IP 55. In intrinsically safe circuits of the type Ex i, equipment can have the degree of protection IP 22.

3.4.3 Scope of electrical equipment

- Lamps with protective basket or impact-resistant cover

- Switches and socket outlets shall only be installed outside the rooms. It must be possible to protect switches against accidental actuation when in the "off" position

- Branching boxes or distributing boxes as well as electric motors (e.g. for flood pumps, fans, ammunition transport and conveyor facilities)

- Other electrical equipment, if absolutely necessary for operation

3.4.4 Cable installation

Only cables belonging to the equipment installed in these rooms should be installed there. All single cables and cable trays shall be protected suitably where they

are exposed to the danger of mechanical damage.

Cables passing through the room are only permissible with special approval.

3.5 Protective measures in the case of ignitable dust

Only lighting fixtures with IP 55 protection, as a minimum requirement, may be used in areas where ignitable dust may be deposited.

In continuous service, the surface temperature of horizontal surfaces and surfaces inclined up to 60° to the horizontal must be at least 75 K below the glow temperature of a 5 mm thick layer of the dust.

3.6 Explosion protection for ships for the carriage of motor vehicles

Regarding hazardous areas and approved electrical equipment on ships for the carriage of motor vehicles, see Section 16.

4. Lightning Protection

4.1 General requirements

All conductive parts located on deck (masts, superstructures etc.) shall be regarded as air-termination and lightning-discharge arrangements, and must be suitably connected with each other and with the earth electrode.

Reference is made to IEC publication 60092-401.

4.2 Hull and mast of metal

If the hull and mast are electrically connected, the construction of a special lightning protection system is not required. In such a case all masts, superstructures, antennas etc. must be regarded as air terminations. This includes stay cables leading from the mast to the deck, if they are not interrupted by isolators for EMC reasons.

4.3 Hull of non-conductive material, mast and superstructures of conductive material

In this case the conductive mast and superstructures serve as air-terminal and lightning-discharge arrangements.

If the mast passes right through the ship to the keel, or if it is connected to its support in an electrically conductive manner, then it must be connected to the earthing plate by the shortest possible route.

5. Electromagnetic compatibility (EMC)

5.1 Electrical and electronic equipment must not be impaired in its function by electromagnetic energy. General measures shall include with equal importance:

5.1.1 Decoupling of the transmission path between the source of interference and equipment prone to interference

5.1.2 Reduction of the causes of interference sources

5.1.3 Reduction of the susceptibility to interference

5.2 IEC

Publications 60533 and 60945 shall be observed for the bridge and the deck zone.

5.3 A reference for the required immunity to interference is provided by appliances and equipment components which have undergone a test to verify their immunity to electromagnetic interference in accordance with the TL Rules - Guidelines for the Performance of Type Approvals, - Test Requirements for Electrical/Electronic Equipment and Systems.

5.4 Further requirements, which in particular can result from the weapon and fire control systems, are to be stipulated in the building specification.

SECTION 2

INSTALLATION OF ELECTRICAL EQUIPMENT

A. Generating Sets and Power Stations

1. Power stations

1.1 Unless specified otherwise in the building specification, power stations shall be arranged below the main deck.

1.2 The generating sets shall be grouped into at least two power stations.

If generating plants with only three generating sets are used, they must also be grouped into at least two power stations.

1.3 The power stations shall be separated from each other as far as possible.

1.4 If, in addition to separation in different spaces, further measures are taken to increase the combat survivability, e.g. strengthened bulkheads, smaller distances between the power stations may be approved.

1.5 Depending on the requirements concerning combat survivability, it is possible that in exceptional cases only one power station in conjunction with an emergency source of electrical power may be approved, see Section 1, B.1.6.

1.6 If a spatial separation of the generating sets and power stations is not feasible for reasons of insufficient space, one generator and one power station may be located in the same watertight compartment.

2. Emergency generators

If an emergency generator, see Section 1, B.1.6, becomes necessary in accordance with 1.5. the installation must comply with the following requirements.

2.1 Emergency generators and their prime movers must be installed above the uppermost continuous deck and behind the collision bulkhead. Exceptions require TL approval. The location in which the emergency generator is installed must be accessible from the open deck; it must be so located that a fire or another incident

- in rooms containing power stations, or in a machinery space category A
- will not impair the operating ability of the emergency source of electrical power, see also E.2.

2.2 As far as is practicable, the room containing the emergency source of electrical power, the associated transformers, converters and the emergency switchboard must not adjoin the boundaries of machinery spaces or of those spaces which contain the main source of electrical power, the associated transformers, converters or the main switchboard.

2.3 Depending on the construction of the ship, e.g. small vessels, other installations may be accepted with special approval by TL.

B. Storage Batteries

1. Installation

1.1 Storage batteries shall be installed in such a way that persons cannot be endangered and equipment cannot be damaged by escaping gases or electrolyte leakage.

The following requirements apply to storage batteries with a charging capacity > 0,2 kW.

1.2 Storage batteries shall be so installed as to ensure accessibility for the changing of cells, inspection, testing and, if necessary, for topping-up and cleaning. Storage batteries shall not be installed in the accommodation area or in stores. An exception may be granted for gastight cells, such as those used in emergency lamps, where charging does not result in the development of harmful gases.

1.3 Storage batteries shall not be installed in positions where they are exposed to excessively high or low temperatures, water spray or other factors liable to impair their serviceability or shorten their service life. The minimum degree of protection required is IP 12.

1.4 Battery charging

1.4.1 When installing storage batteries, attention shall be paid to the capacity of the associated chargers. The charging power shall be calculated as the product of the maximum charger current and the rated voltage of the storage battery. Depending on the operating mode, application and duty of the storage battery to be charged, and on the mode of the charging (charger characteristic), and by agreement with Türk Loydu, the calculation of the charging capacity need not be based on the maximum current. Where a number of storage batteries are installed together, the total sum of the charging power shall be taken into account.

1.4.2 Storage batteries with a charging capacity of up to 2 kW may be installed unenclosed below deck in a well ventilated battery cabinet or container. The air must be ventilated to the open deck or to a room with at least 2,5 times the free volume of the air quantity calculated in 3.5 and 3.6. The unenclosed installation of storage batteries in well ventilated positions in machinery spaces is permitted.

1.4.3 Storage batteries with a charging capacity of more than 2 kW installed below deck shall be accommodated in an enclosed cabinet/container or room with a means of ventilation to the open deck, see also 3.4.

1.5 Storage batteries must be prevented from sliding. The constraints shall not hinder ventilation.

2. Battery-room Equipment

2.1 Only explosion-protected lamps, switches, fan motors and space-heating appliances shall be installed in battery rooms. The following minimum requirements shall be observed:

- Explosion group II C
- Temperature class T 1

Other electrical equipment is permitted only with special approval.

2.2 Where leakage is possible, the inner walls of battery rooms, boxes and cabinets, including all sup ports, troughs, containers and racks, must be protected against the harmful effects of the electrolyte.

3. Ventilation

3.1 All battery rooms, cabinets and boxes must be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

3.2 Ventilation inlet and outlet openings shall be so arranged as to ensure that fresh air flows over the surface of the storage battery.

3.3 Devices which obstruct the free passage of air, e.g. flame arresters and safety screens, shall not be mounted in the ventilation inlet and outlet ducts of battery rooms.

3.4 Where storage batteries are operated only in parallel or switch-over operation with the network, battery-rooms, containers and cabinets may be naturally ventilated, provided that the charging power does not exceed

- 3 kW for lead-acid storage batteries, or
- 2 kW for nickel-cadmium storage batteries

even under boost-charging conditions. If this charging power is exceeded, forced ventilation shall be provided.

3.5 The quantity of air to be removed shall be at least

$$Q = 0{,}11 \cdot I \cdot n$$

where:

Q quantity of air removed in m^3/h

I the current according to the charger characteristic, but at least 1/4 of the maximum charger current or of the charging current reduced in accordance with 1.4

n number of battery cells.

3.6 If only batteries with sealed cells and internal

oxygen consumption are used, the exhaust quantity of air may be reduced to:

$$Q = 0{,}03 \cdot I \cdot n$$

3.7 With natural ventilation, the requirements of 3.5 are fulfilled if the design of the ducts conforms to Table 2.1, assuming an air speed of 0,5 m/s.

The inclination of air ducts shall not exceed 45° from the vertical.

Table 2.1 Cross sections of ventilation ducts

Charging power P [W]	Ventilation duct cross sections [cm^2]	
	lead-acid batteries	nickel-cadmium batteries
P < 1000	80	120
1000 ≤P <1500	120	180
1500≤P<2000	160	240
2000 ≤ P < 3000	240	forced ventilation
P > 3000	forced ventilation	

3.8 For forced ventilation, extraction fans shall be used wherever possible. The fan motors must be either explosion-proof (see 2.1) and resistant to electrolyte or, preferably, located outside of the endangered area. The fan impellers must be made of a material which does not create sparks on contact with the housing, and which dissipates static charges. The ventilation systems must be independent of the ventilation systems serving other rooms.

3.9 Where storage batteries are charged automatically, with automatic start of the fan at the beginning of the charging, arrangements must be made for the ventilation to continue for at least 1 h after completion of charging.

4. Emergency Power Supply

The location in which storage batteries for the emergency power supply are installed must fulfil the same conditions as required for the installation of the emergency generator, see Section 1, B.1.6.

5. Batteries for starting of internal combustion engines

5.1 Batteries for the starting of internal combustion engines shall be installed near the engine.

5.2 For the rating of the batteries, see Chapter 107 -Ship Operation Installations and Auxiliary Systems, Section 6.

6. Caution Labels

The doors or the covers of battery rooms, cabinets or boxes must be fitted with caution labels prohibiting the exposure of open flames and smoking in, or close to, these spaces.

C. Power Transformers and Converters

1. Transformers and converters shall be installed at readily accessible and adequately ventilated places.

2. The location in which transformers and converters for the main electrical power supply are installed must satisfy the same conditions as those applying to the installation of the power stations, or these transformers and converters must be located in the watertight compartments which they supply.

3. The location of transformers and converters for the emergency electrical power supply must fulfill the same conditions as those applying to the installation of the emergency generators.

4. The location of centrally arranged converters for the sub-networks must fulfill the same conditions as those applying to the installation of the power stations.

5. For medium-voltage transformers, see F.

D. Electronics

1. Power electronics equipment and central units for information processing shall be installed in readily accessible and adequately ventilated spaces.

2. The heat generated in the unit shall be removed in a suitable manner. Where electronic equipment is installed in engine rooms or other spaces with enhanced danger of pollution, air filters shall be provided if necessary.

E. Low Voltage Switchboards

Low voltage switchboards are designed for less or equal 1000 V AC or for 1500 V DC.

1. Power Station Switchboards

1.1 The installation shall be performed with due consideration of the requirements concerning the necessary combat survivability, see also A.1.

1.2 The power station switchboards (separately for each power station) should preferably be installed in a special switchboard compartment.

1.3 If installed on the floor above the bilge, the power station switchboards must be completely closed from below.

1.4 Pipework and air ducts shall be arranged so that the switchgear is not endangered in the event of leaks. If the installation of these pipes and ducts close to the switchboard is unavoidable, the pipes shall not have any flanged or screwed connections in this area.

1.5 The heat generated in the switchgear shall be removed, see also Section 5, C.2.

1.6 The control passageway in front of the power station switchboard must be at least 0,9 m wide. An ample view must be provided for the operation of the board. Where free-standing panels are required to be accessible from behind for operation and maintenance, a passageway at least 0,6 m wide shall be provided. The width may be reduced to 0,5 m at the positions of reinforcements and frames.

1.7 The floor in front of, and where necessary behind, power station switchboards with an operating voltage of more than 50 V must be provided with an insulating covering, or insulating gratings or mats shall be in place.

1.8 The operational space behind open switchboards shall be constructed as a separate electrical service room. A label to this effect shall be fitted.

2. Emergency Switchboards

2.1 The emergency switchboard, see Section 1, B.1.6, must be installed close to the emergency generator and/or the emergency battery. The requirements set out in B. shall be observed. The place of installation must satisfy the same conditions as those applying to the installation of the emergency generator.

2.2 The installation of the emergency switchboard is subject to the same conditions as those stated in 1.4 to 1.8 for the power station switchboards.

3. Main Groups

The requirements for power station switchboards also apply to main groups.

4. Groups and Subgroups

4.1 The arrangement of switchboard installations on the open deck is only permissible for switchgear that is absolutely necessary for local operation.

4.2 Cubicles and niches housing switchboards must be made of incombustible material or be protected by a lining of metal or some other fireproof material.

The doors of cubicles and niches must be provided with a name plate identifying the switchgear inside. Adequate ventilation shall be ensured.

F. Appliances for Medium Voltage

Appliances for medium voltage are designed for the range greater 1 kV to 17,5 kV AC.

1. Installation

1.1 The degrees of protection stated in Section 8, Table 8.3 are to be adhered.

1.2 Equipment should preferably be installed in enclosed electrical service rooms.

1.3 If the safety of persons cannot be ensured during operation, the access doors shall be locked in such a way that they can only be opened after isolation and earthing of the supply circuits.

2. Access Doors to Service Rooms

The access doors to spaces in which medium-voltage equipment is installed must be provided with caution labels in accordance with 6.

3. Switchgear

3.1 Pressure release

3.1.1 If the gas pressure resulting from accidental arcs within the switchboard is to be vented via pressure-release flaps, the installation space shall be as specified by the switchgear manufacturer and shall have an adequate volume. Suitable measures shall be taken to ensure that the overpressure occurring within the space is limited to physiologically acceptable limits. The overpressure shall be taken into account for the structural design of the room. It is recommended to lead the accidental-arc gases out of the place of operation by ducts of sufficient cross section.

3.1.2 If the switchboard is designed so that the gas pressure caused by accidental arcs is also, or only, released downwards, the floor shall be constructed so that it can withstand this pressure. Care must be taken to ensure that sufficient space is available below the floor for the expansion of the accidental-arc gases. Combustible materials and low-voltage cables are not admissible in the endangered area.

3.2 SF6 Switchgear

3.2.1 SF6 switchgear shall only be installed in spaces which are adequately ventilated. It shall be ensured that SF6 is prevented from flowing down to lower spaces.

Note:
It must be taken into consideration that the gases escaping in the case of accidental arcing have toxic and corrosive effects.

3.2.2 The SF6 cylinders shall be stored in a separate space with its own venting arrangements. Measures shall be taken to ensure that, in the event of leakage, no gas can flow unnoticed into any lower spaces.

3.3 Insulation of standing areas

3.3.1 For areas in front of switchboards, adequate insulation shall be provided.

3.3.2 This insulation shall be effected by an approved insulating mat.

Note
An insulation mat with a thickness of 2,5 mm can be considered as sufficient.

3.3.3 It shall be impossible to touch the front of the switchboard or other places of operation from outside of this insulating mat.

4. Liquid-Cooled Transformers

4.1 Liquid-cooled transformers shall be provided with a collecting arrangement which permits the proper disposal of the liquid.

4.2 A fire detector and a suitable fire extinguishing system shall be installed in the vicinity of the transformer. If a water spray system is provided as fire extinguishing system, it must be ensured that the transformer is switched off before the water spray system is activated, or that the transformer is designed with the corresponding degree of protection.

5. Safety Equipment

At least the following safety equipment must be provided for medium-voltage facilities:

- a voltage detector suitable for the rated voltage of the equipment
- a sufficient number of earthing cables, together with insulated fitting tools
- an insulating floor cover (mat for repair/ maintenance)
- a sufficient number of warning labels bearing the words "Do not operate switch"

6. Marking

All parts of medium-voltage installations, including the cables and cable trays, shall be fitted with permanent warning labels drawing attention to the voltage level and the danger.

SECTION 3

POWER SUPPLY INSTALLATIONS

A. Electrical Power Demand

1. General requirements

1.1 A power balance for the main, emergency and uninterruptible sources of electrical power has to be submitted to prove the sufficient ratings of units for the generating, storage and transformation of electrical energy for principal- and sub-networks.

1.2 Extreme environmental conditions relevant to the ship's area of operation, e.g. arctic or tropical conditions, shall also be taken into account.

1.3 In compiling the power balance, all installed electrical consumers must be tabulated together with an indication of their power inputs.

1.4 For the various operating conditions, attention shall be given to the following:

1.4.1 The full power input of all consumers continuously required for operation, except for those consumers which remain on standby and are used only when a similar consumer fails.

1.4.2 The power input of all consumers used temporarily, multiplied by a diversity factor.

The consumers mentioned in 1.4.3 are excluded.

The diversity factor shall be applied only once during the calculation.

1.4.3 The full power input of consumers with a high power consumption relative to the main power supply, e.g. lateral thrusters.

1.4.4 Short-term peak loads caused, for example, by the automatic starting of large motors. For this, proof of reserve power is required.

2. Electrical power balance

The power demand must be determined for the following operating conditions:

- Combat (action stations)
- Wartime cruising peacetime
- Cruising peacetime in-port
- Readiness

2.1 Combat

In this propulsion mode, all ship stations are in full combat readiness. The power required in this condition serves to determine the generator output, unless a higher power is demanded by the result of a special power balance.

2.2 Wartime cruising

This is a continuous propulsion mode with increased combat readiness, permitting a direct transition to 'action stations'. The power balance for this condition should permit a statement on the maximum power demand, inter alia, dependent on the aspects of economical operation and NBC measures.

2.3 Peacetime cruising

In this connection, the personnel- and material-related combat readiness of a ship is limited to the requirements of participating in ocean shipping. This is the propulsion mode with the lowest power demand.

2.4 Peacetime in-port readiness

This readiness condition means that the ship is tied up at the pier and gets its electrical power from the shore. The shore connection arrangements must be designed for the power demand determined for this condition.

B. Main Electrical Power Supply

1. Availability of the main source of electrical power

1.1 Where the main source of electrical power is necessary for propulsion and steering of the ship and for its primary duty, the system shall be so arranged that the supply of the primary essential equipment will be maintained or immediately restored in the case of power loss of any one of the generators in service.

1.2 To meet the demand defined in 1.1, at least the following measures are required:

1.2.1 Automatic load shedding of the non-essential and, where necessary, secondary essential equipment to protect the generators against overload.

1.2.2 Load-dependent automatic connection and disconnection of generator units, power management system, see Chapter 106 - Automation, Section 8, A.

The generator units shall be capable of reciprocal operation. The output of each generator unit shall be so rated as to ensure automatic start-up of the primary essential equipment. Where necessary, equipment may be switched on in staggered formation.

1.2.3 The automatic starting and connecting of a generator and the primary essential equipment after black-out shall follow as quickly as possible, but within not more than 30 seconds. Where diesel engines with longer starting times are used, the starting and connecting times may be exceeded with special approval.

1.2.4 Where several generator units are required to provide the ship's power supply in permanent parallel operation, the failure of already one of the units shall cause the immediate trip of non-essential equipment and, if necessary, the secondary essential equipment, where this is the only way to ensure that the remaining units can supply the primary essential equipment.

1.2.5 When the output of a power station fails, the main groups must automatically be changed over to the remaining power station, see also Section 4, I.4.4.

2. Supply of the various networks

2.1 Supply of principal networks

2.1.1 The size and number of generators must be matched to the system management in the various operating conditions.

2.1.2 As the generating power for the principal network, double the capacity calculated for the "action stations" condition (without NBC measures) shall be installed, i.e. a power reserve of 100 %.

The total capacity shall be provided by at least two independent generators for each power station.

2.1.3 If requested in the building specification, other configurations may also be permissible, e.g. generating plants with three generators. In this case, at least *Wi* times the highest power demand determined by the electrical power balance (including ABC measures) shall be installed as the generator power, i.e. a power reserve of at least 50 %.

The power reserve must be adequate for the supply of primary essential equipment, whereby the combat readiness may be restricted.

2.1.4 Depending on the requirements concerning combat survivability, it is possible that in exceptional cases only one power station in conjunction with an emergency power supply may be approved, provided that this power station is supplied by two independent generators.

2.1.5 Parallel operation of all generators must be possible, unless otherwise stipulated in the building specification. It must be ensured that the continuous light-load operation to be expected does not lie below the permissible value for the prime mover. Unless stipulated otherwise, the continuous loading shall not lie below 30 % of the corresponding generator capacity.

2.2 Supply of sub-networks

2.2.1 The capacity and power reserve of the converters, transformers etc. needed for the sub-networks depend on the type and scope of the sub-systems to be supplied. The power required shall be determined according to the operating conditions described in 2.1.

2.2.2 If transformers, storage batteries with their charging equipment, static converters and suchlike are essential components of the main electrical power supply, the required availability of this supply system must remain guaranteed if any single unit fails.

The necessary redundancy can also be attained with the aid of equipment in other watertight compartments.

2.2.3 As far as possible, a decentralized supply of the sub-systems should be achieved.

2.3 Supply of DC sub-networks

2.3.1 The number of batteries to be provided depends on the primary duty and size of the ship as well as the power demand of the consumers to be supplied, as determined by the electrical power balance. The system must be designed so that the capacity required according to the power balance is provided by 80 % of the rated battery capacity. The rated capacity of the battery for a discharging period of 5 hours shall be used.

2.3.2 On ships with one damage control zone, at least two supply units (battery, power supply and charging unit) shall be provided. For ships with two or more damage control zones, there shall be at least one supply unit per damage control zone. A unit shall only supply power to consumers of one damage control zone.

2.4 Supply of hospitals

Unless stipulated otherwise in the building specification for the sub-networks of hospitals, DIN/VDE 0107 shall be applied.

3. Rating and control of alternating and three-phase current generators

3.1 NATO ships

For NATO ships, or if stipulated in the building specification, the NATO Standardization Agreement STANAG shall be observed.

3.2 Apparent Power

The apparent power of three-phase generators shall be such that no inadmissible voltage drops occur in the ship's mains due to the normal starting currents of motors. The start-up of the motor with the greatest starting current shall not give rise to a voltage drop causing other consumers to malfunction, see Section 1, F.1.

3.3 Waveform

3.3.1 The waveform of the line-to-line no-load voltage shall be as close as possible to sinusoidal. The deviation from a sinusoidal fundamental shall at no time exceed 5 % relative to the peak value of the fundamental. The RMS values of the phase voltages shall not differ from each other by more than 0,5 % under balanced load conditions.

3.4 Exciter equipment

Generators and their exciters shall be rated in such a way that:

3.4.1 the generator can be loaded for two minutes at 150 % of its rated current with a power factor of 0,5 lagging (inductive) and still deliver approximately its rated voltage;

3.4.2 the equipment is short-circuit-proof even having regard to the time lag of the generator circuit breakers necessary to the selectivity of the system.

3.5 Regulating Conditions

Under balanced load conditions, three-phase generators and their exciters are required to meet the following conditions, see C.1.7.

3.5.1 Steady regulating conditions

With the generator running at rated speed, the voltage shall not deviate from the rated value by more than + 2,5 % from no-load up to the rated output and at the rated power factor after the transient reactions have ceased.

3.5.2 Transient regulating conditions

With the generator running at rated speed and rated voltage, the voltage shall neither fall below 85 % nor exceed 120 % of the rated value when symmetrical loads of specified current and power factor are suddenly applied or removed. The voltage must regain its rated value ± 3 % in 1,5 seconds. If no particular requirements are specified for the load changes, the above conditions shall be satisfied when the generator, running idle and excited to its rated voltage, is suddenly loaded to 60 % of its rated current with a power factor of

< 0,4 (lagging), and, after steady-state operation has been achieved, the load is suddenly switched off again.

3.5.3 Steady short-circuit current

With a three-phase short circuit between terminals, the steady short-circuits current shall not be less than three times the rated current, and shall not be greater than six times the rated current. The generator and its exciter unit must be capable of withstanding the steady short-circuit current for a period of two seconds without suffering damage.

3.6 Load sharing during parallel operation

Where generators of the same output are operated in parallel, the reactive load of each machine shall not differ from its proportionate share by more than 10 % of its rated reactive power when the active load is shared equally. In the case of generators running parallel with different ratings, the deviation from the proportionate share shall not exceed the lesser of the following values, assuming proportionately equal sharing of the active load:

3.6.1 10 % of the rated reactive power of the largest machine

3.6.2 25 % of the rated reactive power of the smallest machine.

3.7 Direct current generators

Compound generators or shunt-wound generators with automatic voltage regulators are to be preferred for sets supplying ship's mains. Technical details and limiting values shall be agreed.

4. Design and equipment of generator prime movers

4.1 General requirements

The design and mechanical equipment of generator prime movers shall be undertaken in accordance with Chapter 104 - Propulsion Plants.

4.2 Speed change equipment

Every diesel engine driving a ship's main generator must have speed change equipment which permits adequately rapid synchronization.

4.3 Electrical starting equipment

Regarding electrical starting equipment, see Section 7, D.6.

4.4 Speed governors

4.4.1 Regarding requirements for mechanical speed governors, see Chapter 104 - Propulsion Plants.

4.4.2 Regarding additional requirements for electronic/electrical speed control, see Chapter 106 - Automation.

4.5 Load switching

4.5.1 Connection of load

If load switching is provided in two steps, it must be implemented as follows:

Immediately from 'no load' to 50 %, followed by the remaining 50 % of the generator output while remaining within the permissible speed-change limits.

Load switching in more than two steps is permissible, provided that:

- The design of the ship's mains permits the operational application of such units
- Load switching in several steps has been given appropriate consideration at the design stage of the ship's mains, and is endorsed during the plan approval
- Proof of unobjectionable functioning is provided in the course of the on-board tests. This must include due consideration of the loading of the ship's mains under stepped switching-in of essential equipment following breakdown and reinstatement of the ship's mains.

- Furthermore, safety of the ship's mains under parallel operation of the generators has been proved

4.5.2 Regarding further requirements, see Chapter 104 - Propulsion Plants.

4.5.3 Load shedding

Load shedding of 100 % of the generator's rated output must be observed while adhering to the permissible speed changes.

4.6 Parallel operation

4.6.1 The speed characteristics of the prime movers shall be linear over the entire output range.

The governing characteristics of the prime movers of units of the same output operating in parallel must ensure that, over the range from 20 % to 100 % of the total active power, the share of each machine does not deviate from its proportionate share by more than 15 % of its rated active power.

4.6.2 Where the units are differently rated, the deviation from the proportionate share within the stated load range shall not exceed the lesser of the following values:

- 15 % of the rated active power of the largest machine

- 25 % of the rated active power of the smallest machine

4.7 Cyclic irregularity

The following points have to be ensured:

4.7.1 Faultless parallel operation of three-phase generators

4.7.2 Load variations occurring regularly or irregularly shall not give rise to fluctuations in the active power output exceeding 10 % of the rated output of the machine concerned.

C. Emergency Electrical Power Supply

For the emergency electrical power supply reference is also made to Section 1, B.1.6.

1. General requirements

1.1 If an emergency source of electrical power is requested, see Section 2, A., it must take over the supply of the emergency consumers in case of failure of the main source of electrical power. It must be independent of the main source of electrical power.

1.2 The capacity of the emergency source of electrical power must be sufficient to supply all those services which are essential for safety in an emergency.

1.3 The emergency generator set must start up automatically if the main source of electrical power fails, and the supply of the listed consumers must be taken over automatically.

The emergency supply of electrical power must come into operation as quickly as possible, and in any event not later than 45 seconds after the failure of the main source of electrical power.

1.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used by way of exception and for short periods to supply non-emergency circuits.

1.5 For ships which need electrical power to restore propulsion, the capacity of the emergency source of power - or, if applicable, of the power station with the smallest output - shall be sufficient to restore propulsion to the ship in conjunction with other auxiliary machinery, as appropriate, within 30 minutes after blackout. It is assumed that starting energy is not available after blackout.

1.6 For all equipment forming part of the emergency source of electrical power, provision must be made for periodic functional tests, including especially the testing of automatic starting devices. Such testing must be possible without interfering with other aspects of the ship's operation.

1.7 For the rating and control of the emergency generators, the same principles apply as for the main generators in accordance with B.3. As an exception to B.3.3, voltage deviations of ±3,5% under steady conditions and of ± 4 % under transient conditions after 5 s are acceptable.

On NATO ships, compliance with STANAG 1008 is not required for the mains quality, unless this is expressly requested in the building specification.

1.8 Regarding electrical starting equipment, see Section 7, D.6.

1.9 Where fins of stabilizing systems are arranged in the area of embarking stations of lifeboats, these systems shall also be connected to the emergency source of power.

2. Emergency consumers

2.1 With due allowance for starting currents, the emergency source of electrical power must be capable of simultaneously supplying at least the following services for the period specified below:

2.1.1 For 3 hours, the emergency lighting at every embarkation stations for survival craft on deck and along the ship's sides in this area.

2.1.2 For 18 hours, the emergency lighting

- in all service and accommodation corridors, on stairways, at exits and in personnel lift cars and personnel lift trunks
- in engine rooms and main generator stations, including their control positions
- in all damage control areas, bridge, operation command centre, engine control rooms and at each main and emergency switchboard
- at all stowage positions for fire fighting equipment
- in the steering gear compartment
- at the fire pump mentioned in 2.1.5, at the flood pump, at the sprinkler pump, if any, the emergency bilge pump, if any, and at the start-up position for their motors
- in hospital rooms and operating theatres
- in ammunition rooms
- for reserve lighting as per Section 11, B.3.

2.1.3 For 18 hours

- the navigation lights and other navy-specific signal lights,
- the VHF radio installation

2.1.4 For 18 hours

- all internal signalling and communications equipment required in an emergency;
- all ship's navigational appliances stipulated by **SOLAS** V/12;
- the fire detection and fire alarm system;
- the operation of the daylight signalling lamp, the ship's whistle, the manually operated fire alarms and all the internal signals required in an emergency.

2.1.5 For 18 hours

- the required emergency fire pump and the water-spray installations;
- the auxiliary equipment for the emergency diesel-generator set;
- the mobile damage control equipment,
- power supply units and chargers for emergency mains systems.

3. Emergency consumers protecting the main propulsion plant

In rating the emergency source of electrical power,

consideration is to be given, where applicable, to other consumers required to protect the main propulsion plant in the event of a failure of the main source of electrical power. Such consumers may, for example, include the emergency lubricating oil supply.

D. Uninterruptible Power Supply

1. General requirements

1.1 If the main source of electrical power fails, the uninterruptible power supply (UPS) must automatically, and if necessary without interruption, supply the consumers mentioned below for a period of at least 1 h unless duration is specified in the building specification.

1.2 Permissible time for changeover of weapon systems and tactical command systems are to be speci fied by the maker or in the building specification.

2. UPS consumers

With due allowance for starting currents, the uninterruptible power supply must be capable of simultaneously supplying at least the following services:

2.1 Control and monitoring devices for primary essential equipment which needs UPS back-up for the continuity of safe function in case of failure of the main supply.

2.2 General emergency alarm as per Section 9, C.1.

2.3 Public address system as per Section 9, C.2.

2.4 Fire detection and fire alarm system as per Section 9, C.3.

2.5 Voyage data recorder (VDR) as per Section 9, C.5.

2.6 VHF radio installation

2.7 GPS receiver and gyro-compass

E. Auxiliary Power Supply

1. General requirements

1.1 In the event of failure of the electrical power from the ship's mains, the auxiliary power supply should be capable of supplying at least the mobile damage control equipment as well as fixed units for flood ejection, insofar as the latter are not installed in the compartments located between the power stations.

1.2 Depending on the size of the ship, on the spatial separation between the power stations and on measures taken to increase combat survivability, the supply will be taken from the main source of electrical power or the emergency source of electrical power.

2. Connecting cables

2.1 The auxiliary power supply of a permanently installed emergency consumer is routed via a supply socket, flexible cables, permanently installed plug-and-socket connections (bulkhead penetrations), if applicable, and the consumer plugs assigned to the emergency consumer (appliance plug).

The appliance plug is connected via a permanently installed cable to a contactor cabinet, which must be mounted near to the associated emergency consumer.

2.2 The auxiliary power supply of a mobile emergency consumer is routed directly or via flexible cables and, if applicable, permanently installed plug-and-socket connections from a supply socket.

2.3 Flexible connecting cables shall be fitted with plug-and-socket connections and given adequate support in the area of the supply sockets.

3. Contactor cabinets

In the contactor cabinets, change-over arrangements shall be installed for switching between the main power supply and the auxiliary power supply. For emergency consumers which are operated in the flooded condition, the switch-over must occur automatically or be remote-controlled from the location of the corresponding appliance plug. The other emergency consumers are switched over manually at the contactor cabinet.

SECTION 4

INSTALLATION PROTECTION AND POWER DISTRIBUTION

A. Three-Phase Main Generators

1. General

The main generators supply the relevant power station switchboard, either individually or in parallel.

1.1 Independent operation

Independent operation means that each generator supplies its own power station switchboard and also, when the interconnection feeder is activated, the second power station switchboard.

1.2 Parallel operation

In parallel operation, the generators supply their own power station switchboards and also, when the interconnection feeder is activated, the second power station switchboard. Parallel operation must be possible both within a power station and, when the interconnection feeder is activated, reciprocally with the second power station.

2. Protection Equipment

2.1 General requirements

2.1.1 Generators must be at least protected against damage due to short circuits and overloads.

2.1.2 Protection equipment for generators shall be arranged within the switchgear field of the generator to be protected and supplied from the generator side.

2.1.3 Short-circuit protection and overload protection equipment shall be provided in every non-earthed conductor.

2.2 Short-circuit protection

2.2.1 The short-circuit protection shall be set to an overcurrent of more than 50 %, but to a value less than the steady short-circuit current. It must have a short time delay compatible with the selectivity of the system (up to about 500 ms).

2.2.2 The short-circuit protection must not be disabled by undervoltage.

2.2.3 Generators with a rated output of 1500 kVA or more shall be equipped with a suitable protective device which, in the event of a short circuit inside the generator or in the cable between generator and circuit breaker, opens the breaker and de-energizes the generator. Examples of suitable protective equipment are differential protection or generator/neutral-point monitoring.

2.3 Overload protection

2.3.1 The overload protection, which is to be set to a value between 10 % and 50 % overcurrent, must trip the generator circuit breaker with a time delay of not more than 2 minutes. A setting above 50 % overcurrent may be allowed, where this is required by the working conditions and is compatible with the generator characteristics. The overload protection shall not impair immediate reconnection of the generator.

2.3.2 A device shall be installed which, when the generator's rated current is reached, triggers a warning signal after about 5 s and, if the overload persists, automatically disconnects the non-essential and, if necessary, the secondary essential equipment.

2.4 Reverse-power protection

2.4.1 Generators from 50 kVA output upwards that are provided for parallel operation shall be protected by a delayed reverse-power release.

2.4.2 The protection must be selected and set in accordance with the characteristics of the prime mover. The guidance values for the setting are: for turbo-generators 2 % to 6 %, for diesel generators 8 % to 15 % of the rated output, delayed from 2 to 5 seconds. The setting should, if possible, be at 50 % of the tractive power of the prime mover. Should the operating voltages decrease to 50 % of the rated value, the reverse-power protection must remain effective within the limits stated.

2.5 Undervoltage protection

Generator circuit breakers shall be provided with undervoltage protection. In the event of a decrease of the voltage to 35 % of the rated voltage, the generator

circuit breaker must open automatically. Undervoltage releases must have a short-time delay adapted to the short-circuit protection.

2.6 Over voltage protection

The ship's mains shall be protected against overvoltage. The voltage shall be limited to 130 % U_N and max. 5 s, even in the case of failure of the voltage regulators. For U_N see Section 1, B.7.

2.7 Under frequency protection

In the event of a continuous frequency drop of more than 10 %, the non-essential and, where necessary, the secondary essential equipment shall be shed within 5 to 10 s. If this fails to establish the normal operating condition, the supplying generators shall be disconnected from the power supply so that the stand-by unit can cut in.

2.8 Testing

Generator protection devices are subject to mandatory type tests.

3. Switchgear General

3.1.1 Each non-earthed conductor must be switched and shall be protected against short-circuit and overload.

3.1.2 When tripped due to overcurrent, generator circuit breakers must be ready for immediate reconnection.

3.1.3 Generator circuit breakers must be provided with a reclosing inhibitor which prevents automatic reclosure after tripping due to a short circuit.

3.2 Single operation

The following devices shall be provided:

3.2.1 A three-pole circuit breaker with time-delayed overcurrent release and short-time-delayed short-circuit release.

3.2.2 For generators with a rated output below 50 kVA, fuses and load switches or fuses with contactors are also permitted. All generator contactors that may be used shall be provided with a dropout delay (up to approx. 500 ms) and shall be rated for double the generator current.

3.3 Parallel operation

The following devices shall be provided:

3.3.1 For each generator, a three-pole circuit breaker with delayed overcurrent release and with short-time-delayed short-circuit and undervoltage release.

3.3.2 In the case of generators intended for parallel operation, the generator circuit breaker shall be provided with undervoltage protection which prevents closing of the switch if the generator is dead.

4. Synchronizing equipment

Generators intended for parallel operation must be equipped with a synchronizer in accordance with 4.1 and 4.2.

4.1 Equipment to prevent faulty synchronizations

Generators intended for parallel operation must be provided with automatic synchronizing equipment. Instead of automatic equipment, manual synchronizing equipment combined with a check synchronizer may be provided. The conditions of Section 14, F. must be complied with in order to prevent faulty synchronization.

4.2 Manual synchronization

Manual synchronization, e.g. by a synchronizing lamp using the dark method installed within sight of the generator-switch actuating position, must be possible if the appliances listed in 4.1 fail.

B. Emergency Three-Phase Generators

Emergency generators see Section 1, B.1.6, supply the emergency switchboard and the connected emergency consumers.

1. Protective equipment and switchgear

The generator protection shall consist of at least:

- short-circuit protection,
- overload protection,
- undervoltage protection.

However, it is permissible for the overload protection not to disconnect the generator automatically but instead to trigger an optical and acoustic alarm at the emergency switchboard and at the power station switchboards.

2. Overload shedding

If the emergency generator is overloaded, consumers temporarily supplied from the emergency switchboard which are not emergency consumers must be automatically disconnected in order to safeguard the supply to the emergency circuits.

C. Direct Current Generators

1. Single operation

The following devices shall be provided:

1.1 For each generator, a circuit breaker which simultaneously switches all non-earthed poles, with a delayed overcurrent release and a short-time-delayed short-circuit release, or a fuse in each non-earthed pole and a spring-operated load-switch with sufficient breaking capacity.

1.2 Circuit breakers shall always be used for generators with outputs of 50 kW and over.

2. Parallel operation

The following facilities shall be provided

2.1 For each generator, a circuit breaker which simultaneously switches all non-earthed poles, with a delayed over current release and a short-time-delayed short-circuit release, together with a reverse-current protection and short-time-delayed under voltage protection.

2.2 For compound generators, the switch must contain a switching element for the equipotential line which, when switching on, closes simultaneously or earlier and, when switching off, opens simultaneously or later, and is rated for at least half the rated current.

2.3 A polarity-reversing facility for each generator.

D. Power Transformers

1. Transformers intended for parallel operation shall be so designed that the load on no transformer deviates by more than 10 % of its nominal current from the percentage share calculated for it over the whole load range.

2. Transformers shall be protected against short-circuit and overload.

3. Transformers must be switchable on the pri mary side. In installations where feedback is possible, transformers shall be switchable at both the primary and secondary side.

E. Storage Batteries

Storage batteries shall be provided with overload and short-circuit protection near where the batteries are installed. Exceptions are made for batteries for the preheating and starting of internal combustion engines, but their cabling shall be made short-circuit proof.

F. Power Electronics

1. Power electronics facilities shall be protected against overload and short circuits.

2. Inverters intended for the supply of emergency consumers from the emergency battery shall be designed for continuous operation.

G. Shore Connection, External Supply

1. General requirements

1.1 Each ship must be equipped with terminal boxes for shore connection which permit the importing

of power from the shore or other ships and, if stipulated in the building specification, the exporting of power to other ships.

1.2 Terminal boxes for shore supply shall be linked to the ship's system by means of permanently laid cables.

1.3 As the utility connectors, plug-and-socket connections shall be used on board, with the exception of the earthing conductor, if applicable.

2. Equipment for supply on board

2.1 Each ship shall be fitted at least with one terminal box for shore connection. The terminal box shall be arranged at protected position at or above the main deck.

The power demand for the shore connection is determined by the electrical power balance for the operating condition "peacetime in-port readiness".

Through suitable design measures, it must be ensured that an interconnection of different shore supplies through the ship's mains is reliably prevented.

2.2 Each shore connection shall be given its own circuit breaker in the power station switchboard.

2.3 If more than one connecting cable is provided for the shore connection, the individual plug-and-socket connections shall be electrically interlocked with the corresponding shore connection switch in the power station, i.e. it shall only be possible to actuate the shore connection switch when all connections have been made. The shore connection switch must trip when one of the connections is broken.

Note

The shore connecting cable may be stored on board of the ship or at shore basis station.

2.4 Switching-on of the shore supply shall only be possible if the circuit breakers of the main generators have been shut off. Short-term parallel operation of the ship's mains and the shore mains for load transfer is permissible.

2.5 In the power station switchboards, the following monitoring instruments must be provided for each shore connection that is routed to the busbar:

- voltmeter

- ammeter with switch for changing the phase

2.6 The shore connection shall be protected against short circuit and overload.

2.7 All equipment operated from the shore connection must be so constructed as to ensure troublefree operation for the various protection measures, including the possible earthing systems. The voltage fluctuations which may arise through malfunctions in the electrical equipment shall not lead to any damage.

3. Design of the shore connection boxes

3.1 The terminal boxes for shore connections should be fitted with indicating lamps for monitoring the voltage and phase sequence. A brief operating manual must be affixed permanently to the front of the boxes.

3.2 All individual connectors and sockets must be labelled with unique designations indicating the phase or the polarity.

3.3 If necessary, the earthing conductor can be connected outside the shore connection box. For this purpose, a screw terminal which can be used without tools must be provided on the hull in the direct vicinity of the box.

In the case of hulls made of non-ferrous materials, an electrically conductive connection of the prescribed cross section must be made between the screw terminal and the protective conductor system of the ship.

3.4 The following details shall be indicated on a plate fitted to the shore connection box: voltage system and rated voltage, and the frequency in the case of alternating current.

H. Consumer Protection Equipment

1. General requirements

1.1 Protective equipment shall be so selected and coordinated with the generator protection that in the event of a short circuit the selectivity is safeguarded. If necessary, evidence thereof shall be provided.

1.2 Every non-earthed conductor in a distribution circuit must be protected against overload and short circuit.

1.3 Where the three-phase system is isolated from the hull, it is permissible to realize the overcurrent protection in only two conductors, provided that the disconnection of all phases is safeguarded.

2. Final supply circuits

2.1 Circuit breakers with motor protection switches

For a final circuit supplying one consumer with its own overload protection, it is permissible to provide short-circuit protection only at the input point. In this case, fuses two ratings higher than those permissible for rated operation of the consumer may be used for continuous duty.

In the case of short-time and intermittent operation, the rated current of the fuses shall not be greater than 160 % of the rated current of the consumer. The associated switches shall be selected in accordance with the fuse current ratings.

2.2 Where circuit breakers are used, the short-circuit cutout may be adjusted to a maximum of 15 times the rated current of the consumer, though not higher than the anticipated minimum value of the initial short-circuit alternating current in the circuit concerned. For steering gear equipment circuits, see Section 7, A.

2.3 Circuit breakers and motor protection switches with insufficient switching capacity must be fitted with the back-up fuses specified by the manufacturer. Automatic circuit breakers without a selectively graded breaking delay may not be connected in series in a single line.

2.4 Final supply circuits for lighting shall not be fused above 16 A. Regarding the number of lighting fixtures connected to a circuit, see Section 11, B.9.

I. Power Distribution

1. General requirements

1.1 Regarding permissible supply systems, see Section 1, G.

1.2 Mains configurations other than those described below are permissible if at least the same safety of supply is guaranteed for the consumers.

2. Power stations / interconnection feeders

2.1 The generators and the shore connections belonging to a power station feed the busbars of the corresponding power station switchboard directly via circuit breakers. If the busbars are supplied by several generators, the busbars shall be divisible at a point located between the feed points, see Section 5, C.2.2.

2.2 In the case of two power stations, they shall be linked by an interconnection feeder which must be designed for half the power of one power station. If, however, the power stations differ with regard to equipment and output, the interconnection feeder must be rated for at least the output of one generator. The interconnection feeders shall be connected by means of circuit breakers in each power station switchboard.

3. Supply of the consumers

3.1 The consumers are supplied either directly from the power station switchboards or via main groups, groups or sub-groups, see Fig. 4.1.

3.1.1 Main groups

Main groups shall always be supplied from two power station switchboards or transformers, converters etc., via a change-over arrangement.

Primary and secondary essential equipment, as well as non-essential equipment, are connected to the main groups.

3.1.2 Groups

Groups can be supplied directly from a power station switchboard or through a main group.

Secondary essential equipment and non-essential equipment are connected to the main groups.

3.1.3 Sub-groups

Sub-groups can be supplied from a main group or from a group.

Only non-essential equipment are connected to the sub-groups.

4. Change-over arrangements

4.1 For the design of the change-over arrangements (in principal networks, sub-networks, etc.), due consideration shall be given to the network structure and operational conditions of the connected consumers and equipment. In order that the de-energized periods occurring during the change-over do not lead to malfunctions, it is necessary that maximum permissible switching times be observed.

4.2 It must be ensured that parallel operation of the power station switchboards via the main groups is prevented.

An uninterrupted change-over with the interconnection feeder activated between the power station switchboards (converter switchboards) can be approved if the change-over arrangement of the main group switches off immediately after the change-over has taken place.

4.3 If redundant converters are operated at the same time for the supply of 400 Hz sub-networks and one of the converters fails, there shall be an automatic change-over of the 400 Hz supply to the second converter. Change-over arrangements shall be located within the main group to be changed over or in its immediate vicinity.

4.4 For the automatic change-over of main groups, see Section 3, B.1.2.5.

If the change-over of main groups leads to malfunctions in sensitive primary essential equipment (e.g. weapon control and fire control systems), adequate back-up for the power feeling, e.g. UPS, shall be provided.

5. Load balancing in three-phase systems

Where, in three-phase systems, AC consumers are connected between two phases, the consumers shall be distributed in such a way that, under combat conditions, the loads on the individual outer conductors should not differ from each other by more than 15 % of rated current of source.

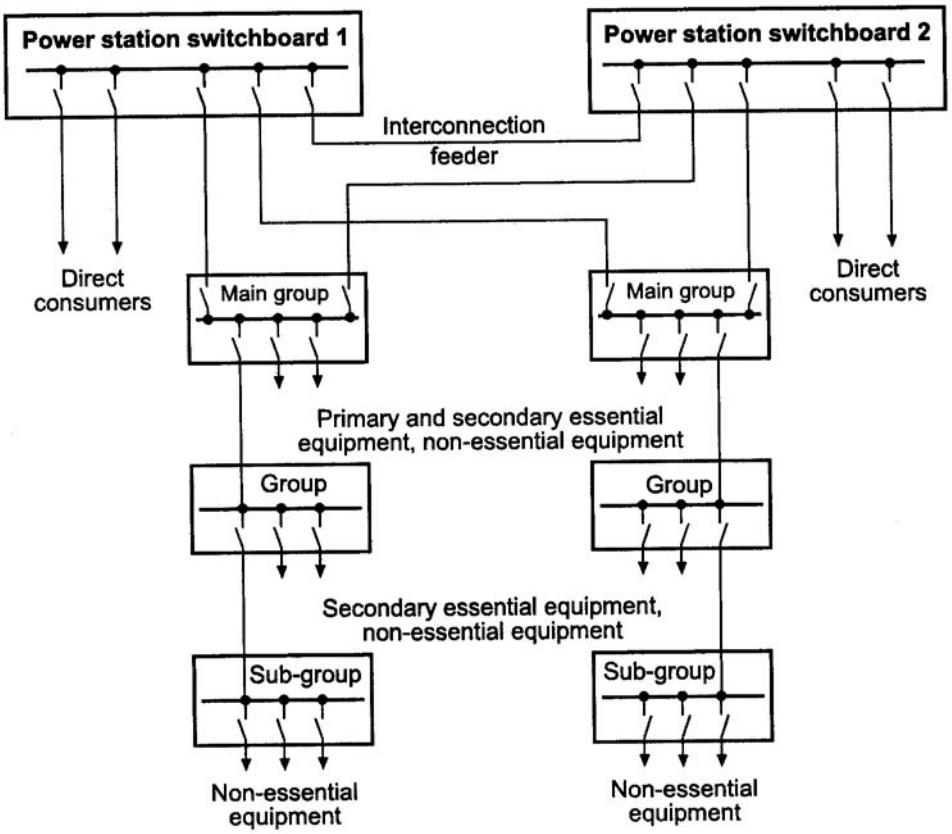


Figure 4.1 Example for the supply of equipment from two power station switchboards

6. Essential supply cables

6.1 Primary essential equipment shall be supplied directly from one of the main groups or via both power station switchboards.

6.2 Redundant primary and secondary essential equipment for the same function (e.g. main and stand by lubricating oil pumps) shall be fed via two separate cables from the power station switchboards or from the main group(s) or group(s) (for secondary essential equipment only).

7. Emergency supply cables

For emergency supply cables reference is also made to Section 1, B.1.6.

7.1 Insofar as there is an emergency generator, emergency consumers shall be supplied directly from the emergency switchboard or via sub-distribution panels of the emergency switchboard, to which only consumers in the relevant department are connected.

7.2 In normal operation, the emergency switch board shall be supplied by an interconnection feeder from the power station switchboard. The feeder shall be protected against overcurrent and short circuits at the power station switchboard, and the feeder must be automatically disconnected in the emergency switchboard if the supply from the power station switch board fails.

If two or more power stations are planned, the incoming feeders must be designed with a change-over arrangement, as described under 4.

7.3 A return supply from the emergency switchboard is permitted, e.g. when starting operation from the dead-ship condition or in exceptional situations during harbour operations. For return supply operation, the automatic feeder disconnection called for in 7.2 may be temporarily overridden.

8. Navigation, signal and navy-specific lights

8.1 The navigation lights as well as the navy-specific signal lights (e.g. towing lights, wake lights, pulsed lights) shall be supplied by a switchboard reserved solely for this purpose.

8.2 On ships with two power stations, this switchboard shall be given two incoming feeders from different main groups or from groups of different power stations.

8.3 On ships with only one power station, this switchboard shall be given one incoming feeder from the main source of electrical power and one from the emergency source of electrical power.

8.4 The masthead, side and stern lights shall each be supplied separately from the navigation lights panel; each circuit shall be protected against overload and short circuit. The individual main and reserve lights of the same type may have separate circuits in a common cable.

8.5 Failure of navigation light shall trigger an alarm. Where the monitoring device is connected in series with the navigation light, it must be ensured that a failure of the device does not cause the navigation light to disappear.

8.6 The navigation lights shall be fitted with a range adjustment device for common and continuous range reduction from 100 % to 5 %.

8.7 Where navigation lights are supplied from the main source of electrical power, the voltages at the lamp-holders shall not permanently deviate by more than 5 % above or below the rated voltage.

Where, in the event of a failure of the main electric power, navigation lights are supplied from the emergency source of electrical power, the voltages at the lamp-holders may temporarily deviate by up to 10 % above or below the rated voltage.

9. Control, monitoring and ship's safety systems

The supply of control, monitoring and ship's safety systems shall comply with the following requirements, see additionally Section 9:

9.1 These systems shall be supplied by their own circuits. Provision shall be made for the selective disconnection of the separate circuits in case of a short circuit.

9.2 A common distribution network with an uninterruptible source of emergency power may be used to supply systems which are required to remain operative even if the main source of electrical power fails. For this network, there must be two supply possibilities from different power station switchboards or main groups.

If the network is of the battery back-up type, the following shall be provided:

9.2.1 a power supply unit with a capacity sufficient for all the connected consumers together with a charger which, acting in buffer operation with the back-up battery, is capable of supplying continuously all the connected consumers and maintaining the battery in the charged condition; or

9.2.2 two chargers which meet the conditions stated in 9.2.1.

9.3 With regard to residual ripple, the supply facilities specified in 9.2.1 and 9.2.2 must be designed to ensure troublefree operation of the connected systems even when the battery is temporarily disconnected.

9.4 Failure of the power supply units and chargers must be signalled visually and acoustically.

9.5 Battery chargers with a charging capacity of $P \geq 2$ kW shall be tested at the manufacturer's works in the presence of a surveyor.

10. Emergency shutdown facilities

Emergency shutdown facilities placed outside the sites at which the equipment is installed shall be provided for the following consumers. The consumers may be arranged in groups, provided that redundant consumers are allocated to at least two electrically independent groups. Emergency shutdown facilities

shall be provided for e.g.

- fuel pumps
- separators
- fan motors
- auxiliary blowers for main engines, see Chapter 107 - Ship Operation Installations and Auxiliary Systems

11. Radio equipment (GMDSS)

11.1 Main power supply

The main sources of electrical power (power stations) must at all times maintain a sufficient supply of power to operate the radio equipment and to charge all reserve power sources for the radio equipment.

11.2 Reserve power supply for radio equipment

11.2.1 A reserve source or sources of energy shall be provided to supply radio equipment, for the purpose of conducting distress and safety radio communications, in the event of failure of the ship's main and emergency sources of electrical power.

11.2.2 It must be possible to operate the radio equipment from the reserve power supply at all times.

11.2.3 Further stipulations for the reserve source of energy are set out in the **SOLAS** Convention, Chapter IV, and the relevant **IMO** guidelines.

SECTION 5

LOW-VOLTAGE SWITCHGEAR ASSEMBLIES

A. General Requirements

1. These Rules apply to low-voltage switchgear with operating voltages of up to 1000 V AC or 1500 V DC.

2. Electrical installations shall be protected against damage due to overloading and short circuit.

3. The thermal- and electro-dynamic stresses due to overcurrents shall not cause damage to parts of the installation during the response time of protective devices or during the total operating time of switches.

4. Overcurrent protective devices shall be selected on the basis of the following criteria:

- Overload current,
- Short-circuit current,
- Reclosing capability.

5. Regarding design, construction and testing of low-voltage switchgear assemblies, attention is drawn to IEC publication 60092-302.

6. For further notes, see Section 4.

B. Calculations

1. Calculation of short-circuit currents

1.1 Short-circuit current calculations shall be carried out in accordance with a standard accepted by TL, e.g. IEC publication 61363-1. Equivalent standards may be approved.

Note

A computer-backed calculation program is obtainable from TL. The CD-ROM of the TL Rules (TLRP) includes the calculation program.

1.2 When calculating the maximum short-circuits currents to be expected, the following shall be taken into account:

1.2.1 all generators which operate in parallel to provide the maximum power demand,

1.2.2 all motors whose simultaneous operation must be expected.

1.2.3 All data used for the short-circuit current calculation shall be submitted.

1.2.4 The following shall be determined:

- the peak short-circuit current i_p
- the initial symmetrical short-circuit current I''_k

1.3 Roughly, the short-circuit currents at the main busbar can be calculated as follows:

1.3.1 $$I''_{kG} = \frac{I_{rG} \cdot 100}{xd''(\%)}$$

I''_{kG} = Initial symmetrical short-circuit current of a generator

I_{rG} = Rated current of the generator

xd" = Subtransient reactance of the generator in per cent

1.3.2 $I''_{kM} = 6 \cdot I_{rM}$

I''_{kM} = Initial symmetrical short-circuit current of a motor

I_{rM} = Rated current of the motor

1.3.3 The total initial symmetrical short-circuit current can be calculated by summation of the individual component currents.

1.3.4 The value of the peak short-circuit current i_p can be calculated by multiplying the total initial symmetrical short-circuit current I''_k by the factor 2.3.

1.4 The short-circuit calculation shall consider all possible short circuits necessary for an evaluation of the system. The following types of short circuits are to be investigated in all cases:

– Generator short circuits

– Short circuits on main busbars

– Short circuits on the busbars of emergency switchboards and main groups and groups

1.5 The short-circuit current calculation must be accompanied by a list of the proposed switching devices and their characteristic data.

The rated making capacity, the rated breaking capacity and the power factor of the switching appliances shall be stated.

1.6 TL reserve the right also to request proof of the minimum short-circuit currents to be expected.

2. Heat losses (heat balance)

Switchgear assemblies must be so designed that under operational conditions the permissible temperature-rise limits in accordance with IEC publication 60092-302 are not exceeded.

TL reserve the right to request proof of the heat balance.

3. Dynamic and thermal loading

Switchgear assemblies must be so designed that no permanent damage to busbars, busbar mountings and the wiring is caused by the dynamic and thermal loading arising in the event of a short circuit.

TL reserve the right to request proof of the dynamic and thermal stability in the event of a short circuit.

C. Construction

1. General requirements

1.1 All devices, instruments and operating devices shall be permanently identified by name plates. Wherever possible, clear text shall be used. Fuse current ratings shall be stated. The setpoints of adjustable protective devices shall be marked. The rated operating parameters of all measuring instruments shall bemarked in red, either on the scales or on plates fixed nearby.

1.2 All screwed joints and connections shall be secured against self-acting loosening.

1.3 All conductors shall be secured to be jig-proof and kept away from sharp edges. Conductors leading to equipment mounted in doors shall be laid so that they are tension-free.

1.4 Power station switchboards, main groups, groups and emergency switchboards shall be fitted with insulated hand rails or handles at the operating sides.

1.5 All components including their connections must be accessible for the purposes of maintenance, repair and replacement.

1.6 Large doors in switchboards (> 0.5 m^2) must be fitted with arresting devices.

1.7 Electrical components mounted in the doors of switchboards, e.g. switchgear, measuring devices and fuses for voltages over 50 V, must be safeguarded against accidental contact. Such doors shall be earthed.

1.8 Where fuses are fitted above switchgear or bare connecting wires or leads, measures shall be taken to ensure that falling parts (e.g. fuse cartridges) cannot come into contact with live components.

1.9 Operating devices and fuses must be safely accessible.

1.10 For circuit breakers and load-switches, the minimum distances above the arc chutes specified by the manufacturers shall be maintained.

1.11 Knife-type fuses are only permitted if they can be safely withdrawn and inserted.

1.12 For all power station switchboards and emergency switchboards manufactured in closed cabinet form, it is recommended that fire fighting openings or fire fighting nozzles be provided at readily accessible points for the use of portable fire extinguishers.

1.13 Depending on the application and deployment profile of the ship, additional

environmental tests, e.g. shock resistance and vibration resistance, must be determined for switchgear, see Chapter101 - Classification and Surveys, Section 4.

1.14 Cable ducts and covers for contact protection shall be made of halogenfree material.

1.15 Power station switchboards and main group switchboards and other switchboards with a higher amount of indication lamps, should be equipped with lamp test facilities.

2. Power station switchboards

2.1 Observation of the measuring and indicating devices and actuation of the switchgear must be possible from the front side of the switchboard with the doors closed.

2.2 Separation arrangements for busbar systems in power station switchboards shall be constructed as follows:

2.2.1 For ships with only one power station:

The main busbar must be so arranged that it is divisible by circuit breakers, and must be designed with regard to the arrangement of the generators and to the connection of the branches so that, in the event of damage in one section of the switchboard, the primary essential equipment remains operational as far as is possible after the disconnection.

2.2.2 For ships with two or more power stations:

The main busbars of each power station switchboard must be divisible by disconnect-switches or isolating links with regard to the assignment of the generators.

2.3 The consumers must be divided up over the separable sections so that the supply to redundant consumers can always be ensured in the event of a single failure in the busbar system of a power station switchboard. Special attention must be paid to maintaining the combat survivability.

2.4 If the total installed power of all generators which can be connected in parallel exceeds 3 MW, the generator panels must be separated from each other by arc-resistant partitions. Busbar penetrations must be resistant to tracking, flame-retardant and self-extinguishing.

2.5 Switchgear and synchronizing equipment for generators

For switchgear and synchronizing equipment for generators see also Section 4, A.

2.6 Measuring and monitoring devices for generators

2.6.1 Where circuit breakers are used, the following shall be provided:

- 1 indicating light: circuit breaker connected
- 1 indicating light: circuit breaker released

2.6.2 The following is required for each three-phase alternator:

- 1 voltmeter which can, if necessary, be switched to the other alternators
- 1 ammeter, switchable to all phases
- 1 active power meter for alternators of 50 kVA and over
- 1 frequency meter which can, if necessary, be switched to the other alternators

2.6.3 The following are required for each direct-current generator:

- 1 voltmeter and 1 ammeter

2.6.4 The following circuits shall be supplied from the generator side, and shall be separately protected against short circuits:

- generator protection devices and the undervolt-age trip of the generator circuit breaker,

- measuring instruments,
- indicating lights,
- diesel-engine speed-adjusting equipment,
- motor drive for circuit breaker.

2.7 Switchgear and fuses for equipment

2.7.1 Each supply line run from the power station switchboards must be provided with a circuit breaker with overcurrent and short-circuit protection, or with a fuse for each non-earthed conductor and an all-pole switch, or with a contactor with control switch. Instead of the overcurrent release, an overcurrent alarm can be provided for the supply cables of main groups.

Where fuses and switches are used, the sequence bus-bar - fuse - switch shall be chosen. The specified sequence may be changed where motor switches of utilization category AC-23 A are used as load switches, provided that the switches are weldproof in the event of a short circuit, see B.3.

The rated peak withstand current (dynamic limiting current) of switches must be greater than the cut-off current of the associated fuse in the event of a short circuit.

2.7.2 For steering gear, see Section 7, A.

2.8 Measuring instruments for consumer feeders

The power station switchboards shall be fitted with ammeters for major consumers, unless these are already mounted on the consumers themselves. It is permissible for one ammeter to be switched over to a number of circuits. A central indicator is admissible.

3. Emergency switchboards

3.1 The requirements for power station switchboards apply in analogous manner to emergency switchboards, see Section 1, B.1.6.

3.2 Control and supply circuits of the emergency electrical power plant must be so switched and protected that interruptions or short circuits caused by fire or another event,

- in a space housing the main generators and/or the power station switchboard, or
- in a machinery space

do not impair the operating ability of the emergency source of electrical power. Where necessary, the emergency switchboard shall be fitted with isolating switches.

4. Main group, groups and subgroups

4.1 These groups shall be equipped with the necessary devices for the protection of the connected circuits and for the supply of consumers, see Section 4.

4.2 Feeder circuits with fuses must be switched with load switches. In the case of final circuits with fuses up to 63 A, load switches may be dispensed with if each connected equipment can be disconnected by a switch fitted nearby.

4.3 For navigation lights panels, see Section 4, I.8.

5. Motor starters

5.1 Each motor shall be provided with its own switching device.

5.2 It shall be indicated whether the motor is switched on.

5.3 If the switching device does not disconnect all of the live conductors, additional measures shall be taken for the protection of personnel.

5.4 Motors shall be provided with starters if:

- currents or voltage drops higher than those permissible for the system are liable to occur, if connected directly

- this is necessary for the start-up of the motor or the driven machine

- this is required by the design of the generators

5.5 Starting shall only be possible from the zero position of the starter.

D. Selection of Switchgear

1. General requirements

1.1 Switchgear must conform to IEC publications as defined in these Rules, or to another standard approved by TL.

1.2 Switchgear shall be selected with regard to its rated current, its rated voltage, its thermal and dynamic stability and its switching capacity.

The following must be observed:

1.2.1 The rated short-circuit making capacity shall be not less than the calculated peak short-circuit current i_p at the place of installation.

1.2.2 The rated service short-circuit breaking capacity shall be not less than the a.c. component of the short-circuit current I_{ac} (t) at the moment

$$t = \frac{T}{2}.$$

Note

See also B. 1., calculation of short-circuit currents.

2. Circuit breakers

2.1 Circuit breakers are distinguished according to the utilization categories of IEC publication 60947-2 into:

2.1.1 Utilization category A

These are circuit-breakers not designed for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, e.g. without intentional short-time delay for selectivity under short-circuit conditions, and therefore do not need proof of the rated short-time withstand current (I_{cw}).

Application example:
As consumer circuit breakers for final circuits and for groups and sub-groups if selectivity is guaranteed.

2.1.2 Utilization category B

These are circuit breakers which are designed for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, e.g. with intentional short-time delay for selectivity under short-circuit conditions. Such circuit-breakers must have proof of the rated short-time withstand current (I_{cw}). Utilization category B circuit breakers must be able to withstand the short-circuit current to be expected where they are fitted, for the duration of at least 500 ms.

Application example:
As generator circuit breakers and as circuit breakers for the bus-tie breaker and for main groups.

2.2 Additional requirements for generator circuit breakers:

2.2.1 Following tripping due to an overcurrent, the breaker must immediately be ready for reclosing. For this reason, thermal tripping devices are not permitted.

2.2.2 After tripping due to a short circuit, a reclosing block must prevent automatic remaking of the breaker onto a short circuit still persisting.

3. Load switches

3.1 The current rating of load switches must be at least equal to that of the fuse protecting the circuit, and they must have a making/breaking capacity in accordance with AC-22 A or DC-22 A (IEC publication 60947-3).

3.2 The sequence busbar - fuse - switch should be maintained.

3.3 If the sequence busbar-switch-fuse is chosen, the making/breaking capacity must comply with category AC-23 A or DC-23 A (IEC publication

60947-3), and attention shall be paid to increased insulation qualities of the switching unit.

4. Fuses

4.1 Fuse links must have an enclosed fusion space. They must be made of ceramic or other material recognized as equivalent.

4.2 Fuses may be used for overload protection only up to a rating of 315 A.

Exceptions to these Rules are subject to approval.

E. Choice of Electrical Protection Equipment

1. General requirements

Protective devices shall be coordinated with each other in such a way that, in the event of a fault, the defective circuit is disconnected and the power supply to essential equipment is maintained.

2. Short-circuit protection equipment

2.1 The rated short-circuit breaking capacity I_{cn} of a switching device shall not be less than the maximum current to be broken in the event of a short circuit at the place where the protective device is fitted.

2.2 The rated short-circuit making capacity I_{cm} of a circuit breaker shall not be less than the maximum instantaneous asymmetric short-circuit current at the place where it is fitted.

2.3 The peak short-circuit strength of a switching unit and its components must correspond to the maximum short-circuit current which can arise at the place where it is fitted.

2.4 Circuit breakers whose making/breaking capacities are less than the anticipated maximum short-circuit currents shall be protected by back-up fuses of sufficient breaking capacity.

3. Selective arrangement

3.1 The short-circuit protection of essential equipment and the circuit breakers of the bus-tie breaker must be selective and must ensure that only the switching device nearest to the fault initiates disconnection of the defective circuit. For this purpose:

- the tripping time of protective devices connected in series must be carefully coordinated
- the switching devices must be capable of carrying the short-circuit current during the total break time of the device plus the time lag required for selectivity

3.2 Exceptions may be permitted in the case of circuits feeding redundant plants or non-essential equipment if selectivity relative to the generator switch is maintained.

4. Over current protection devices

The current/time characteristics of overcurrent protection devices shall be compatible with the system components to be protected, and with the requirements of selectivity.

5. Allocation of short-circuit and over current protection devices

5.1 Short-circuit protection is required for every non-earthed conductor.

5.2 Overcurrent protection is required for at least one conductor in insulated direct-current and single-phase alternating-current circuits.

Overcurrent protection is required for at least two phases in insulated, load-balanced three-phase circuits.

5.3 Overcurrent protection is required for each non-earthed conductor in earthed systems. The continuity of earthed conductors shall not be interrupted by short-circuit or overcurrent protection devices, except in the case of multipole disconnection devices which simultaneously interrupt all the conductors, whether earthed or not.

5.4 The decisive quantity for the overcurrent protection of the entire circuit (switchgear,

switchboard wiring, supply cables and equipment) according to regulations is the rated current I_n of the connected equipment or, in the case of grouped supply cables, the evaluated total rated current.

6. Motor protection

6.1 Motors with a power rating of more than 1 kW must be individually protected against overloads and short circuits. For steering-gear motors, see Section 7.

6.1.1 The protective devices must be compatible with the mode of operation of the motors and must provide reliable protection against thermal overload.

6.1.2 If the current/time characteristic of the overload protection device does not correspond to the starting conditions of a motor, provision may be made to suppress operation of the device during the start-up period. The short-circuit protection must remain operative.

6.2 The switchgear of motors whose simultaneous restarting on restoration of the supply voltage might endanger operation must be provided with undervoltage protection which prevents automatic restart.

6.3 Where necessary, the start-up of motors which are required to restart automatically following restoration of the voltage must be staggered in such a way that the starting currents do not overload the ship's mains.

7. Control circuits

7.1 The control circuits of essential systems must be independent of other control circuits.

7.2 Common control circuits for groups of consumers are permitted only when this is required by functional relationships.

7.3 For emergency shutdowns, see Section 4,I.10.

7.4 Control-power transformers must be protected against short circuit and overload. Fuses may be used on the secondary side as overload protection. Where the rated current on the secondary side is less than 2 A, the overload protection may be omitted.

7.5 Switching elements shall not be located in the earthed part (N) of an earthed control circuit.

7.6 Insulation monitoring devices may be dispensed with in the case of limited secondary systems, such as control circuits.

8. Measuring and signalling circuits

Current loops for signalling and measuring equipment and also indication lamps shall be protected against short circuit and overload in each non-earthed conductor.

Indicating lamps with an operating voltage ≤ 24 V or solutions where measures are taken to prevent an influence on control and power circuits in the case of short circuit are excepted.

9. Exciter circuits

Exciter circuits and similar circuits whose failure could endanger operation may be protected only against short circuit.

10. Monitoring of insulation resistance

Each non-earthed primary or secondary system serving power, heating or lighting installations shall be fitted with an equipment which monitors the insulation resistance relative to the ship's hull and gives an optical or acoustic alarm if the insulation resistance value is abnormally low, see also Section 14, F.4.8.

11. Testing of protection devices for generators and large consumers on board

Electronic or computerized protection devices for generators and large consumers shall be so designed that the function of the protection equipment can be tested on board.

Special attention shall be paid to:

- Arrangements for ready identification of the last valid settings, in the event of possible change

- Facilities and instructions for testing the settings and functions on board

F. Conductors and Busbar Carriers

1. Busbars, bare or painted

1.1 General requirements

1.1.1 Busbars must be made of copper or copper-plated aluminium, or corrosion-resistant aluminium.

1.1.2 The dimensions of main busbars and section busbars made of copper shall conform to Table 5.1 as a function of their permitted load.

The temperature rise shall not exceed 45 K and shall not have any harmful effect on adjacent components.

1.1.3 Parallel-run busbars of the same phase shall be installed not less than one bar thickness apart. Earth conductors, neutral conductors of three-phase mains and equalization lines between compound-wound generators must have at least half the cross section of the phase conductor.

1.2 Connections to equipment

Cross sections of connection bars and wires to equipment shall be of such size as to avoid thermal overloading of the equipment at full load as well as in the event of a short circuit.

2. Busbar carriers

Busbars shall be mounted in such a way that they withstand the stresses caused by short-circuit currents and maintain the required clearance and creepage distances relative to other voltage-carrying or earthed components. Corresponding evidence thereof shall be submitted.

3. Clearance and creepage distances

3.1 The values indicated in Table 5.2 apply to main busbars and the associated non-fused connection bars for power station, emergency and control switchboards and for main groups and groups.

3.2 Lower values than those indicated in Table 5.2 may be approved if the following conditions are met:

- Switchgear of standard design
- Approved QM system
- Reduction of pollution by appropriate installation and degree of protection
- Type-tested switchboard system

Table 5.1 Permissible loading of copper main busbars and section busbars of rectangular cross-section at 45C ambient temperature (45 K temperature rise)

Width x thickness [mm]	Maximum permissible loading [A] with 50/60 Hz							
	Painted (matt-black)				Bare			
	Number of bars				Number of bars			
	1 I	2 II	3 III	4 II II	1 I	2 II	3 III	4 II II
15 x 3	230	390	470	-	200	350	445	-
20 x 3	290	485	560	-	250	430	535	-
20 x 5	395	690	900	-	340	620	855	-
20 x 10	615	1145	1635	-	530	1020	1460	-
25 x 3	355	580	650	-	300	510	615	-
25 x 5	475	820	1040	-	405	725	985	-
30 x 3	415	670	735	-	350	590	700	-
30 x 5	555	940	1170	-	470	830	1110	-
30 x 10	835	1485	2070	-	710	1310	1835	-
40 x 5	710	1180	1410	-	595	1035	1350	-
40 x 10	1050	1820	2480	3195	885	1600	2195	2825
50 x 5	860	1410	1645	2490	720	1230	1560	2380
50 x 10	1260	2130	2875	3655	1055	1870	2530	3220
60 x 5	1020	1645	1870	2860	850	1425	1785	2740
60 x 10	1460	2430	3235	4075	1220	2130	2850	3595
80 x 5	1320	2080	2265	3505	1095	1795	2170	3370
80 x 10	1860	2985	3930	4870	1535	2615	3460	4275
100 x 10	2240	3530	4610	5615	1845	3075	4040	4935
120 x 10	2615	4060	5290	6360	2155	3545	4635	5580

Note:
The maximum permissible loading applies to switchboards not closed at the rear. In the case of fully enclosed switchboards adequate ventilation is to be ensured, or the loading values stated are to be reduced. IEC-Pub. 60439-001 has to be performed.

Table 5.2 Clearance and creepage distances

Rated service voltage [V] (AC/DC)	Minimum clearance [mm]	Minimum creepage distance [mm]
U ≤125	10	12
125 < U ≤ 250	15	20
250 < U ≤ 690	20	25
U > 690	25	35

4. Insulated wires

4.1 Insulated wires must be of the stranded type, and must satisfy the requirements for cables and wires set out in Section 12. The cross section of the conductor shall be at least sufficient for the rated current of the connected equipment. Conductors shall be selected in accordance with Table 5.3.

4.2 Non-fused conductors leading from the main busbar to fuses and circuit breakers shall be as short as possible, but not longer than 1 m.

4.2.1 These wires shall not be run and mounted together with other wires. They must be short-circuit-proof, or installed in a short-circuit-proof manner.

Table 5.3 Current rating of wires in switchgear

Nominal cross-section of conductor - total cross-section in the case of conductors connected in parallel [mm^2]	Bunched, exposed or in conduits		Wires run singly, at least one conductor diameter apart
	Several power circuits together	One power circuit together with its associated measuring and control wires	Circuits of all kinds
	Current [A]	Current [A]	Current [A]
1	9	12	15
1,5	12	15	19
2,5	16	20	25
4	20	27	34
6	26	35	42
10	36	48	58
16	48	65	78
25	66	86	102
35	82	107	125
50	104	133	157
70	130	164	194
95	157	198	231
120	186	231	272

Note:

The current ratings shown applies to conductors with a maximum permissible operating temperature [T] on the conductor of 70°C and an ambient temperature of 45°C. For conductors with a maximum permissible operating temperature [T] deviating from 70°C, the current rating is to be determined by applying the correction factor [F].

T	60 °C	65 °C	70 °C	75 °C	80 °C	85 °C
F	0,77	0,89	1,00	1,10	1,18	1,26

4.2.2 Control wires for essential equipment must be so run and protected that they cannot be damaged by short-circuit arcs.

G. Measuring Instruments and Instrument Transformers

1. Measuring instruments

1.1 The measuring error of switchboard instruments shall not exceed 1,5 % of the full scale value. Instruments with directional response shall be used for DC generators and batteries.

1.2 Voltmeters must have a scale range of at least 120 % of the rated voltage, and ammeters a scale range of at least 130 % of the maximum anticipated continuous-service current. Ammeters shall be so rated that they are not damaged by motor starting currents.

1.3 The scale range of power meters must be at least 120 % of the rated power. For generators connected in parallel, the scale range must also register at least 15 % reverse power. Where power meters have only a single current path, all generators must be measured in the same phase. If the total value of all consumers connected to a single phase exceeds 10 % of the power of the smallest generator, the power meters must be equipped with multiple movements in order to record the unbalanced load on the outer conductors.

1.4 Frequency meters shall be capable of registering deviations of ± 5 Hz from the rated frequency.

1.5 Rated values are marked at the instruments scale or by separate plate.

2. Instrument transformers

2.1 Instrument transformers must conform to class 1 as a minimum requirement.

2.2 Current transformers for protective devices shall not exhibit a current error of more than 10 % in the expected overcurrent range.

H. Testing of Switchboards and Switchgear

1. Type-tests

The following devices and components are subject to mandatory type-testing:

- Circuit breakers, load-switches, disconnect-switches and fuses for direct connection to the main busbars and to non-fused, multi-terminal busbars of power station, emergency and control switchboards and of main groups
- Generator protection devices
- Standardized switchgear in series manufacture with reduced clearance and creepage distances, See F.3.2

2. Tests at manufacturer's factory

2.1 All switchboards shall be tested at the manufacturer's factory.

2.2 The following items are subject to testing in the presence of a surveyor:

Switchboards of:

- power stations
- emergency supply
- electric propulsion plants
- main groups
- groups
- motor starters for essential equipment
- motor control centre
- fan groups
- steering gear plants
- boiler plants

- chilled water plants
- anchor capstan
- warping winches
- degaussing system

TL reserve the right to stipulate a factory test for other switchboards.

2.3 Scope of tests

2.3.1 Visual inspection

Checking of manufacture against the approved drawings. The components and materials used must conform to the Rules.

2.3.2 Functional test

Testing of functional performance on the basis of a test schedule and the approved drawings.

2.3.3 High-voltage test

The test voltage specified in Table 5.4 and 5.5 shall be applied between the conductors themselves and between the conductors and the switchboard frame. The duration of the test is one minute in each case.

Table 5.4 Test voltage for main circuits

Rated insulation voltage U_i DC and AC [V]	Test voltage (AC) (r.m.s) [V]
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 690$	2500
$690 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500
$1000 < U_i \leq 1500$ (**1**)	3500
(1) *Only for DC voltage*	

Table 5.5 Test voltage for auxiliary circuits

Rated insulation voltage U_i DC and AC [V]	Test voltage (AC) (r.m.s) [V]
$U_i \leq 12$	250
$12 < U_i \leq 60$	500
$U_i > 60$	$2\ U_i + 1000$ but at least 1500

Measuring instruments and other auxiliary apparatus may be disconnected during the test.

- Test voltage for main circuits:

  For main circuits, the test shall be carried out with the values according to Table 5.4.

- Test voltage for auxiliary circuits:

  For auxiliary circuits, the test shall be carried out with the values according to Table 5.5.

- Test voltage for type-approved switchgear:

  For the verification of the dielectric property of type-approved switchgear, the test voltage for routine tests may be reduced to 85 % of the values according to Table 5.4 and 5.5.

2.3.4 Insulation resistance measurement

The voltage test shall be followed by measurement of the resistance of insulation. The insulation resistance measurement shall be performed at a DC voltage of at least 500 V.

In large installations, the switchboard may be divided into a number of test sections for this purpose. The insulation resistance of each section shall be at least 1MOhm.

SECTION 6

POWER ELECTRONICS

A. General

For power electronics in electrical propulsion plants, see Section 13.

The requirements of IEC publication 60146 "Semiconductor Power Converters" shall be observed.

B: Construction

1. The rules set out in Section 5 - Low-voltage Switchgear, shall be observed, wherever applicable.

2. Each power electronics system shall be provided with separate means for disconnection from the mains.

In the case of consumers up to a nominal current of 315 A, the combination of fuse/contactor may be used. In all other cases, a circuit breaker shall be provided on the mains side.

3. Equipment shall be readily accessible for purposes of measurement and repair. Devices such as simulator circuits, test sockets, indicating lights etc. shall be provided for functional supervision and fault location.

4. Control and alarm electronics must be galvanically separated from power circuits.

5. External pulse cables shall be laid twisted in pairs and screened, and kept as short as possible.

The use of optical waveguides is recommended.

C. Rating and Design

1. Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation, see Section 1, F.

2. Rectifier systems must guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see Section 1, F. In the event of unacceptable large frequency and/or voltage variations in the supply voltage, the system must shut down or remain in a safe operating condition.

3. For the supply of mains, the number and rating of electronic facilities shall be so scaled that, in the event of failure of any one power-electronics facility, the remainder of the installation is sufficient to:

- Feed all essential equipment which may be in simultaneous operation under combat conditions, see E-balance
- Start the biggest consumer without exceeding the maximum permissible voltage and frequency variations

To maintain the required availability, bypass switching may be resorted to.

4. The semiconductor rectifiers and the associated fuses shall be so selected that their load current is at least 10 % less than the limit current determined in accordance with the coolant temperature, the load and the mode of operation.

5. The permissible periodic peak blocking voltage of the individual component must be greater by a factor of at least 1,8 than the peak value of the undistorted supply voltage. This value may be reduced for static converter circuits with separate power supplies.

6. Electrical charges in power electronic modules must drop to a voltage of less than 50 V within a period of less than 5 s after disconnection from the mains supply. Should longer periods be required for discharge, a warning label shall be affixed to the appliance.

7. If the replacement of plug-in printed circuit boards can cause the destruction of components or the uncontrolled behaviour of drives while the unit is in operation, a caution label to this effect must be provided.

8. The absence of external control signals, e.g. due to a circuit break, shall not cause a dangerous situation.

9. Control-circuit supplies shall be safeguarded against unintended disconnection, if this could endanger or damage the plant.

10. It is necessary to ensure that, as far as possible, faults do not cause damage in the rest of the system, or in other static converters.

10.1 Special attention shall be paid to the following points:

10.1.1 mutual interference of static converters connected to the same busbar system,

10.1.2 calculation of commutating impedances reacting to voltage distortion and reacting to other consumers,

10.1.3 the selection of the ratio between the subtransient reactance of the system and the commutating reactance of the static converter,

10.1.4 consideration of reactions from rectifier installations on the commutation of DC machines,

10.1.5 consideration of voltage drops in the ship's mains due to inverter operation,

10.1.6 influence by harmonics and high-frequency interference,

10.1.7 influence on the ship's mains by energy feeding back.

10.2 Where filter circuits and capacitors are used for reactive current compensation, attention shall be paid to the following:

10.2.1 reaction to the mean and peak value of the system voltage in case of frequency fluctuations,

10.2.2 inadmissible effects on the voltage regulation of generators.

10.3 HF filters which are used must be suitable for operation within the IT network.

D. Cooling

1. General requirements

1.1 Natural cooling is preferred.

1.2 Excessive temperatures shall be signalled by an alarm.

2. Water cooling

In the case of water cooling, the flow rate of the coolant shall be monitored.

Coolant flow rates that are inadmissibly low shall trigger an alarm.

3. Air cooling

Failure of the cooling shall be indicated by an alarm.

E. Control, Adjustment and Monitoring

1. Control

1.1 Control, adjustment and monitoring must ensure that the permissible operating values of the facilities are not exceeded.

1.2 Static converter devices used for feeding sub networks shall be switched off automatically and without delay for the following faults:

1.2.1 when the input voltage exceeds or falls below the relevant limit values

1.2.2 when an phase voltage fails

1.2.3 in the event of internal faults

1.2.4 when the temperature exceeds the limit.

1.3 The control shall be so engineered that the installation is protected from damage during the switching-on and switching-off sequence, dedication alterations and faulty operation.

2. Monitoring

2.1 The power supply to all control circuits shall be monitored for voltage failure.

2.2 The following conditions shall be indicated:

2.2.1 input voltage detected

2.2.2 output voltage detected

2.2.3 malfunctions

2.2.4 overtemperature

2.3 For the monitoring of individual modules and assemblies of essential equipment, components shall be provided which in the event of a fault facilitate its recognition.

F. Protection Equipment

1. Power electronic equipment shall be protected against exceeding of its current and voltage limits. For protective devices, it must be ensured that upon actuating

- the output will be reduced or defective subsystems will be selectively disconnected
- drives will be stopped under control
- the energy stored in components and in the load circuit cannot have a damaging effect, when switching off

2. In equipment with a current rating of more than 100 A, each bridge arm or parallel-connected rectifier shall be protected e.g. by a special semiconductor fuse. Exceptions are quenching circuits in self-regulating systems and converters operated with a load-independent current. For all other equipment, fuses on the input/output side may also be used.

3. Special semiconductor fuses shall be monitored. After tripping, the equipment has to be switched off, if this is necessary for the prevention of damage. The activation of a safety device shall trigger an alarm.

4. Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semiconductor components.

G. Tests

1. General requirements

1.1 Power electronics assemblies shall be individually tested at the maker's works. A Works Test Report shall be rendered on the tests carried out. Essential equipment from 50 kW/kVA upwards shall be tested in the presence of a TL Surveyor.

1.2 On application, power electronics devices may be type-tested.

2. Extent of routine tests

2.1 Voltage test

Prior to the start of the functional tests, a high-voltage test shall be carried out. The RMS value of the alternating test voltage is:

$$U = 2\,U_n + 1000\ [V] \quad \text{(duration 1 minute)}$$

but at least 2000 V, where U_n is the maximum nominal voltage between any two points on the power electronics device.

For this purpose, switchgear in power circuits shall be bridged, and the input and output terminals of the power electronics devices and the electrodes of the rectifiers shall be electrically connected with each other. The test voltage shall be applied between the input/output terminals, or between the electrodes and

- the cabinet
- the mains connection side, if the power electronics device is electrically isolated from the mains.

2.2 Test of insulation resistance

Following the voltage test, the insulation resistance shall be measured at the same connections as for the voltage test. The measurement shall be performed at a voltage of at least 500 V DC.

2.3 Operational test

The function shall be demonstrated as far as possible.

2.4 Testing of protection and monitoring devices

The response thresholds and the coordinated operation of the protective and monitoring devices shall be verified.

SECTION 7

POWER EQUIPMENT

A. Steering Gear

1. General requirements

1.1 Each ship must have at least 2 main steering gear systems, each ensuring the Ml adjustment speed, and an emergency steering gear system.

1.2 The electrical systems of the two main steering gear systems and the emergency steering gear system must be so designed that a malfunction in one of them shall not affect the operation of the others.

1.3 With regard to increased vibration loads in the steering gear compartment, see Section 1, E.

1.4 The requirements set out in Chapter 107 – Ship Operation Installations and Auxiliary Systems, Section 2 shall be observed.

2. Power supply

2.1 The power supply to the steering gears shall be routed on separate cable trays which lie as far apart as possible.

2.2 A separate power supply circuit leading directly from each power station switchboard via the supply change-over switches or feeding from the main groups shall be provided for each steering gear power unit.

2.3 If there is only one power station, the second incoming feeder shall be taken from the emergency power supply.

2.4 Mechanically separated switches shall be provided as incoming circuit breakers.

2.5 After an electrical power failure, the steering gear power units must restart automatically when the power is restored.

2.6 The power supply to the steering gear shall also comply with the provisions set out in Section 4, I.

2.7 The systems shall be so designed that it is possible to put each power unit optionally into individual or combined operation from the bridge or the steering gear compartment. Mechanically separated switches shall be provided for this purpose.

The supply of the bridge remote control for the power units must be run from the associated switchgear in the steering gear compartment. For incoming feeders to the steering gear control systems, see 6.

3. Design of the electrical drives

3.1 To determine the torque characteristics required for the electric motors of power units, due consideration shall be given to the breakaway torque and the effective maximum torque of the steering gear under all operating conditions, see Chapter 107 – Ship Operation Installations and Auxiliary Systems, Section 2.

3.2 The following requirements apply to the modes of operation (duty types acc. IEC 60034-1):

3.2.1 Steering gear with intermittent power demand:

- S 6 - 25 % for converters and the motors of electrohydraulic drives
- S 3 - 40 % for the motors of electro-mechanical steering gears.

The ratio of pull-out torque to rated torque shall be at least 1,6 in all cases.

3.2.2 Steering gear with constant power demand:

- S 1 - 100 % continuous service

3.3 For the motor design, Section 14 shall be observed.

3.4 If the steering gear is used for limiting the heeling angle of the ship, this operating mode shall be given due consideration.

4. Switchgear

4.1 Each steering gear motor must have its own separate switchgear. Combined contactor cabinets are not permitted.

Each steering gear motor must have an ammeter.

4.2 The remote control systems of the power units and the rudder control must be capable of being disconnected or isolated inside the contactor cabinets (e.g. by removing the fuse-links or switching off the automatic circuit breakers). These switches or fuses shall be specially marked.

5. Protection equipment

5.1 The circuits for the control systems and motors of steering gears shall be protected only against short circuits.

5.2 Where fuses are used, their current ratings shall be two steps higher than the rated current of the motors. However, in the case of intermittent-service motors, the fuse rating shall not exceed 160 % of the rated motor current.

5.3 Where thermal relays are provided to protect the stalled motor, they shall be set to a value equivalent to twice the rated current of the motor.

5.4 The instantaneous short-circuit trip of circuit breakers shall be set to a value not greater than 15 times the rated current of the drive motor.

5.5 The protection of control circuits shall correspond to at least twice the maximum rated current of the circuit, but shall not be below 6 A, if possible.

6. Steering gear control systems

6.1 Ships with electrically operated steering gear controls shall have two independent steering gear control systems. Separate cables and wires shall be provided for these control systems. A common steering wheel or a common tiller may be used.

6.2 If a sequential (follow-up) control system and a time control system are provided, each of these systems shall be able to operate on each power unit. Switching of the control systems must be possible on the bridge.

Where two identical control systems are installed, each control system can be permanently assigned to a power unit.

6.3 Provision must be made for operating the steering gear from the bridge and the steering gear compartment.

6.4 The incoming feeders to the electrical steering gear control systems must be taken from the power unit supplies in the steering gear compartment, or from the corresponding power unit feeders in the power station switchboards.

6.5 The electrical separation of the steering gear control systems from each other must not be impaired by the addition of extra systems, such as autopilot systems or units to limit the heeling of the ship.

6.6 For switching over between different control modes, a common control selector switch may be provided. At the switch, the circuits of the various control systems shall be so arranged that they are electrically and physically separated.

6.7 Systems where manual control can override the automatic control system must be so designed that a self-induced return to automatic control is not possible except where the course preselection of the automatic system is automatically kept in line. The switchover from automatic to manual control by "override" shall be indicated optically and acoustically at the steering position.

6.8 From the main steering station on the bridge, it must be possible to isolate completely any additional steering control positions on the open deck and any portable steering consoles with flexible cables. Portable steering consoles shall be connected via plugs with pin coding. It is necessary to ensure that the rudder-angle indicator can be read within the range of operation of the portable steering console.

6.9 Repeaters and limit switches - if provided must be linked electrically and mechanically to the respective control system and mounted separately to the rudder stock or the adjusting devices.

7. Alarms and indicators

7.1 Alarms and indicators for steering gears and controls are given in Table 7.1.

Table 7.1 Alarms and indicators of steering gear and controls

No.	Alarms/indicators	Main and auxiliary steering gear	
		Bridge	Engine room
1	Operation of power unit	x	x
2	Power failure of power unit/ control	x	⊗
3	Overload of electric drive or phase failure of supply	x	⊗
4	Low level of hydraulic oil tank	x	⊗
5	Power failure of steering control system	x	⊗
6	Hydraulic lock alarm	x	⊗
Note : *x = Single indication, see also 7.3* *⊗ = Group indication*			

7.2 The failures listed under nos. 2 - 6 of Table 7.1 shall be signalled optically and acoustically. Cancellation of the acoustic signal shall be possible. Cancellation of an acoustic alarm shall not inhibit the indication of a failure in the other steering gear drive units in operation.

Alarms on the bridge shall be announced at a position close to the main steering station.

7.3 In case of a fixed relationship between control system and power unit, the alarms no. 2 and no. 5 of Table 7.1 may be grouped.

8. Rudder-angle indicator

For the rudder-angle indicator in its particulars see Section 9, B.3.

9. Tests

9.1 For the testing of the electrical machines, see Section 14.

9.2 The following monitoring devices are subject to mandatory type-testing:

- Phase-failure relays

- Level switches.

9.3 Steering gear control systems with all components important for the function are subject to mandatory type-testing, e.g. steering mode selector switch, follow-up / non-follow-up control devices.

10. Control of steering propeller systems for main propulsion units

10.1 The requirements set out in 6., as and where appropriate, shall be met.

10.2 Monitoring and testing

The requirements set out in 7. and 9., as and where appropriate, shall be met.

10.3 Indicator

The effect on the course shall be indicated. The regulations in Section 9, B.3. apply as and where appropriate.

B. Lateral Thrust Propellers and Manoeuvring Aids

1. Rating

Manoeuvring aids shall generally be rated for continuous duty.

Drives used only for lateral thrust must be designed at least for short-term duty (S 2 - 30 mins) at all speeds.

2. Protection equipment

2.1 The equipment shall be protected in such a way that, in the event of an overload, an optical and acoustic warning is first given on the bridge, followed by an automatic power reduction or disconnection of the

system if the overload persists. The acoustic warning must be acknowledgeable on the bridge. For plants with automatic current limitation the warning is not required.

2.2 If fuses are used for short-circuit protection, a phase-failure supervision is required to prevent the system from being started if one phase fails.

2.3 It must be ensured that, if a lateral thrust propeller stalls, the main power supply to the drive is disconnected quickly enough to avoid endangering the selectivity of the system with regard to the generator switchgear.

2.4 For lateral thrusters with variable-pitch propellers, a switch-on interlock shall be provided to prevent starting if the pitch angle is $\neq 0$ or the hydraulic oil pressure is too low.

2.5 Motors for short-term duty shall be monitored for critical winding temperature. An exceeding of temperature limits shall be alarmed. If the maximum permissible temperature is reached, the output shall be automatically reduced or the motor shall be switched off.

3. Controls, monitors and indicators

3.1 For lateral thrusters, the main steering station on the bridge must be provided with the following indicators:

- an indicating light showing that the system is ready for operation
- an indicating light signalling an overload for systems without power control
- depending on the type of equipment, indicators showing the power steps and the desired direction of motion of the ship

3.2 The following indications and alarms shall be provided in the engine room or engine control room:

- faults which may cause failure or endanger the drive shall be signalled optically and acoustically as collective alarms
- an ammeter for the drive motor at the power station switchboard

3.3 The direction of movement for the controls of lateral thrust units must correspond to the desired direction of motion of the ship. Power for the electrical control system must be taken from the main power supply to the drive.

C. Controllable Pitch Propellers for Main Propulsion Systems

1. The design and operation of these systems shall conform to the Rules set out in Chapter 104 - Propulsion Plants, Section 7.

2. Provision must be made to enable the system to be controlled from the bridge and from the engine room. Failure of the control system must be signaled optically and acoustically on the bridge and in the engine room.

3. From the main steering station on the bridge, it must be possible to isolate completely any additional electrical remote-control facilities provided on the open deck, e.g. on bridge-wings.

4. Input/output units and actuating devices shall be type-tested.

D. Auxiliary Machinery and Systems

1. Fire-extinguishing systems

1.1 Fire pumps

The power supply to the motors and the fire-pump control systems shall be so arranged with regard to the assignment to power stations, the routing of the power-supply cables and the location of the controls that a fire in an autonomous department cannot render all the fire pumps unserviceable, see also Chapter 107-Ship Operation Installations and Auxiliary Systems, Section 9. If remote starting is provided for fire pumps, pump controls shall be so designed that in the event of failure of the remote control the local control remains operative.

1.2 Pressure water spraying systems (sprinklers)

1.2.1 For automatic, electrically powered fire pumps and fire detection systems, a direct supply of the pumps, compressors and alarm systems from both power station switchboards and main groups is required.

1.2.2 The design of the fire detection system shall meet the requirements set out in Section 9, C.

1.2.3 The switches at the power station switchboards or main groups that are required for the power supply to all units forming part of the alarm and extinguishing systems must be clearly marked.

1.2.4 For the routing of the cables, see Section 12.

1.2.5 For the design of these systems, see also Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9.

2. Fans

2.1 Power-driven fans for accommodation, service spaces, control stations and machinery rooms must be capable of being switched off from an easily reachable position that is as safe from fire as possible and located outside the spaces to be ventilated. The switches for switching off the machinery space ventilation must be separated from the switches for switching off the other fans. Section 4, I.10 must be observed.

2.2 Regarding NBC protection, see Chapter 107- Ship Operation Installations and Auxiliary Systems, Section 11.

3. Fuel pumps and separators

Controls must be provided to enable the electric motors of fuel pumps and of fuel and lubricating oil separators to be stopped from outside the spaces concerned.

4. Pumps discharging overboard

The motors of pumps discharging overboard and whose outlets are located in the lifeboat launching area above the light waterline shall be equipped with switches next to the launching station of the lifeboats.

5. Turning gear

5.1 The remote control of electrically driven turning gear shall be so designed that the gear motor stops immediately if the switch or pushbutton is released. The remote control shall be designed with safety extra-low voltage.

5.2 A disconnect switch must also be fitted near the drive unit.

5.3 The turning gear must be equipped with a device which prevents the diesel engine from being started as long as the turning gear is engaged, see also Chapter 104 - Propulsion Plants.

6. Electric starting equipment for main and auxiliary engines

6.1 General requirements

6.1.1 Regarding additional requirements for the starting equipment of diesel engines see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 6.

6.1.2 The starter batteries shall only be used for starting (and preheating where applicable) and for the monitoring equipment and controller associated with the engine.

Maintaining and monitoring of the charge condition of the batteries must be ensured.

6.2 Main engines

See Chapter 106 - Automation, Section 6.

6.3 Auxiliary engines

See also Chapter 106 - Automation, Section 7.

6.3.1 Emergency generator sets

If an emergency generator set is installed, the starting equipment must comply with the following regulations.

6.3.1.1 Each emergency generator set that has to be started automatically shall be equipped with an approved starting device with sufficient power for at least three successive starting operations, even at an ambient temperature of 0 °C. If starting is impossible at this temperature or if lower temperatures are likely to be encountered, heating shall be provided to ensure starting of the generator sets. A second source of energy which is capable of three further starting operations within 30 minutes shall be provided in addition.

This requirement can be waived if the set can also be started manually.

6.3.1.2 To guarantee availability of the starting devices, it must be ensured that:

- Electrical and hydraulic starter systems are supplied from the emergency switchboard

- Compressed-air starter systems are supplied via a non-return valve from the main and auxiliary compressed-air vessels, or by an emergency air compressor supplied with power via the emergency switchboard

- The starting, charging and energy storage equipment is located in the emergency generator room

6.3.1.3 If automatic starting is not a requirement, starting equipment which ensures safe manual starting is permitted, e.g. by hand-crank, spring-powered starter, manual hydraulic or ignition cartridge starter.

6.3.1.4 If a direct start by hand is not possible, starting devices as per 6.3.1.1 and 6.3.1.2 shall be provided, whereby manual initiation of the starting process is acceptable.

6.3.1.5 The starting equipment of emergency generators shall only be used for that purpose.

6.3.2 Emergency fire extinguishing sets

If manual starting by hand crank is not possible, the emergency fire extinguishing set shall be equipped with an approved starting device capable of at least 6 starting operations within 30 minutes, two of them carried out within the first 10 minutes, even at an ambient temperature of 0 °C.

7. Standby circuits for consumers

7.1 Standby circuits shall be provided for the reciprocal operation of essential equipment with the same function. Changeover to another unit due to a fault shall be signalled optically and acoustically.

7.2 Automatically controlled groups of consumers shall be so structured that a fault in one group does not affect the functioning of other groups.

E. Deck Machinery

1. Anchor windlasses and capstans

1.1 Rating of motors

Motors shall be rated in accordance with Chapter 107-Ship Operation Installations and Auxiliary Systems, at least for short-term duty (S 2 - 30 min), unless the kind of operation for which the ship is intended imposes more stringent demands.

The motors must be able to deliver 1,6 times the rated torque for 2 minutes without dangerous overheating.

1.2 Overload protection

To prevent excessive overloading of the motors and, as far as possible, the gears, electrical overload protection shall be provided as follows:

1.2.1 Unless the motor is not protected against overheating by winding temperature monitoring, a time-delayed overcurrent protection shall be provided, which in case of overload causes shut-off of the motor after 2 minutes of operation at 1,5 times the rated torque.

1.2.2 In addition, an electromagnetic release shall be fitted which is so adjusted that the drive is disconnected when the maximum torque of the anchor windlass is attained. Tripping may be delayed for up to about 3 s in the case of three-phase motors. The

device shall be connected in such a way that, after tripping, the motor can be restarted only from the zero position.

The electromagnetic release may be dispensed with if the clutch and transmission gears are made so strong that jamming the windlass does not cause any damage.

1.2.3 The electromagnetic release is not required in electrohydraulic drives where the maximum torque is limited by a safety valve.

2. Lifting gear

2.1 Emergency shut-down

Lifting gear shall be equipped with an emergency switch which allows immediate stopping of the drive, should the control system fail. Brakes must be released automatically if the ship's power supply fails.

2.2 Control equipment

Levers and hand wheels for the control of lifting equipment must return automatically to the zero position when released.

2.3 Cargo winches and cranes

This equipment shall conform to IEC publication 60204-32.

F. Electrical Heating Equipment and Heaters

1. Space heating

1.1 Space heaters shall be designed and mounted in such a way that combustible components are not ignited by the heat generated. They shall not suffer damage due to overheating.

1.2 For reasons of fire protection, particular attention shall be paid to the special instructions regarding the fitting and mounting of each unit.

1.3 For the construction of this equipment, see Section 14, J.

2. Oil and water heaters

These are subject to the provisions of Section 14, J. and Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 15, G. and Section 16.

G. Heel-Compensating Systems

1. The system must be centrally controlled and monitored. The following facilities shall be provided:

- indicator showing whether the system is in operation
- optical/acoustic fault indication inclination angle indicator

2. The control console shall be provided with a manual emergency OFF switch for systems relevant to the safety of the ship and which are operated only under supervision.

3. Systems relevant to the safety of the ship which are also operated without supervision shall be provided with a manual emergency OFF switch and an automatic OFF switch which shuts down the system without fail when the maximum permitted angle of inclination is reached.

4. Control units for heel compensation systems which are relevant for the ship's safety are subject to mandatory type testing.

H. Containers

1. In the case of navy-specific containers used for temporary purposes on board, the following minimum requirements shall apply. Additional requirements, if needed, shall be set out in the building specification. Reference is made to the TL Rules, - Special Equipment, - Guidelines for the Construction, Repair and Testing of Freight Containers.

2. Plug-in connections for containers must be supplied from own distribution panels. At these distribution panels, it must be clearly visible whether they are energized and which consumer feeder is switched on.

3. It is permissible to group several plug-in connections together via one feeder line, provided that the individual local connections are protected against over current and short circuit and the feeder line is rated for the total power demand.

4. The electricity supply of the power circuits and the controls, as well as the emergency OFF pushbutton must always be routed via flexible and shielded cables.

5. For power circuits up to 250 A, plug-in connections according to IEC publication 60309-1 and 60309-2 shall be used.

6. An interlock shall be provided which only permits the making and breaking of the connection when it is in the de-energized state (see Section 11, C.).

7. Through mechanical measures (e.g. differing pin arrangements), it must be ensured that these connections cannot be interchanged with any plug- and socket connections/plug-in connections that are intended for other purposes or for other voltages, frequencies or currents.

8. On the outside, the containers must be fitted with the possibility of connecting a protective earthing conductor of adequate cross-section (at least 50 mm^2) directly to the hull of the ship. This can be combined with the frame connection.

9. Each container with a hazard potential shall be fitted with an emergency OFF pushbutton.

9.1 The emergency off circuit must be operated at safety extra-low voltage and must ensure that, when the pushbutton is pressed or the circuit is interrupted, the power circuit of the containers is switched off automatically.

9.2 The emergency power supply of a container may be excepted from the switching-off required in 9.1.

9.3 An emergency switch-off can extend to several containers.

10. Containers that are permanently manned shall be fitted with

- Lighting
- Public address system, general emergency alarm
- Manually-operated fire alarm

SECTION 8

MEDIUM – VOLTAGE INSTALLATIONS

A. Scope

These rules also apply to three-phase networks with rated (phase-to-phase) voltages of > 1 kV and not greater than 17,5 kV, and rated frequencies of 50 Hz or 60 Hz.

B. General Provisions

1. Reference to other regulations

The general provisions of this Chapter, especially Section 5, also apply, as and where appropriate, to medium voltage installations, except where more particular requirements are laid down in this Section.

2. Rated mains voltage

The values indicated in Table 8.1 are recommended as standard rated voltages and frequencies.

3. Clearances and creepage distances

3.1 Clearances

Clearances (phase-to-phase and phase-to-hull) for switchgear shall not be smaller than indicated in Table 8.2.

Intermediate values for rated voltage can be allowed, provided that the next higher minimum clearance is adopted.

3.2 Creepage distances

3.2.1 Creepage distances between live components, and between live and earthed components, must be designed in accordance with the rated voltage of the system, allowance being made for the nature of the insulating material and for transient overvoltages due to switching operations and faults.

3.2.2 In the busbar area, creepage distances shall not be less than 25 mm/kV for non-standardized components. The highest voltage for equipment according to IEC publication 60071-3 shall be used as a basis for the dimensioning.

Table 8.1 Rated voltages and rated frequencies

Rated voltage [kV]	Highest voltage for equipment [kV]	Rated frequency [Hz]
3,0 3,3	3,6	50 60
6,0 6,6	7,2	50 60
10,0 11,0	12,0	50 60
15,0 16,5	17,5	50 60

Table 8.2 Minimum clearances for voltage installations

Highest voltage for equipment [kV]	Minimum clearance [mm]
3,6	55
7,2	90
12,0	120
17,5	160

3.2.3 Insulators shall conform to IEC publication 60168 and 60273.

3.2.4 The creepage distances at busbar penetrations shall be in compliance with IEC publication 60137.

3.2.5 The minimum creepage distance behind current limiting circuit breakers and fuses shall not be less than 16 mm/kV.

4. Degrees of Protection

4.1 The degrees of protection specified in Table 8.3 are to be complied with, in addition to the provisions of Section 1,

4.2 If the required degree of protection is not fulfilled by the unit itself, adequate protection must be ensured through appropriate structural measures.

4.3 Protective measures

4.3.1 A hazard to persons through electrical shock and accidental arcs shall be excluded independently of the required protection against foreign bodies and water.

4.3.2 Main switchgear installations shall be subjected to an internal arc test according to IEC 60298 AA6, fulfilling the criteria 1 to 6. This can be omitted if the switchgear has to be isolated before access is given to the place of installation. For installation, see Section 2, F 1.1.

5. Equipotential Bonding, earthing

5.1 All conductive, but in normal operation non-live, components of a medium-voltage installation or equipment shall be provided with an electrically conductive connection to the hull.

5.2 All metal components in the electrical operational compartments shall be included in the equipotential bonding.

6. Earthing

6.1 Metal parts not belonging to electrical equipment shall be earthed if, in the event of a fault, they are liable to come into contact with live components either by direct contact or arcing.

Attention shall be paid to adequate dimensioning of the earthing conductors e.g. for copper conductors the current density shall not exceed a value of 150 A/mm^2 in the event of a fault.

Table 8.3 Minimum degrees of protection against foreign bodies and water (as per IEC 60529)

Equipment / Location	Switchboards	Electrical machinery		Power transformers
		Motors, generators	Terminal boxes	
Locked electrical operational compartments **(1)**	IP 32	IP 23	IP 44	IP 23
Generally accessible operational compartments (category A machinery spaces) and zones below deck (e.g. passage ways)	IP 44	IP 44	IP 44	IP 44
Open deck	-	IP 56	IP 56	-

(1) *Accessible only to trained specialist personnel. Subject to implementation of appropriate safety measures, lower degrees of protection are possible by agreement with* ***T****L (see Section 2, E.1. and F.1.1).*

6.2 Metal components that have permanent and electrically conductive connections to the hull need not be separately earthed.

Bolted connections for the fixing of units or components are not considered electrically conductive connections.

7. Selectivity

For essential systems, selectivity is to be ensured independently of the neutral point design.

C. Network Design and Protection Equipment

1. Electrical Operating Systems

1.1 Essentially, the following arrangements are permitted:

– conductors, insulated from the hull,

– 3 conductors with earthed neutral.

1.2 Medium-voltage systems are permitted only for permanently installed power plants.

1.3 Subject to prior testing, flexible interconnecting cables may be approved by TL in special cases. The necessary measures will be decided in accordance with the particular application.

2. Systems with earthed neutral

2.1 The neutral point connection must incorporate a resistance or other current-limiting device, so that in case of a fault the earth-fault current is limited to the full-load current of the largest generator connected to the switchboard. However, the earth-fault current shall not be less than three times the minimum threshold current of the earth-fault monitor.

2.1.1 In order to fulfill the selectivity requirement expressed in B.6, measures shall be taken for installations with current-limited neutral earths to ensure selective disconnection of earth-faulted outputs, e.g. differential protection relays in all switchboard inputs and output.

2.1.2 Electrical equipment must be designed so that, pending the response of the protective device, it is able to withstand a short-circuit current produced by a single-pole fault against the ship's hull.

2.2 Highly resistive earthed mains, which outputs will not be isolated in case of an earth fault, are permitted, if the insulation of the equipment is designed according 3.2

2.3 Directly earthed mains without current-limiting device require the prior approval of TL.

2.4 Isolating links with neutral earthing

For each neutral point, isolating links are to be provided for the purposes of maintenance and measurement.

2.5 Design of the neutral point connection

2.5.1 All earth resistances shall be connected to the hull. To prevent possible effects on electronic systems, it is recommended that the individual earth resistances should be conductively linked by cables on the earth side.

2.5.2 Generators for parallel operation may have a common hull connection for the neutral point. For each isolatable busbar section directly supplied by generators, a separate neutral point connection shall be provided.

3. Systems with isolated neutral

3.1 Since intermittent earth-faults can cause transient overvoltages in networks with an isolated neutral, endangered equipment shall be fitted with overvoltage protection.

3.2 All insulation of cables, consumers, transformers, generators etc. shall be designed for the phase-to-phase voltage, if earth-faults will not be isolated immediately.

4. Protection Equipment

The provisions of Sections 4 and 5 shall apply, as and where appropriate, to the selection of protection equipment. In addition, the following requirements have to be observed.

4.1 Faults on the generator side of circuit-breakers

Protective devices shall be provided for phase-to-phase faults in the generator connection line, interturn short-circuits within the generator and phase-frame faults in earthed networks. The protective device (differential protection) must trip the generator circuit breaker and de-excite the generator.

4.2 Earth-fault monitoring

Every earth-fault in the system must be visually and audibly signalled.

4.3 Power transformers

4.3.1 The protective devices of power transformers are subject to the provisions of Section 4, D.

4.3.2 Ship supply transformers shall be fitted with differential protection.

4.3.3 Transformers used for supplying primary essential consumers shall be fitted with winding temperature monitors.

4.3.4 Liquid-cooled transformers

4.3.4.1 Liquid-cooled transformers shall be fitted with protection against outgassing of oil.

4.3.4.2 The liquid temperature shall be monitored. An alarm shall be actuated before the maximum permissible temperature is attained. When the temperature limit is reached, the transformer shall be disconnected.

4.3.4.3 The liquid filling level shall be monitored by means of two separate sensors. The monitoring system shall actuate an alarm at the first stage and then cause disconnection at the second, when the permissible limit is exceeded.

4.4 Voltage transformers for control and measuring purposes

4.4.1 Voltage transformers shall be protected on the secondary side against short-circuit and overload.

4.5 HVHRC Fuses

The use of HVHRC fuses for overload protection is not permitted. They shall be used for short-circuit protection only.

5. Low-voltage networks

Low-voltage networks fed via transformers from a medium-voltage network are to be protected against the overvoltages which may result from an insulation failure between the primary and secondary windings.

D. Electrical Equipment

1. General

1.1 Standstill heating

All electrical equipment which may occasionally be taken out of service and which is not located in heated and ventilated areas shall be equipped with a standstill heater. This heater should switch on automatically when the equipment is switched off.

1.2 Installation

For installation of electrical equipment see Section 2, F.

2. Switchgear

2.1 Construction

2.1.1 Medium-voltage switchboards shall have metal clad enclosures which are fully partitioned and closed on all sides.

Incorporated low-voltage compartments for control and monitoring systems shall be separated from the medium-voltage partition in such a way as to render impossible any contact with parts having a rated supply voltage of more than 1000 V.

For main medium-voltage switchboards and distribution switchboards, type approval according to IEC publication 60298 shall be verified.

Switchgear supplying secondary essential or nonessential equipment may be of metal enclosed type.

2.1.2 Fully partitioned switchboards

All sections of an air-insulated medium-voltage switchboard shall be partitioned with respect to each other and the surroundings so that they are arc-resistant. Continuous busbar compartments or switch compartments are inadmissible.

Each section shall be subdivided into at least three arc-resistant, partitioned function compartments: the terminal compartment, the switch compartment and the busbar compartment.

2.1.3 Partly partitioned switchboards

If the main medium-voltage switchboard is subdivided into two independent and autonomous installations, a continuous busbar compartment is permissible, provided that a protection system (arc monitor, busbar differential protection) is installed which detects internal faults and isolates the affected part of the installation within 100 ms, respectively accidental arcing is reliable prevented by design measures e.g. solid insulated busbar systems.

2.1.4 A sufficient number of isolating links and earthing and short-circuit devices shall be provided to enable maintenance work to be performed safely on parts of the equipment.

2.1.5 Where drawout switchgear units are used, the following conditions must be met:

- Functional testing and maintenance must be capable of being performed in safety, even when the busbar is live.
- Drawout switchgear units shall be fitted with mechanical interlocking devices effective in the operating and disconnected position. A key interlock is permitted for maintenance purposes.
  Drawout switchgear units are to be lockable in the operating position.
- The fixed contacts for drawout switchgear units are to be so arranged that, in the withdrawn position, the live contact components are automatically covered, or that complete withdrawal is possible only after a cover has been fitted.

2.1.6 Doors which give access to medium voltage are to be interlocked in such a way that they can be opened only after clothing the earthing switch.

2.1.7 It shall be possible to split main medium-voltage switchboards into two sections by means of at least one circuit breaker. This breaker shall be fitted with selective protection.

2.1.8 Switchboards insulated with protective gas shall have an independent volume of gas for each half-switchboard which is monitored for loss of pressure. A visible and audible warning shall be issued before the affected half-switchboard is disconnected.

The corresponding safety instructions shall be displayed in case work has to be done to repair any damage. Before work starts, the compartments shall be ventilated adequately. The appropriate protective equipment (breathing apparatus, protective clothing etc.) shall be kept ready.

2.2 Auxiliary systems

2.2.1 Where electrical energy and/or mechanical energy is required for the operation of switches, a means of storing such energy which is designed for at least two ON/OFF switching cycles of all the connected components shall be provided.

Tripping due to overload, short circuit or under voltage shall be independent of any stored electrical energy.

2.2.2 Number of energy sources

For the supply of auxiliary circuits two independent uninterruptible power supplies shall be provided. If one of these uninterruptible power supplies fails, the remaining unit shall supply all switchboard sectors. The switch-over to the reserve source of energy shall be automatically and actuate an alarm. Each uninterruptible power supply shall be fed from both power stations by choice. The supply shall be monitored.

2.3 Tests

2.3.1 An individual test in accordance with IEC 60298 shall be performed in the manufacturer's works in the presence of a TL surveyor.

A functional test of the interlocking conditions, protective functions, synchronization and the various operating modes shall be performed.

A test schedule shall be compiled and submitted for approval.

2.3.2 It is recommended that a partial-discharge test be performed in accordance with IEC publication 60298, Appendix FF, if organic insulating materials or gas-insulated busbar penetrations are used.

2.3.3 High-voltage test

A voltage test at power-frequency shall be performed on every switchgear unit.

The value of the alternating withstand voltage shall be selected in accordance with Table 8.4. The duration of the test is 1 minute in each case.

The following tests must be carried out in every case:

– Conductor to earth,

– Between conductors.

For this purpose, each conductor of the main circuit is connected in turn to the high-voltage connection of the test unit. All the other conductors of the main and auxiliary circuits are to be connected to the earth conductor, or to the frame and the earth connection of the test unit.

Table 8.4 Test voltages for switchgear

Rated voltage [kV]	Test voltage (R.M.S. value) AC withstand voltage [kV]	Impulse test voltage [kV]
1 – 3,6	10	40
3,6 – 7,2	20	60
7,2 – 12	28	75
12 – 17,5	38	95

The electrical tests are to be performed with all switching devices in the closed position, and with all withdrawable parts in the operating position.

Voltage transformers or fuses may be replaced by dummies which simulate the field distribution of the high-voltage layout.

Overvoltage protection devices may be isolated or removed.

2.3.4 Impulse voltage test

An impulse voltage test in accordance with Table 8.4 may be recognized as equivalent to the high-voltage test. The duration of the test comprises 15 successive pulses.

The unsynchronized connection of sub-networks and the feedback on the medium voltage side shall be prevented by means of interlocking.

2.4 Low voltage switchgear design

2.4.1 If the ship's low-voltage network is supplied from the medium-voltage system a circuit breaker for the longitudinal separation of the main busbar shall be provided.

2.4.2 The arrangement of supply- and consumer sections shall be in accordance with Section 5, C. 2

2.4.3 The feeder sections of the low-voltage switchboard shall be partitioned with arc-resistant segregations.

2.4.4 The unsynchronized connection of subnet-works and the feedback on the medium-voltage side shall be prevented by means of interlocking.

3. Switchboard Equipment

3.1 General

Control circuit equipment is subject to the conditions laid down for low-voltage switchgear, see Section 5.

Note:

A single-fault event in the synchronization circuit or in the black-out monitoring must not lead to an asynchronous connection.

3.2 Circuit breakers

Circuit breakers are to conform to IEC publication 60056.

3.2.1 For drawout circuit breakers, see 2.1.5.

3.2.2 Circuit breakers shall be interlocked with the associated earthing switch.

3.3 Load switch-disconnectors and isolating switches

3.3.1 Load switch-disconnectors and isolating switches shall conform to IEC publication 60265.

3.3.2 Isolating switches shall be interlocked so that they can only be switched under no load. The use of load-switch-disconnectors is recommended.

3.3.3 Earthing switches shall have making capacity.

3.4 HVHRC fuses

HVHRC fuses shall conform to IEC publication 60282.

3.5 Power contactors

Power contactors shall conform to IEC publication 60470.

3.6 Transformers

3.6.1 Transformers shall conform to the following IEC publications:

– Current transformers, IEC publication 60044-1,

– Voltage transformers, IEC publication 60044-2.

3.6.2 Earthing of current and voltage transformers

The secondary winding of every current- and voltage transformer shall be earthed by means of a copper conductor at least 4 mm^2 in cross-section.

Open delta windings shall only be earthed at one point.

3.6.3 Relays

Relays for measuring and protective devices shall conform to IEC publication 60255.

4. Electrical machines

4.1 Construction

4.1.1 Generator stator windings

The ends of all stator windings shall be run to terminals in the terminal box.

4.1.2 Winding temperature monitoring

The stator windings of electrical machines shall be equipped with temperature detectors. Inadmissible temperature rises shall actuate visual and audible alarms. Measures are to be taken which protect the measuring circuit against overvoltages.

4.2 Terminal boxes

Terminals with operating voltages ≤ 1000 V shall be provided with their own terminal boxes. Terminals shall

be marked clearly.

4.3 Tests

The tests specified in Section 14, A apply to medium-voltage machines, as and where appropriate.

5. Power Transformers

5.1 Design

5.1.1 Power transformers shall conform to IEC publication 60076.

5.1.2 Dry-type transformers should be used by preference. They shall conform to IEC publication 60726. Exceptions shall be agreed with TL**.**

5.1.3 Only transformers with separate windings shall be used. Auto-transformer starters form an exception.

5.1.4 Transformers producing a low voltage from a medium voltage shall be equipped with an earthed shielding winding between the low-voltage and medium-voltage coil.

5.1.5 If oil-cooled transformers are used, measures shall be taken to ensure that the windings are completely covered by oil, even for inclinations of 22,5°.

5.2 Ship supply transformers

5.2.1 If the ship's low-voltage network is supplied from the medium-voltage network, at least two independent ship supply transformers which fulfill the conditions expressed in Section 3, B.2.2, shall be installed. The supply shall be taken from the associated medium voltage switchboards of the power stations.

For each power station, an independent low voltage power station switchboard shall be provided.

5.2.2 Ship supply transformers shall be provided with instrumentation comprising a voltmeter and an ampermeter. It shall be possible to indicate the current and voltages of all three phases.

5.3 Tests

Power transformers shall be individually tested at the manufacturer's works in the presence of a TL Surveyor.

5.3.1 The scope of the tests is stated in Section 14, C.

6. Cables

6.1 General

6.1.1 Medium-voltage cables shall conform to IEC publication 60092-354 or 502. Only halogen-free cables are admissible; in the case of special cables with specific approval by TL, low-halogen cables will be permitted.

6.1.2 The requirements stated in Section 12 apply as and where appropriate.

6.2 Selection of cables

6.2.1 The rated voltage of a cable shall not be less than the rated operational voltage of the circuit in question.

6.2.2 In insulated-neutral networks, the phase-to-phase voltage (U) of the network shall be deemed to be the rated voltage (U_o) of the cable between one conductor and the ship's hull.

6.3 Tests

Tests shall be performed in accordance with Section 14, G, as and where appropriate.

The voltages for the high-voltage test are indicated in Table 8.5.

E. Installation

1. General

For installation see also Section 2, F.1.

2. Cable installation

2.1 Cable routes

Medium-voltage cables shall not be run through the accommodation area. In the case of cable layouts not adhering to this rule, approval by TL is required prior to the start of installation work.

2.2 Separation from low-voltage cables

2.2.1 Medium-voltage cables shall be laid with a minimum distance of 50 mm to the low-voltage cables.

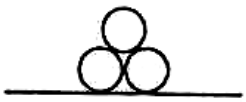
2.3 Design of the installation

2.3.1 Medium-voltage cables laid in open cable trays shall be provided with continuous metal shields and armourings against mechanical damage; shields and armourings shall be electrically conductive connected to the ship's hull.

2.3.2 Medium-voltage cables without armouring shall be laid so that they are protected against mechanical damages, e.g. in closed metal ducts which are electrically conductive connected to the ship's hull.

For the installation of single core cables for A.C. wiring the metal ducts shall be made of non magnetic material, unless the cables are installed in trefoil formation.

2.3.3 For bends, the minimum-bending radius permitted by the manufacturer shall be observed; if not specified than the bending radius shall be not smaller than 12 times of the outer diameters of the cables.



2.4 Marking of cable ducts and conduits

Cable ducts and conduits for medium-voltage cables shall be marked in accordance with Section 2, F.

2.5 Connections

2.5.1 As far as is feasible, all connections of a medium-voltage cable shall be covered with suitable insulating materials.

2.5.2 In terminal boxes where the conductors are not insulated, the phases are to be separated from each other and from the hull potential by mechanically robust barriers of suitable insulating material.

2.6 Sealing ends, joints and kits

2.6.1 For medium-voltage kits from 3,6 / 6 kV measures shall be taken to attenuate the electrical fields which occur at points where cable insulations are removed (sealing ends).

2.6.2 The materials of sealing ends and joints shall be compatible to the corresponding cables.

2.6.3 The construction of joints shall permit the separate through-connection of all shields and armourings.

2.6.4 Sealing ends shall enable shields and armourings to be brought out.

2.6.5 The technical documentation and test certificates of sealing ends and joints shall be submitted.

2.7 Assembly

The manufacturer's assembly instructions shall be observed.

3. Tests

3.1 Tests following installation

When the installation work has been completed, medium-voltage cables are to undergo voltage tests in the presence of a TL Surveyor; the sealing ends and cable joints shall also be tested. The test is to conform to IEC publication 60502.

Note:

Compliance with the safety regulations for tests at high voltage is the responsibility of the testing body.

3.2 The following tests can be applied alternatives:

3.2.1 High-voltage test at 70 % of the DC voltage test value shown in Table 8.5 for a period of 15 minutes between conductor and shield, or

3.2.2 Test using the rated (phase-to-phase) voltage/frequency between conductor and shield for a period of 5 minutes, or

3.2.3 Test using the operating voltage of the system for a period of 24 hours.

3.3 The insulation resistance is to be measured before and after the high-voltage test (500 V DC/200 MΩ).

Table 8.5 Test voltages for medium-voltage cables

Max. system voltage U_m	kV	1,2	3,6	7,2	12	17,5	24,0
Rated voltage U_o /U	kV/kV	0,6/1,0	1,8/3,0	3,6/6,0	6,0/10,0	8,7/15,0	12,0/20,0
AC test voltage	kV	3,5	6,5	11,0	15,0	22,0	30,0
DC test voltage	kV	8,4	15,6	26,4	36,0	52,8	72,0

Notes: U_o *: rated voltage between conductor and earth or metal shield.*
U : rated voltage between the conductors for which the cable is designed

SECTION 9

CONTROL, MONITORING AND SHIP'S SAFETY SYSTEMS

A. General

1. Scope

1.1 This Section sets out requirements for the equipment and design of control, monitoring and ship's safety systems necessary for the operation of the ship and the machinery installation and for the safety of the ship.

1.2 The general requirements stated in this Section also apply to the open and closed-loop control and measuring systems of essential equipment, see Section 1, B.2.

1.3 Regarding additional requirements for ships with unmanned engine room see Chapter 106 - Automation.

1.4 Additional, equipment needed for the military mission beyond the operational requirements of the ship platform shall be laid down in the building specification.

2. Planning and Design

2.1 The requirements laid down for each unit and system depend on their use and the process-technological conditions. The Rules stipulate the minimum requirements.

2.2 If special operating conditions call for a particular system design, additional requirements may be imposed, depending on the operational and system-specific considerations.

2.3 The design of safety measures, open and closed loop controls and monitoring of equipment must limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

2.4 Where appropriate, the following basic requirements shall be observed:

– Compatibility with the environmental and operating conditions,

– Compliance with accuracy requirements,

– Recognizability and constancy of the parameter settings, limiting- and actual values,

– Compatibility of the measuring, open and closed loop controls and monitoring systems with the process and its special requirements,

– Immunity of system elements to reactive effects in overall system operation,

– Non-critical behaviour in the event of power failure, restoration and of faults,

– Unambiguous operation,

– Maintainability, the ability to recognize faults and test capability,

– Reproducibility of values.

2.5 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

2.6 If dangers to persons or the safety of the ship arising from normal operation or from faults or mal-functions in machinery or plant, or in control, monitoring and measuring systems, cannot be ruled out, safety devices or safety measures are required.

2.7 If dangers to machinery and systems arising from faults or malfunctions in control, monitoring and measuring systems cannot be ruled out, protective devices or protective measures are required.

2.8 Where mechanical systems or equipment are either completely or partly replaced by electric/electronic equipment, the requirements relating to mechanical systems and equipment according to Chapter 104 Propulsion Plants shall be met accordingly.

3. Design and Construction

3.1 Machinery alarm systems, protection and safety systems, together with open and closed loop control systems for essential equipment shall be constructed in such a way that faults and malfunctions affect only the directly involved function.

This also applies to measuring facilities.

3.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities must be provided to permit manual operation

3.3 In the event of disturbances automatically switched-off plants shall not be released for restarting until having been manually unlocked.

3.4 For the design of safety devices, safety systems, and of open- and closed-loop control and alarm systems, see Chapter 106 - Automation.

3.5 For the use of fire resistant cables, see Section 12, D.

4. Application of Computers and Computer Systems

If computers are used for tanks essential to the safety of the ship or its crew, they shall conform to the requirements for hardware and software according to Section 10.

5. Maintenance

5.1 Access must be provided to systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps etc. shall be provided to allow functional checks to be carried out and faults to be located.

5.2 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

5.3 Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign must be fitted to indicate the risk.

5.4 Circuit boards and plug-in connections must be protected against unintentional mixing up. Alternatively they must be clearly marked to show where they belong to.

B. Ship Control Systems

1. Engine Telegraph Systems

1.1 General requirements

At least two mutually independent command transmission units shall be provided for the commands from the bridge to the position in the engine room or machinery control room from which speed and direction of thrust of the propellers is normally controlled. One of these units shall be an engine telegraph system.

The second appropriate means of command transmission must be independent of the main engine telegraph system.

Suitable means of communication shall be provided from the bridge and the engine room to all other positions from which speed and thrust of the propeller can be varied.

1.2 Main engine telegraph system

1.2.1 The controls of the transmitters and receivers must be safeguarded by suitable means, e.g. notching, against inadvertent move.

1.2.2 Engine telegraphs shall be of the two-way systems type in which the signal given by the receiver is also immediately discernible at the transmitter.

1.2.3 In the case of installations with several control positions the acknowledged command must be indicated at all control positions. Where control positions are selected by switching, additionally indication shall be provided of which one is in use.

1.2.4 Transmitters and receivers shall be equipped with call-up devices which remain in operation from the start of the command transmission until it is correctly acknowledged. The audible signal shall be hearable at all points in the engine room. If necessary, optical signals shall be provided in addition to the audible signals.

1.2.5 Power supply must be provided from the main source of electrical power.

1.3 Emergency engine telegraph system

1.3.1 The function of the emergency engine telegraph system shall conform to that of the main system in accordance with 1.2.1 and 1.2.2.

Power supply must be provided from the emergency source of electrical power.

1.3.2 Instead of the emergency engine telegraph system a telephone system may be fitted.

2. Indicators on the Bridge

2.1 All instruments and indicators important to the control of the ship must be legible at all times.

2.2 All indicators and illuminations for instruments must be provided with dimmers.

3. Rudder Angle Indicators

3.1 The ship's main control station must be equipped with a rudder angle indicator whose transmitter is actuated by the rudderstock.

3.2 All the equipment forming part of the rudder angle indicator system must be independent of the steering gear control.

3.3 The rudder angle indicator must be legible from all control stations on the bridge. The display must be continuous.

3.4 If the rudder angle is not clearly apparent at the emergency manual steering gear control position in the steering gear compartment, an additional rudder angle indicator must be fitted.

3.5 The above requirements also apply, as and where appropriate, to rudder propeller systems. The indicators shall be so designed that they indicate the direction of motion of the ship.

3.6 If the steering gear shall be also supplied from the emergency source of electrical power, the rudder angle indicator must be supplied from the main and emergency source of electrical power, see also Section 7, A. 2.

4. Voice Communication and Signalling Systems

4.1 Important voice communications (intercommunication systems and talkback systems)

4.1.1 The voice communications specified below shall be designed to ensure fully satisfactory vocal intercommunication under all operating conditions.

The systems shall be designed to provide individual links, although this feature may be dispensed with if it is ensured that the bridge can cut into existing conversations at all times.

4.1.2 The following voice communications are required:

4.1.2.1 Bridge-Radio room,

This link is not required if communications can be made without recourse to equipment.

4.1.2.2 Bridge-machinery control centre (MCC)

4.1.2.3 Bridge-Engine rooms,

Required is a two-way call-up and intercommunication systems between the bridge and all the control positions in the machinery rooms from which the main propulsion plant can be controlled. The call-up devices in the engine room shall be so designed that they are discernible from any position in the engine room, even when operating at full power.

This voice communication is not required if a main and emergency telegraph is available, see 1.1

4.1.2.4 Bridge-Steering gear compartment,

An intercommunication system is required between the bridge and the steering gear control position in the steering gear compartment.

4.1.2.5 Bridge –combat information centre (CIC)

4.1.2.6 Bridge –damage control centre (DCC)

4.1.3 If the voice communication system requires an electrical power supply, this supply shall be from the main source and another independent source of electrical power.

4.2 Voice communications in an emergency

4.2.1 An intercommunication system shall be provided which enables commands to be transmitted between strategically important locations, the assembly point, the emergency control stations, the muster stations and the launching stations of lifesaving equipment.

4.2.2 This system may comprise portable or permanently installed devices.

4.3 Wireless calling system (paging system)

4.3.1 The wireless calling system is used for conveying information and alarms to selected crew members; it does not replace the mandatory equipment to be installed permanently.

4.3.2 Alarms shall be given higher priority than person-to-person calls. Calls to persons must not suppress alarms.

4.3.3 Command and alarm functions shall be provided as for conventional permanently wired systems.

4.3.4 The minimum duty period of the mobile units after a complete charging cycle should be at least 12 hours. At the end of the duty period, an alarm should be issued in good time before the unit switches off automatically.

4.3.5 The radio links between the fixed stations and the mobile units shall be tested automatically at regular intervals, but at least once a minute. Loss of the connection shall trigger an alarm.

4.3.6 Evidence that the system works satisfactorily in all areas of the ship shall be provided by means of an on-board test.

4.3.7 Charging stations shall be made available in sufficient quantity.

4.3.8 In the event of failure of the main source of electrical power, the fixed stations must be supplied from another independent source of electrical power.

4.4 CO_2 alarm systems

For the general design and construction of CO_2 alarm systems, see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9.

4.4.1 For machinery spaces, boiler, cargo pump rooms and similar spaces acoustic alarms of horn or siren sound is to be provided which shall be independent of the discharge of CO_2. The audible warning is to be automatically actuated at a suitable time before flooding occurs and is to be clearly distinguishable from all other alarm signals.

The period of time necessary to evacuate the space to be flooded shall be considered as adequate, but not less than 20 s. The system is to be designed such that flooding is not possible before this period of time has elapsed.

Opening the door of the release station must trip the CO_2 alarm in the protected space.

The alarm must continue to sound as long as the flooding valves are open. A visual alarm is also to be installed where necessary.

4.4.2 Where adjoining and interconnecting spaces, e.g. machinery space, purifier room, machinery control room, have separate flooding systems, any danger to persons must be excluded by suitable alarms in the adjoining spaces.

4.4.3 Alarm systems are also to be provided in ro-ro spaces, spaces for the transport of reefer containers and spaces to which personnel normally have access. In small spaces, e.g. small compressor rooms, paint stores, etc., alarms may be dispensed with on application.

4.4.4 If the alarm is operated pneumatically, a permanent supply of compressed air for the alarm system is to be ensured.

4.4.5 In the event of failure of the main source of electrical power, the CO_2 alarm system must be supplied from another independent source of electrical power.

4.5 Refrigerating compartment closure alarm

A closure alarm shall be provided to a permanently manned location.

4.6 Sound signalling system

The ship's sound signalling system must remain operative if the electrical main power supply fails.

4.7 Monitoring devices for military use

For military use monitoring warning devices are to be provided as:

- Diver in water
- Helicopter in operation
- Shoot warning
- Citadel in operation
- Hospital call

4.8 Fire resistant cables

For the use of fire-resistant cables, see Section 12, D.

C. Ship Safety Systems

1. General Emergency Alarm

1.1 An alarm system shall be provided to alert the crew or to call them to the assembly points. It must be possible to release the alarm from the bridge, the combat information centre (CIC) and from other strategical important locations.

1.2 Means for alarm alarm announcement shall be provided in a sufficient number and loudness to ensure that all persons inside the ship and on deck are alerted.

1.3 In areas with high noise levels, additional optical means of alarm may be required.

1.4 Once released, the alarm must sound continuously until it is switched off manually or is temporarily interrupted for an announcement through the public address system. At least 2 signal generators must be provided.

1.5 If the main source of electrical power fails, the general emergency alarm system must be powered by the uninterruptible power supply of electrical power, see Section 3, D.

2. Public Address System

2.1 In addition to the general emergency alarm system, a public address system is required which can be operated from the bridge, the CIC, the DCC, and other strategical important locations. The public address system must be audible throughout the accommodation area, at the crew's normal working places, at the stations manned during combat and at the strategical important locations.

2.2 If the public address system is used to announce the general emergency alarm, the following requirements shall be fulfilled:

2.2.1 The requirements for the general emergency alarm shall be fulfilled.

2.2.2 At least two amplifiers shall be provided, each of them separately supplied and fused.

2.2.3 At least two loudspeaker circuits, supplied from separate amplifiers, shall be installed in each watertight compartment.

The loudspeaker circuits shall be so arranged that an announcement at a reduced acoustic irradiation is maintained in the event of a failure of an amplifier or loudspeaker circuit.

2.2.4 Where loudspeakers with built-in volume controls are used, the volume controls must be disabled by the release of the alarm signal.

2.2.5 It shall be possible to transmit the undistorted and clearly audible alarm signal at all times. Other simultaneous transmissions must be automatically interrupted.

2.2.6 It shall be possible to operate all loudspeakers at the same time.

2.2.7 Short circuits in loudspeakers shall not lead to a failure of the entire loudspeaker circuit.

This requirement is deemed to have been met if the individual loudspeakers are supplied via transformers and a short circuit on the secondary side of the transformer does not impair the function of the other loudspeakers.

2.2.8 If the main source of electrical power fails, the loudspeaker system must be powered by the uninterruptible power supply of electrical power, see Section 3, D.

3. Fire Detection and Fire Alarm Systems

3.1 General requirements

For general requirements see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9 and for scope of use also Chapter 106 - Automation.

3.1.1 A centralized fire detection system for the entire ship must be supplied from at least two power station switchboards or different main groups or from the main and emergency source of electrical power. In the event of failure of a power supply, there shall be an automatic switch-over, uninterruptible power supply according to Section 3, D. to the other source of electrical power. On switching over, an alarm must be triggered.

If the other source of electrical power is a storage battery, it must meet the functional requirements stated in Section 3, C.2.1.4.

3.1.2 Decentralized fire detection systems (with autonomous departments) must be supplied according to 3.1.1.

3.1.3 The operational readiness of the alarm system shall be indicated, and failure of the power supply must trigger an alarm.

3.1.4 Fire detection systems shall not be used for other purposes, except for the automatic closure of fire doors, shut-off fans or similar functions.

3.1.5 Fire detection and fire alarm systems are subject to mandatory type-testing.

3.2 Design

3.2.1 Activation of a fire detector shall initiate an alarm at the central fire alarm panel and at the additional indicating devices.

At the central fire alarm panel, and if necessary at other safety stations, it must be possible to identify the place where the triggered fire detector is fitted.

Where the detectors in the alarm mode are not all simultaneously indicated at the central fire alarm panel, the central panel must have the means of scanning all the detectors which have responded, in order to establish clearly whether other detectors are in the alarm mode besides the one indicated.

3.2.2 The fire detection system must be self-monitoring. Faults - such as a supply failure, short circuit or wire break in detection loops, the removal of a detector from its base, and earth faults in detection loops with all-pole insulation - must be optically and audibly signalled at the central fire alarm panel. Fault alarms must be acknowledgeable and, wherever possible, distinguishable from a fire alarm.

The emission of acoustic and optical alarms must continue until they are acknowledged at the central fire alarm panel.

Acknowledgement of the acoustic fire alarm must be made before acknowledgement of the optical fire alarm. The acknowledgements of acoustic and optical fire alarm signals must be independent of each other.

Acknowledgement shall not disconnect the detection loop, nor shall it suppress further alarm signals.

The simultaneous response of fire detectors shall not impair the operation of the system.

The first fire alarm indicated shall not prevent the indication of further alarms.

3.2.3 The fire alarm panel must be provided with means for the testing and disconnecting of individual detectors or detector loops. When a particular detector/ detector loop is disconnected, this must be clearly recognizable.

The failure or disconnection of one detector or detector loop shall not affect the operation of another detector or detector loop.

Wire breaks, short circuits and earth faults shall not lead to failure of the entire central fire alarm panel.

3.2.4 The central fire alarm panel shall be located on the bridge, in the Machinery Control Centre (MCC) and, if necessary, in other control stations and it must be distinguishable from other alarms.

3.2.5 If a fire signal is not acknowledged within two minutes, an acoustic fire alarm should be automatically released in all crew accommodation areas, service rooms, control stations and machinery spaces. This alarm system need not to be integrated into the fire detection system; the general emergency alarm signalling appliances may be used for this purpose.

3.3 Fire detectors

3.3.1 All fire detectors must be so designed that they remain serviceable, without the replacement of components, on having passed regular testing.

3.3.2 Automatic fire detectors shall respond to heat, smoke or other combustion products, flames or a combination of these factors. Detectors which are activated by other influences may be approved, provided they are not less sensitive than the aforementioned detectors.

3.3.3 Heat detectors shall be certified to operate before the temperature exceeds 78 °C but not until the temperature exceeds 54 °C, when the temperature is raised to those limits at a rate of less than 1 °C per minute. In rooms with high ambient temperatures (e.g. drying rooms), a detector response temperature exceeding the maximum room temperature by 30 °C is permissible.

3.3.4 Fire detectors which signal a fire at an early stage of its development (e.g. smoke detectors) shall be fitted in areas such as machinery spaces, passageways, staircases and escape routes.

3.3.4.1 The position and number of detectors shall be specified in the building specification under consideration of machinery space ventilation, so that all endangered areas are safely covered, see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9. This particularly applies to areas in which boilers, waste and sludge incinerators, generators, switchboards, refrigeration machinery and purifiers are installed and also for the engine casing and at the exhaust gas ducts and in exhaust gas-fired boilers with finned pipes.

3.3.4.2 In workshops and rooms where detectors are liable to be actuated, e.g. by welding, they may be temporarily rendered ineffective. The detectors must automatically become operative again after a preset time.

3.3.5 Heat detectors shall be used as the sole detector only in accommodation areas.

3.3.6 Flame detectors shall only be used in addition to the mandatory detectors.

3.3.7 The detectors shall be mounted in such a way that they can operate properly. Mounting places near ventilators, where the operation of detectors may be impaired or where mechanical damage may be expected, shall be avoided.

Detectors mounted on the ceiling must generally be placed at least 0,5 m away from bulkheads.

In general, the maximum monitored area, and the maximum distance between detectors, shall not exceed the following values:

- for heat detectors 37 m^2 or a distance of not more than 9 m
- for smoke detectors 74 m^2 or a distance of not more than 11m

The distance from bulkheads shall not exceed:

- 4,5 m for heat detectors
- 5,5 m for smoke detectors

3.3.8 Manually operated call points shall be provided in the accommodation area, the service areas, control station and at every exit.

No part of a passageway shall be more than 20 m. away from a manually operated call point.

3.3.9 If manually operated call points are not sufficiently recognizable with the aid of a replacement emergency lighting arrangement installed nearby, they must be provided with an illuminated sign.

3.3.10 Fire detectors for use in critical environments, see also 3.3.4.1, can be fitted with appropriate filters, provided that evidence of their suitability is given.

3.4 Installation

3.4.1 Within each damage control zone the fire detectors shall form one separate loop or autonomous fire detection system.

3.4.2 The detector loop shall be so arranged within a damage control zone that in the event of damage, e.g. wire break, a short circuit or a fire, only a part of the loop becomes faulty.

3.4.3 Cables forming part of the fire detection system shall be so arranged as to avoid direct contact to galleys, machinery spaces and other closed spaces with a high fire risk, except if it is necessary to transmit a fire signal from these spaces, to initiate a fire alarm in these spaces, or to make the connection to the appropriate source of electrical power.

3.4.4 A monitoring loop covering a control station or a service area or an accommodation area shall not simultaneously monitor a machinery space.

4. Watertight door control systems

For watertight doors and openings relevant to the stability of the ship in the damaged state, control and monitoring devices shall be provided as follows:

4.1 For bulkhead doors Chapter 102 - Hull Structures and Ship Equipment, Section 9, B. shall be observed. For bow doors, side shell and stern doors, see Chapter 102 - Hull Structures and Ship Equipment, Section 22, B. and C.

4.2 Optical indicators showing whether the door is closed or open shall be provided at the remote control position. Closing of the door shall be announced on the spot by an acoustic signal.

4.3 Access doors and access hatch covers normally closed at sea shall be provided with means of monitoring. Indicators shall show, locally and at a permanently manned station, whether these doors or hatch covers are open or closed.

4.4 Indicators shall be provided at the remote control position to signal a failure of the control system.

4.5 The operating console on the bridge or at the damage control centre (DCC) must be provided with a schematic system showing the arrangement of the watertight doors in the ship.

5. Voyage data recorder (VDR)

5.1 If a voyage data recorder is specified in the building specification, the VDR should be supplied from the main- and uninterruptible power supply, see Section 4, I.9. 1and I.9.3.

5.2 Data or alarms for the Voyage Data Recorder have to be free of reactive effects to ship's operations.

SECTION 10

COMPUTER SYSTEMS

A. General

1. Scope

These Rules apply additionally, if computer systems are used for tasks essential to the safety of the ship, cargo, crew or embarked troops and are subject to classification. They are not applicable for weapon and tactical command systems.

2. References to Other Rules and Regulations

2.1 IEC publication 60092-504 “Electrical Installations in Ships“ Part 504: Special features – Control and instrumentation.

2.2 IEC publication 61508 “Functional Safety of Electrical / Electronic/ Programmable Electronic Safety Related Systems”.

3. Requirements Applicable to Computer and Systems

3.1 Computer systems shall fulfill the requirements of the process under normal and abnormal operating conditions. The following shall be considered:

– Danger to persons

– Environmental impact

– Endangering of technical equipment

– Usability of computers and computer systems

– Operability of all equipment and systems in the process**.**

3.2 If process times for important functions of the system to be supervised are shorter than the reaction times of a supervisor and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

3.3 Computer systems shall be designed in such a way that they can be used without special computer knowledge. Otherwise, appropriate assistance shall be provided for the user.

B. Requirement Classes

1. General Requirements

1.1 Computer systems are assigned, on the basis of a risk analysis, to requirement classes as shown in Table 10.1. This assignment shall be accepted by TL. Table 10.2 examples for such an assignment.

1.2 The assignment is divided into five classes considering the extent of the damage caused by an event.

1.3 Only the extent of the damage directly caused by the event is considered is, but not any consequential damage

1.4 The assignment of a computer system to the corresponding requirement class is made under consideration of the maximum possible extent of direct damage to be expected.

Table 10.1 Definition of requirement classes

Requirement class	Extent of damage		
	Effects on persons	Effects on the environment	Technical damage
1	none	none	insignificant
2	slight injury	insignificant	minor
3	serious, irreversible injury	significant	fairly serious
4	loss of human life	critical	considerable
5	much loss of human life	catastrophic	loss

Table 10.2 Examples of assignment into requirement classes

Requirement class	Examples
1	Supporting systems for maintenance Systems for general administrative tasks Information and diagnostic systems
2	"Off line" cargo computers Navigational instruments Machinery alarm and monitoring systems Tank capacity measuring equipment
3	Controls for essential equipment Machinery protection systems/equipment Speed governors "Online" cargo computers, networked (bunkers, draughts etc.) Remote control for main propulsion Fire alarm system, gas and hazardous-material detection systems Citadel pressure monitor, radiation contamination unit, chemical agent warning system, gunshot warning system NBC protection and defence functions Fire extinguishing systems Bilge drainage systems Integrated monitoring, control and regulation (MSR) systems Control systems for tank, ballast and fuel transfer Rudder control systems Navigational systems Course control and regulation systems for propulsion and steering
4	Electronic injection systems
5	Course control systems, including positioning systems (where manual intervention to avert danger in the event of failure or malfunction is no longer possible).

1.5 In addition to the technical measures stated in this section also organizational measures may be required if the risk increases. These measures shall be agreed with TL.

2. Risk Parameters

2.1 The following aspects may lead to assignment to a different requirement class, see Table 10.1.

2.1.1 Dependence on

- Type and size of ship
- Number of persons endangered
- Ship's speed.

2.1.2 Presence of persons in the endangered area with regard to duration respectively frequency

- Rarely
- Often
- Very often
- At all times.

2.1.3 Averting of danger

To evaluate the possibility of averting danger, the following criteria shall be considered:

2.1.3.1 Operation of the technical equipment with or without supervision by a person.

2.1.3.2 Temporal investigation into the processing of a condition able to cause a damage, the alarming of the danger and the possibilities to averting the danger.

2.1.4 Probability of occurrence of the dangerous condition

This assessment is made without considering the available protection devices.

Probability of occurrence:

- Very low,
- Low,
- Relatively high.

2.1.5 Complexity of the system

- Integration of various systems
- Linking of functionalities.

2.2 The assignment of a system into the appropriate requirement class shall be agreed on principle with TL.

3. Measures Required to Comply with the Requirement Class

3.1 The measures needed to comply with the requirements of classes 4 and 5 may require separation of computer equipment from conventional equipment or a redundant, diversified design for the computer equipment.

3.2 Protection against modification of programs and data

3.2.1 The measures required depend on the requirement class and the system configuration (see Table 10.3).

3.2.2 Computers and computer systems shall be protected against unintentional or nauthorised modification of programs and data.

3.2.3 For large operating systems and programs, other storage media, such as hard disks, may be used by agreement.

3.2.4 Significant modifications of program contents and system-specific data, as well as a change of version, shall be documented and must be retraceable.

Notes:
A significant modification is a modification which influences the functionality and/or safety of the system.

Table 10.3 Program and data protection measures in relation to the requirement class (examples)

Requirement class	Program/Data memory
1	Protection measures are recommended e.g. CD-ROM, magnetic disk
2	Protection against unintentional/unauthorised modification e.g. buffered RAM
3	Protection against unintentional/unauthorised modification and loss of data e.g..EEPROM
4	No modifications by the user possible e.g. EPROM
5	No modifications possible e.g. ROM

3.2.5 For systems of requirement class 4 and 5 all modifications, even the modifications of parameters, shall be submitted for approval.

3.2.6 The examples of program and data protection shown in Table 10.3 may be supplemented and supported by additional measures in the software and hardware, for example:

- User name, identification number
- Code word for validity checking, key switch
- Assignment of authorizations in the case of common use of data / withdrawal of authorizations for the change or erasing of data
- Coding of data and restriction of access to data, virus protection measures
- Recording of workflow and access operations.

C. System Configuration

1. General Requirements

1.1 The technical design of a computer system is given by its assignment to a requirement class. The measures listed below for example, graded according to the requirements of the respective requirement class, shall be ensured.

1.2 For subsystems, evidence shall be proved that the design is self–contained and reactionless.

1.3 The computer systems must be fast enough to perform autonomous control operations and to inform the user correctly and carry out his instructions of the correct time under all operating conditions.

1.4 Computer systems shall monitor the program execution and the data flow automatically and cyclically e.g. by means of plausibility tests or monitoring of the program and data flow over time.

1.5 In the event of failure and restarting of computers and computer systems, the process shall be protected against undefined and critical states.

2. Power supply

2.1 The power supply shall be monitored and failures shall be indicated by an alarm.

2.2 Redundant systems shall be separately protected against short circuits and overloads and shall be selectively fed.

3. Hardware

3.1 The design of the hardware shall be clearly arranged. Easy access to interchangeable parts shall be provided for repairs and maintenance.

3.2 Plug–in cards and plug-in connections shall be appropriately marked to protect against unintentional transposition or, if inserted in an incorrect position, shall not be destroyed and shall not cause any malfunctions which might lead a danger.

3.3 For integrated systems, it is recommended that sub–systems be electrically isolated from each other.

3.4 Computer systems shall preferably be designed without forced ventilation. If forced ventilation of the computers is necessary, it shall be ensured that an alarm is given in the case of an unacceptable rise in temperature.

4. Software

4.1 Examples of software are:

- Operating systems
- Application software
- Executable code
- Database contents and structures
- Bitmaps for graphics displays
- Logic programs in PALs (Programmable Application Logics)
- Microcode for communication controllers.

4.2 The producer shall prove that a systematic procedure is followed during all the phases of software development.

4.3 After drafting the specification, the test scheduling shall be made (listing of the test cases and establishment of the software to be tested and the scope of testing). The test schedule lays down when, how and in what depth testing shall be performed.

4.4 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests must be retraceable.

4.5 The version of the Software with the relevant date and release shall be documented, and the assignment to the particular requirement class must be recognizable.

5. Data Communication Links

5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and shall be specified accordingly.

5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

5.3 The data communication link shall be continuously self-checking, for detection of failures in the link itself and of data communication failure in the nodes.

5.4 When one and the same data communication link is used for two or more essential functions, this link shall be redundant.

5.5 Switching between redundant links shall not disturb data communication or continuous operation of functions.

5.6 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

5.7 If approved systems are extended, prove of trouble-free operation of the complete system shall be provided.

6. Integration of Systems

6.1 The integration of functions belonging to independent systems shall not decrease the reliability of a single system.

6.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

6.3 Any failure of the transfer of data between autonomous subsystems which are linked together shall not impair their independent functions.

7. User Interface

7.1 The handling of a system shall be designed for ease of understanding and user–friendliness and shall follow ergonomic standards.

7.2 The status of the computer system shall be recognisable.

7.3 Failure or shutdown of subsystems or functional units shall be indicated by an alarm and displayed at every operator station.

7.4 For using computer systems, a general comprehensible user guide shall be provided.

8. Input Devices

8.1 The feedback of control commands shall be indicated.

8.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

8.3 Operator panels located on the bridge shall be individually illuminated. The lighting must be adapted to the prevailing ambient conditions in a manner which excludes glare.

8.4 Where equipment operations or functions may be changed via keyboards appropriate measures shall be taken to prevent an unintentional operation of the control devices.

8.5 If the operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

- Use of a special key lock
- Use of two or more keys.

8.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation must be recognizable as such.

8.7 With regard to their position and direction of operation, control elements shall correspond to the controlled equipment.

9. Output Devices

9.1 The size, colour and density of text, graphic information and alarm signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

9.2 Alarms and information shall be displayed in a logical priority. The meaning of the individual indications must be clearly identifiable by text or symbols.

9.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

10. Graphical User Interface

10.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

10.2 When general-purpose graphical user interfaces are employed, only the functions and information necessary for the respective process shall be available.

10.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

D. Testing of Computer Systems

1. Computer systems of requirement class 2 are subject to mandatory type-testing, see Section 16, E.

2. Evidence, tests and assessments of computers and computer systems shall be obtained and carried out in accordance to the requirement class.

3. Through the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

4. If other proofs and tests are provided by the manufacturer which are of an equivalent nature, they may be recognized.

5. The test schedule of system tests shall be specified and submitted before the hardware and software test are carried out.

6. Modifications after completed tests which have influence on the functionality and/or the safety of the system shall be documented and retested in accordance to the requirement class.

7. Tests in the Manufacturer's Work

The following tests shall be performed in the manufacturer's works:

- Function tests
- Simulation of the operating conditions
- Fault simulation
- Simulation of the application environment.

8. Tests on Board

The following tests shall be performed on board:

- Complete system tests
- Integration tests.

SECTION 11

LIGHTING AND SOCKET-OUTLETS

A. General

1. The design and construction of lighting installations and socket-outlets are also required to conform to Sections 1, 3, 4 and 14.

2. The use of lighting fixtures and socket-outlets currently employed ashore is permitted in accommodation spaces, day rooms and service rooms.

However, they must conform to the fundamental requirements set out in Sections 1 and 14.

3. The lighting system is to be arranged such that a single fault will not cause total loss of illumination in any compartment.

B. Lighting Installations

1. General requirements

Lighting installations are differentiated as follows:

1.1 Primary lighting (Main lighting), see 2.

1.2 Secondary lighting (Reserve lighting), see 3.

1.3 Transitional lighting, see 4.

1.4 Escape, evacuation and rescue lighting (Escape route lighting), see 5.

1.5 Portable lighting (Auxiliary lighting), see 6.

1.6 Operational lighting (Special lighting), see 7.

2. Primary lighting (Main lighting)

2.1 Primary lighting includes all permanently installed. Illumination facilities supplied via at least two main groups. This lighting is used to illuminate all ship spaces and all decks around to provide safe access. This lighting serves also for carrying out operations at control stations.

2.2 The rated illumination intensity for different spaces in the ship is mentioned in Table 11.1.

3. Secondary lighting (Reserve lighting)

3.1 Secondary lighting shall remain active in the event of failure of the corresponding primary lighting and is supplied by a source of electrical power independent from primary lighting.

This lighting should permit the following functions:

- Continuation of ships operation
- Execution of damage control and repair measures
- Illumination of the passageways, escape routes and embarkation stations for survival craft on deck and along the ship's sides in this area

Switches must only be arranged locally if the possibility of switching off or adjusting the brightness is required, e.g. on the bridge.

3.2 The standard values for illumination intensity for different space in the ship are mentioned in Table 11.2.

3.3 In the areas of command positions relevant to safety, such as

- Control stations, control positions and combat stations
- Radio transmission posts in radio rooms
- Auxiliary control positions for ship safety

the lighting fixtures shall be so mounted that they provide adequate illumination for the relevant work place.

3.4 For the operating stations in the helicopter hangar, a reserve lighting with a workplace orientation shall be provided. This shall be designed for the operating mode "hangar door opened". Except for those illuminating the passageways within the hangar, the lighting fixtures shall be provided with switches.

3.5 For the medical area, the following requirements shall be observed:

3.5.1 In medical treatment rooms, a brightly illuminated zone shall be provided in the operating area around the operating lamp.

3.5.2 In patients' rooms, the secondary lighting is to be provided with switches. Here it shall be ensured that, in the event of failure of the primary lighting, the secondary lighting is switched on automatically. The functional readiness of the lighting fixtures is to be indicated at all times.

3.5.3 If crew spaces are also intended for use as dressing stations, the secondary lighting in these rooms is to be designed as for patients' rooms.

3.6 In ship control stations with monitor workplaces, the secondary lighting shall be designed to meet the requirements of the operational deployment.

3.7 If the primary lighting can be operated at maximum brightness during the operational deployment, the secondary lighting is to be designed as for command positions, see 3.3.

3.8 If the primary lighting of the ship command position, e.g. CIC, is not switched on during the operational deployment or is operated at reduced brightness, the following shall be provided:

- Orientation lighting for passageways and fringe areas below the working level

- Lighting fixtures for marking the escape routes at exits and emergency exits

- workplace-oriented lighting fixtures shall be provided at all workplaces or equipment which shall be monitored and operated even if the primary lighting fails.

3.9 Secondary lighting fixtures are to be marked as such for easy identification.

4. Transitional lighting

Transitional lighting is a fixed lighting provided upon loss of primary lighting and prior to operation or instead of the secondary lighting, where a level of continuous illumination has to be maintained for operational purposes.

If the transitional lighting is applied as secondary lighting, the operating time is to be agreed with the Naval Administration, but should be at least 1 hour.

5. Escape, evacuation and rescue lighting (Escape route lighting)

5.1 For the illumination and marking of escape routes and passageways, including the marking of the exits from accommodation areas and from ship command positions with monitor workplaces, e.g. CIC, in which the main illumination is switched off during operational deployment, an additional red-light system or equivalent shall be provided.

5.2 This system is to be supplied by an independent source of electrical power with an operating time of at least 3 hours.

6. Portable lighting (Auxiliary lighting)

6.1 Portable lighting consists of portable handheld lamps (powered by storage batteries and mounted on walls and bulkheads if not in use) that are switched on automatically on failure of the primary lighting.

6.2 The charging units for the battery-powered handheld lamps are supplied from the primary lighting installation.

6.3 All alleyways, day rooms and all working spaces normally occupied, including all rooms/places occupied during combat, shall each be provided with a portable handheld lamp which can be recharged.

6.4 Where provided, portable lighting shall be appropriate for the hazardous zone classification of the compartment in which it will be used.

7. Operational lighting (Special lighting)

Operational lighting shall be provided in areas where there is an operational requirement for different levels of illumination from that provided by the primary system.

7.1 Door operated lighting

Lighting fixtures whose light can shine outside when doors are opened, including container doors, hatch-covers or hangar doors, shall be controlled via door switches or so mounted, screened or darkened that no disturbing light can shine onto the upper deck.

7.2 Maintenance lighting

For ship control stations in which the primary lighting is only switched on for maintenance purposes, the switches shall be protected against unintentional actuation by means of switch covers.

7.3 Adaption areas lighting

7.3.1 Visually critical zones shall be constructed as adaptation areas. These include:

- Passageways and spaces with direct access to the upper deck or aircraft hangar
- Corridors to spaces darkened during normal operation
- Ready rooms for personnel standing by for missions at night on the upper deck, e.g. underway replenishment
- Corridors between the CIC (combat information centre) and steering position
- Passageways within the aircraft hangars

7.3.2 The type of illumination required in each case is to be controlled by means of a day/night switch. If required this switch-over should be made centrally at the steering position, if required.

8. Scope of the lighting installation

8.1 The lighting fixtures shall be arranged in sufficient quantity to achieve a good level of illumination. Values recommended for primary lighting are contained in Table 11.1.

For the areas mentioned below, special requirements shall be met:

8.2 Lighting must be provided for external launching facilities and the area on deck in which persons embark or disembark.

8.3 Launching equipment for boats shall be provided with lighting so that the boat deck and the operating station are uniformly illuminated.

8.4 Gangways shall be so provided with lighting that an adequate illumination intensity is ensured for the walking surface.

Table 11.1 Recommended rated illumination intensities for primary lighting

Space	Rated illumination intensities $(E)_N$ [Lux]
- Medical treatment rooms (with the operating lamp switched off) - Galleys	500
- Patients' rooms - CIC, MCC, DCC, FCC (maintenance lighting) - Navigation and detecting rooms (maintenance lighting) - Radio rooms, control stations and control positions - Working spaces, in front of switchboards and watch stations - Office rooms - NBC locks - Dressing stations	250
- Workshops - Hangars, well decks - Service rooms (excluding galleys) - Messrooms, lecture rooms - Accommodation, cabins - Chart rooms - Main passageways - Stairs in main passageways	200
- Steering positions (maintenance lighting) - Working spaces	150
- Alleyways - Storerooms (or equivalent) - Washrooms and shower rooms - Compass rooms - Marshalling areas	100
- Stowage areas (or equivalent) - Toilet rooms	80
- Bilges - Shower cubicles	40
- Upper deck	10

Table 11.2 Standard intensity values for Secondary lighting (Reserve lighting)

Space	Standard intensity values $(E)_N$ [Lux]
Safety-relevant areas in/at: - Places for medical care, e.g. dressing stations - Control stations, control positions - Auxiliary control positions for damage control - Radio transmission positions - Medical treatment rooms	100
- First-aid rooms - Command positions within the citadel - Control stations, control positions and auxiliary control positions - Working spaces - Hangars - Ready rooms - Protection rooms - Messrooms - Workshops with special hazard features, e.g. metalworking - Operating positions of units and consoles with functions relevant to technical safety	15
- Corridors, companionways - Staircases	5
- Corridors/ companionways between CIC and steering position	5

8.5 Workplaces on the upper deck which are subject to special demands regarding safety, e.g.:

- Replenishment at sea platforms/-stations
- Pilot transfer
- Scrambling nets
- Rescue slings

- Aircraft refuelling stations

shall be adequately illuminated.

The lighting fixtures shall be so mounted that the personnel on the bridge and at the workplaces are not dazzled. It shall be possible to switch the lighting fixtures from the bridge, with separate arrangements for the various working areas.

8.6 In the ship's hospital, an operating theatre lamp shall be provided at each operating position. This lamp must be supplied from two incoming feeders. The main feeder must be taken from the power supply for the hospital, whilst the stand-by feeder must be taken from another independent source of electrical power, e.g. UPS. If the main supply fails, the switch over to the stand-by supply must take place automatically.

8.7 Ships for the carriage of motor vehicles need additional luminaires according to Section 15, F.

9. Design of the lighting installation

9.1 If autonomous compartments are stipulated, then at least one group distribution panel shall be installed for the lighting in these compartments.

In all other cases, at least one group distribution panel is required for the lighting of each compartment containing control stations and/or vital service spaces.

9.2 Subgroups for the lighting can be installed as required in each case. They must be supplied from a group distribution panel, and must only be arranged in the same compartment as the group distribution panel.

9.3 The number of lighting points (lamps) connected to one final circuit shall not exceed:

- 10 lamps for voltages up to 55 V
- 14 lamps for voltages over 55 V
- 24 lamps for voltages over 125 V

For the permissible load of final subcircuits, see Section 12, C.1.

Single-pole switching of final circuits for lighting in systems is permitted only in the accommodation area.

9.4 In the areas listed below, the lighting must be supplied by at least two separately fused circuits.

The lighting fixtures shall be so arranged that sufficient illumination for orientation is maintained should one circuit fail.

9.4.1 In main engine rooms, service spaces, workshops, safety stations and control stations

9.4.2 in ammunition rooms

9.4.3 in the combat information centre (CIC), machinery control centre (MCC), damage control centre (DCC), flight control centre (FCC)

9.4.4 in large galleys

9.4.5 in passageways

9.4.6 at stairways leading to the boat deck

9.4.7 in day rooms and messrooms

9.4.8 in the ship's hospital

9.5 The passageways on the upper deck must be illuminated. It must be possible to control the lamps from the navigation bridge.

The lighting fixtures shall be provided with shades to prevent direct radiation of light upwards and to the side past the deck.

9.6 Doors, hatchways, hangar doors and emergency exits shall be so illuminated that closing and locking devices, indications of whether the doors are open or closed, actuation instructions and safety risks, e.g. coamings, can be distinguished clearly.

9.7 Rooms darkened during operation, e.g. steering position, CIC, must be provided with dedicated workplace lighting, i.e. with:

- Screens to limit the light cone and to prevent direct and indirect dazzle

- Brightness controls to adjust the brightness to the visual environment

9.8 Lighting fixtures selected for a particular compartment shall be appropriate for the hazardous zone classification of the compartment.

For lighting fixtures in ammunition rooms, see Section 1, J.3.4.

The lighting in rooms potentially endangered by explosive materials must be switched outside these rooms. Such switches must have a lamp indicating the operating state and must be protected against unintentional switching.

9.9 All lighting fixtures shall be so mounted that combustible parts are not ignited by the heat generated, and that they themselves are not exposed to damage. The minimum distances indicated on the lighting fixtures shall be observed.

Where no minimum distances are specified, the minimum distances in the direction of radiation indicated in Table 11.3 shall be applied for lighting fixtures in accordance with IEC publication 60598-1 "Luminaires, Part 1: General Requirements and Tests".

Table 11.3 Minimum distances for the mounting of lighting fixtures

Rated power [W]		Minimum distance [m]
	up to and incl. 100	0,5
over 100	up to and incl. 300	0,8
over 300	up to and incl. 500	1,0

9.10 For lighting fixtures mounted in corridors, the head clearance shall be at least 1,80 m.

9.11 In shower rooms and bathrooms, the following electrical installations are permitted for the relevant areas (IEC publication 60364-7-701); see Fig. 11.1.

9.11.1 Area 0, none

9.11.2 Area 1, lighting fixtures with safety extra-low voltage (SELV), maximum 12 V with protection IP 55

9.11.3 Area 2, lighting fixtures with protective insulation in protection IP 34

9.11.4 Area 3, lighting fixtures in protection IP 34, switches as built-in types (in the lighting fixtures), socket-outlets only in connection with:

- isolating transformer, or
- safety extra-low voltage, or
- RCD (residual current protective device), max. 30 mA

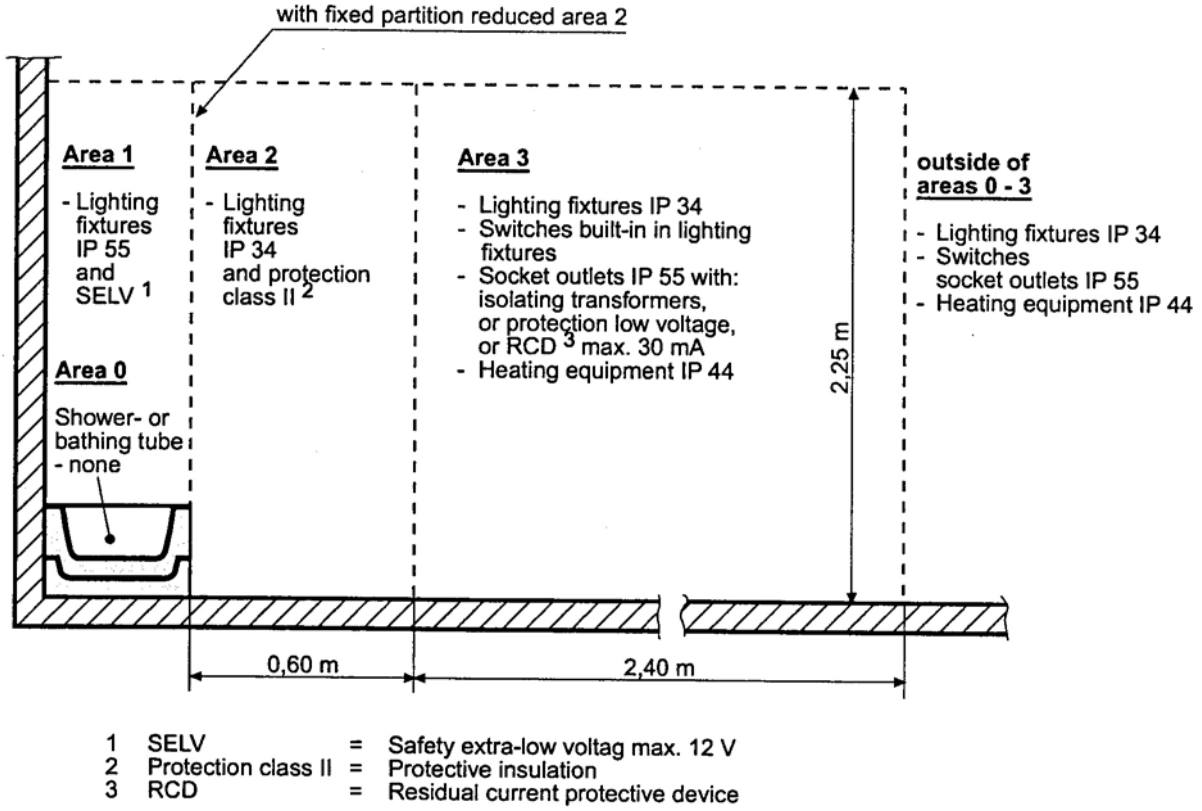


Fig. 11.1 Permitted electrical equipment in shower rooms and in bathing room

9.11.5 Outside of areas 0-3, lighting fixtures in protection IP 34, switches and socket-outlets in protection IP 55.

C. Socket-Outlets

1. General requirements

1.1 The supply for socket-outlets in the accommodation, day rooms and service rooms (250 V) shall be run from lighting groups / subgroups. The maximum fuse rating for a circuit is 16 A.

1.2 In the bridge area, at least one socket-outlet shall be provided on the port side as well as at least one on the starboard side for connecting handheld signalling lamps.

1.3 If boats are fitted with an engine that is started electrically, a socket-outlet must be mounted near the boat launching equipment for connecting a transportable battery charger unit to charge the starter batteries. This socket-outlet must be connected to a separate supply circuit and fused at 16 A.

1.4 For socket-outlets of distribution systems with different voltages and/or frequencies, non-interchangeable plugs and socket-outlets shall be used.

1.5 Socket-outlets outside the accommodation area must be connected to separate circuits.

When calculating the permissible connected load, one socket shall be deemed equivalent to two lighting points, see B.9.3.

1.6 Plug-in connections shall not be installed below the floor in engine rooms and boiler rooms.

1.7 Socket-outlets for power circuits over 16 A AC or 10 A DC must be interlocked in such a way that the plug can be neither inserted nor withdrawn when the socket contacts are live.

2. Socket-outlets for showers and bathrooms

For the permissible arrangement of socket-outlets, in shower and bathrooms see IEC publication 60364-7-701.

3. Socket-outlets for holds with military cargo

Sockets in holds for military cargo shall be installed only in locations with sufficient protection against mechanical damage.

4. Socket-outlets for containers

In case of navy-specific containers used for temporary purposes aboard the following is valid:

4.1 For the plug-in connections in containers, see Section 7, H.

4.2 Several socket-outlets may be grouped together for common supply via one power cable, provided that the individual connections are protected at site against overcurrent and short-circuit, and the supply cable is rated for the total power demand. For details see Section 12, C.

SECTION 12

CABLE NETWORK

A. Choice of Cables and Wires

1. General Instructions

Cables and conductors must conform to the requirements stated in Section 14, G.

IEC publication 60092-352 shall be observed.

2. Rated Voltage

The rated voltage of a cable shall be not less than the operating voltage of the relevant circuit.

In insulated distribution systems, the outer conductor voltage of the system shall be deemed to be the rated voltage of the cable between a conductor and the ship's hull.

3. Temperatures

At places where higher ambient temperatures are expected, cables must be used whose permissible temperature is at least 10 K above the maximum anticipated ambient temperature.

A correction of the permissible current rating shall be made in accordance with Table 12.1.

Cables on diesel engines, turbines, boilers etc., where there is danger of excessive heating, must be so routed that they are protected against inadmissible external heating stress, or cables are to be used which are approved for the maximum arising ambient temperature.

4. Mechanical Protection

The choice of cables must consider the mechanical stressing, see D., Installation.

5. Flexibility

5.1 Machines or equipment mounted on vibration absorbers and shock absorbing elements (rubber or springs) shall be connected with cables or wires of sufficient flexibility and provided with compensating bends.

5.2 For flexible parts of installations supplied via scissor-type cable supports, suspended loops, festoon systems etc., the use of suitable, flexible cables is required.

6. Mobility

Mobile equipment shall be connected via flexible cables, e.g. of type HO7RN-F, CENELEC HD 22 or equivalent.

For voltages above 50 V, flexible connecting cables or -wires intended for equipment without double insulation must also include an earthing conductor.

The earthing conductor shall have a green/yellow coloured marking.

7. Selection of cables. routing and EMC

Cables and wires shall be used according to the application categories, Table 12.2 and EMC-categories, see C.4.5.

Note :

The application and routing of the cables as well as the EMC requirements should be taken into consideration when selecting the cables.

The application categories are mentioned in the type approval certificates for cables.

B. Determination of Conductor Cross-Sections

1. Rating Method on the Basis of Maximum Current-Carrying Capacity

1.1 Conductor cross sections are to be determined on the basis of load with due regard to the requirements of C.1. to C.3.

The calculated current must be equal to, or smaller than, the permissible current for the chosen conductor cross section.

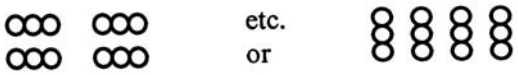
1.2 The permissible current-carrying capacities of cables listed in Tables 12.5 -12.8 apply to an ambient temperature of 45°C and to the stated permissible operating temperature of the cables or wires.

1.3 The current-carrying capacities listed in Tables 12.5 -12.8 apply to flat cable configurations

containing not more than 6 cables laid side by side, or to groupings of not more than 3 cables or insulated wires, as follows:

Flat arrangement:

Groupings of not more than 3 cables:



The triple groups must be laid in each direction with a spacing corresponding to at least one outer diameter of the largest cable or largest insulated wire.

1.4 If the specified configurations cannot be adhered to, or the passage of cooling air is not assured, the current-carrying capacity must be reduced to 85 % of the values given in the tables, and the overcurrent protection must be modified accordingly.

Exceptions are made for bundles of cables and insulated wires which are not part of the same circuit and/or which will not be loaded with their rated currents simultaneously.

1.5 For the laying of single-core cables and wires in single-phase and three-phase alternating current systems, see D. 7.

1.6 Cables whose maximum permissible conductor temperatures differ from each other by more than 5 K may be bundled together only if the permissible current-carrying capacity of the lowest capacity type is taken as the rating basis for all cables.

Table 12.1 Corrective factors for rating capacity of conductor cross-sectional areas

Permissible Operating temperature		Ambient temperature (°C)										
		35	40	45	50	55	60	65	70	75	80	85
(°C)	Table	Correction factor										
60	12.5	1,29	1,15	1,0	0,82	-	-	-	-	-	-	-
75	12.5	1,15	1,08	1,0	0,91	0,82	0,71	0,58	-	-	-	-
80	12.6	1,13	1,07	1,0	0,93	0,85	0,76	0,65	0,53	-	-	-
85	12.6, 12.7	1,12	1,06	1,0	0,94	0,87	0,79	0,71	0,61	0,50	-	-
95	12.8	1,10	1,05	1,0	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 12.2 Application categories for power, control and communication cables

Category	Range of application	Remarks
1	Within the ship in all areas and on open deck	Cables with shielding and outer sheath
2	Within the ship in all areas, except where EMC requirements exist and not in hazardous areas	Cables without shielding
3	Only in crew and troop accommodation/ day rooms, for final supply circuits of lighting, sockets and space heating	Cables without shielding, with single wire (solid) conductors up to 4 mm^2
4	At diesel engines, turbines, boilers and other devices with higher temperatures	Heat-resistant cables (wires)
5	Other application areas, not specified in 1 – 4	See type test certificate

1.7 Parallel cables are permitted only with conductor cross-sections of 10 mm^2 (AWG 7) and over.

Only cables of the same length and having the same conductor cross-section may be installed as parallel cables. Equal current-distribution shall be ensured.

Parallel cables may be loaded to the sum of their individual current-carrying capacities, and must be common fused.

2. Rating on the Basis of Voltage Drop

2.1 For ships within NATO, or when stipulated in the building specification, the voltage drop must comply with the requirements of STANAG 1008.

2.2 Under normal service conditions, the voltage drop between the busbars (main/emergency switch-board) and the consumers shall not exceed 6 %, or 10 % in the case of battery-supplied networks of 50 V or less. Navigation lights are subject to the requirements of Section 4, I.

2.3 Where short-term peak loads are possible, for instance due to starting processes, it is to ensure that the voltage drop in the cable does not cause malfunctions.

2.4 For cables in 400 Hz systems, the increase of the reactance by the factor of 400 : 60 = 6,7 in relation to 60 Hz systems shall be given due consideration.

Furthermore, increased voltage losses due to larger effective components must be considered, i.e. skin effect, proximity effect and eddy-current losses. For cross sections greater than 16 mm^2, an allowance of approx. 10 % must be added to the voltage drop determined for the 60 Hz system. Cables $\geq$ 35 mm^2 should not be used.

3. Consideration of Current Peaks

The cross section shall be so chosen that the conductor temperatures do not exceed the maximum limits specified below neither under short-circuit nor start-up conditions:

for EPR (EPM or EPDM) (85 °C) 200 °C
for XLPE (VPE) (85 °C) 250 °C
for silicone (95 °C) according to specification

The figures in brackets are the permissible operating temperatures at the conductor in continuous operation.

4. Minimum Cross-Sectional Areas and Their Current-Carrying Capacity

4.1 The conductor cross sections indicated in Table 12.3 are the minimum cross sections for external cabling or, if applicable, for internal wiring, e.g. of switchgear and consoles.

4.2 The maximum current-carrying capacity of conductor cross sections for external cabling is indicated in Tables 12.5 - 12.8. For cables and wires in telecommunications systems apply the values listed in Table 12.4.

A maximum permissible current of 1,0 A is applicable to the 0,2 mm^2 (AWG 24) conductor cross section regardless of the number of cores.

4.3 In accommodation and day rooms, flexible cables with a conductor cross section of not less than 0,75 mm^2 (AWG 18) may also be used for the connection of movable equipment with a current consumption of up to 6 A.

4.4 For the cross sections for earthing conductors, see Section 1, J.

4.5 Exciter equalizer cables for three-phase generators in parallel operation must be rated for half the nominal exciter current of the largest generator.

C. Rating, Protection and Installation of Circuits

1. Individual Consumers and Rating of Final Subcircuits

1.1 Cables shall be rated according to the expected operating load based on the connected load and the mode of operation of the consumers.

1.2 The following loads are to be assumed for 230/115 V AC lighting circuits and socket-outlet circuits:

- For each lighting point, at least 60 W,

- For each socket-outlet, at least 120 W.

2. Consideration of a Diversity Factor for Group Supply Cables

2.1 If all the connected consumers in a part of the system are not simultaneously in operation, a diversity factor may be used for determining the cross section.

A diversity factor is the ratio of the highest operating load expected under normal operating conditions to the sum of the rated loads of all the connected consumers.

2.2 The load ascertained by the application of a diversity factor shall be deemed to be the continuous load for the determination of the cross-section.

2.3 For cargo cranes with one drive motor, the supply cable shall be rated according to the current rating of the maximum load capacity.

2.4 Where shipboard cranes have more than one motor, the feeder cable to an individual crane can be rated as follows:

The value of the current used for cross section determination shall be equal to 100 % of the output of the lifting motors plus 50 % of the output of all the other motors. With the current calculated in this way, the cross section of the cable shall be selected for continuous operation.

3. Overload Protection of Cables

3.1 Cables shall be protected against short circuit and over current.

3.2 Rating and setting of the protection devices shall be in compliance with the requirements in Section 4.

3.3 Cables protected against over current at the consumers side require only short-circuit protection on the supply side.

For steering gear, see Section 7, A.

Table 12.3 Minimum cross-sectional areas

	Nominal cross section			
	External wiring		Internal wiring	
	International	AWG	International	AWG
Power, heating and lighting systems	1,0 mm^2	17	1,0 mm^2	17
Control circuits for power plants	1,0 mm^2	17	1,0 mm^2	17
Control circuits in general, safety systems in accordance with Section 9	0,75 mm^2	18	0,5 mm^2	20
Telecommunications equipment in general, automation equipment	0,5 mm^2	20	0,1 mm^2	28
Telephone and bell installations, not relevant for the safety of the ship or crew call installations	0,2 mm^2	24	0,1 mm^2	28
Data bus and data cables	0,2 mm^2	24	0,1 mm^2	28

Table 12.4 Rating of telecommunication and control cables

Number of core pairs [2 cores]	Number of cores	Nominal cross-section 0,5 mm^2 (AWG 20)		Nominal cross-section 0,75 mm^2 (AWG 18)	
		Permissible load [A] max.	Rated fuse current [A]	Permissible load [A] max.	Rated fuse current [A]
1x2	2	-	-	10,5	10
2x2	4	5	6	7,5	6
4x2	8	4	4	6	6
7x2	14	3,5	4	4,5	4
10x2	20	3	4	4	4
14x2	28	3	2	3,5	4
19x2	38	3	2	3,5	4
24x2	48	2	2	3	2
48x2	96	2	2	-	-
The values in the table relate to an ambient temperature of 45 °C and a conductor temperature of 85 °C.					

3.4 Exciter cables for DC motors and DC generators operating in parallel shall not be fused.

Exciter cables for individually connected DC generators and synchronous three-phase alternators shall be fused only if there are special reasons for it, e.g. where the cables are passing through various compartments of the ship.

4. Separation of Circuits/Cables

4.1 A separate cable shall normally be provided for each circuit having its own over current -and short-circuit protection. Deviating from this requirement the following may be combined in a common cable:

4.1.1 A main circuit and its control circuits which have their tapping off after the main switch.

4.1.2 Various control circuits laid separately from the main circuits.

4.1.3 Various main circuits and their control circuits belonging to a common system, e.g. for several drives of an air-conditioning system, if all the cores of the cable can be centrally disconnected from the supply.

4.2 Separate cables must be provided for safety extra low-voltage circuits.

4.3 Separate cables must be provided for intrinsically safe circuits.

4.4 Cables for medium-voltage installations shall be run at a distance of at least 50 mm from low-voltage cables and marked appropriately.

4.5 The EMC aspect must be taken into account for the laying of cables and the assignment of cables to cable bundles or cable trays, see IEC publication 60533 and Section 1, J.5.

Depending on the type of signals carried by a cable, this cable can be assigned to one of the following EMC categories:

- EMC category 1 - insensitive; source of interference

  e.g. power supply cables, general control cables, cables for lighting installations, cables for alarm systems, slow digital logic

- EMC category 2 - insensitive; not a source of interference

  e.g. cables for signal information dependent on voltage, frequency and phase; machinery alarm systems

- EMC category 3 - sensitive; not a source of interference

  e.g. telephone cables, telecommunication and signalling cables, cables for synchro connections, cables for video signals, RF and TV antenna distribution systems, synchronization and pulse cables of low power, e.g. multicoaxial cables for digital data transmission, probe cables for magnetic self-protection

- EMC category 4 - very sensitive; not a source of interference

  e.g. reception antenna cable; microphone leads, analog signal cables for high-impedance measurement inputs

- EMC category 5 - insensitive; a strong source of interference

  e.g. cables for transmitter output stages and transmitter antennas, such as echosounder TX/ RX cable

5. Cable Laying for Circuits

5.1 For single-phase and three-phase AC systems, multi-core cables are to be used wherever possible.

5.2 Should it be necessary to lay single-core cables for the carriage of more than 10 A in single-phase or three-phase AC circuits, the special requirements of D. 7. shall be fulfilled.

5.3 In three-phase systems without hull return, three-core cables shall be used for three-phase connections.

5.4 In DC systems without hull return multi-core cables shall be provided in all cases of smaller cross-sections.

Where single-core cables are used for large cross sections, the outgoing and return cables must be laid as close as possible to each other over their entire length to avoid magnetic stray fields.

5.5 The generator cables, all cables run from the power station switchboards, group switchboards or emergency switchboard, and all interconnecting cables for essential equipment, must be laid as far as possible

uninterrupted in length to the distribution panels or to the equipment.

5.6 The cables of intrinsically safe circuits shall be laid at a distance of at least 50 mm separated from the cables of non-intrinsically safe circuits. The laying of intrinsically safe circuits together with non intrinsically safe circuits in a pipe is not permitted.

Cables of intrinsically safe circuit shall be marked.

D. Installation

1. Routing of Cables

1.1 The routes of cables shall be such that cables are laid as straight as possible and are not exposed to mechanical damage.

The laying of main cable trays under the floors above the bilges and in the bilges shall be avoided, as far as practicable. Similarly, no main cable trays shall run over the open deck, unless they are specially protected.

1.2 For bends, the minimum bending radius permitted by the manufacturer shall be observed. Unless specified otherwise the radius shall be not smaller than 6 times of the outer diameters of the cables.

1.3 Heat sources such as boilers, hot pipes etc. must be bypassed, so that the cables are not subjected to additional heating. If this is not possible, the cables are to be shielded from thermal radiation.

1.4 In positions where unacceptable tensile stresses are liable to occur, precautions shall be taken to distribute the expansion movement uniformly over a cable loop provided for such purpose. The diameter of the cable loop shall be at least 12 times the diameter of the thickest cable.

1.5 Cables shall not be laid within room insulations.

Exceptions are permitted for lighting, socket-outlets and control circuits in accommodation and refrigerated rooms, provided that the maximum loading of the cables does not exceed 70 % of their current carrying capacity.

1.6 Where, for safety reasons, distribution groups, essential equipment and emergency consumers are required to have duplicated incoming feeders, the routes of the supply cables and control cables shall be placed as far apart as possible, and special attention must be paid to maintaining the combat survivability in the event of a condition able to cause damage.

The same measures shall be observed for cables runing through watertight compartments and for cables serving essential equipment and emergency consumers. If necessary, additional mechanical protection must be provided.

1.7 Cables for supply of essential equipment and emergency consumers, e.g. lighting and important communication and signalling systems shall, wherever possible, bypass galleys, laundries, category A engine rooms and their casings and any areas with a high fire risk.

On ships whose construction or small size precludes fulfilment of these requirements, measures must be taken to ensure the effective protection of these cables where they have to be run through the rooms mentioned above, e.g. by the use of fire-resistant cables or by flame-retardant coating. Such an installation requires approval by TL.

1.8 Supply cables for emergency consumers shall not be run through fire zones containing the main source of electrical power and associated facilities. Exceptions are made for cables for supply of emergency consumers located within such areas.

1.9 The electrical cables to the emergency fire pump shell not pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers.

They shell be of fire-resistant type in accordance with IEC publication 60331.

1.10 With a view to increasing the combat survivability and fire safety, all cables for essential equipment (including their power supply) whose function must also be safeguarded for a certain time, even in case of fire, must be of fire-resistant construction wherever they pass through areas with a high fire risk outside of the installation space of the units to be supplied or through other compartments.

1.10.1 Unless stipulated otherwise in the building specification, a functional endurance of at least 3 h must be safeguarded for the following systems in the event of fire, through the use of fire-resistant cables:

- Fire alarm and general emergency alarm system
- Fire extinguishing systems and their alarm devices
- Flood pumps
- Power supply, control and status indicators of fire doors and watertight bulkhead doors
- Emergency lighting / stand-by lighting
- Public address (PA) systems

1.10.2 For systems that are self-monitoring or failsafe or are duplicated as per 1.6 with cable runs as widely separated as is practicable, no fire-resistant cables are necessary.

2. Fastening of Cables and Wires

2.1 Cable trays and cableways shall preferably be made of metallic materials which are protected against corrosion.

Cables and wires should preferably be fastened with corrosion-resistant metal clips or metallic bindings. Exceptions are made for cables which are laid in pipes or cable ducts. Metallic bindings must be shrouded with a flame-retardant, halogen free or low-halogen plastic, or must only be used together with separating layers made of an equivalent plastic material.

For the fastening of cables, halogenfree or low-halogen plastic clips/straps can also be used.

2.2 Where suspended cables are fastened by the use of plastic clips or straps, metallic cable fixing devices, spaced not more than 2 m apart, shall be used additionally in the following areas:

- Generally in escape routes and emergency exits, and on the open deck
- Cargo holds, machinery rooms, control rooms and service rooms where bunched cables are fastened on riser cable trays or under the cable trays

2.3 Only suitable materials shall be placed together when fastening cables to aluminium walls.

Clips for mineral-insulated cables with copper sheaths must be made of copper alloy if they are in electrical contact with the latter.

2.4 Single-core cables shall be fastened in such a manner that they are able to withstand the electro dynamic forces occurring in the event of short circuits.

2.5 The distances between the supports for cable racks and the fastenings used shall be selected with due regard to the cable type, cross section and number of cables concerned.

2.6 Cable trays made from plastics shall be tightened in such a way that in case of fire they do not obstruct the escape routes by cables (hanging down). Evidence of flame retardation shall be provided.

2.7 It is recommended, that cables and cable bunches shall not be painted.

If they still would be painted the following must be observed:

- The paint must be compatible with the material of the cables, and

- The flame-retardant properties of the cables and cable bunches must be maintained.

2.8 For ship sections made of light alloys, special attention must be paid to proper selection of the fastening materials, particularly with regard to corrosion protection.

3. Stress Relief

Cables shall be so installed that any tensile stresses which may occur remain within the permitted limits. This shall be particularly observed for cables on vertical runs or in vertical conduits.

4. Protection Against Mechanical Damage

4.1 Cables on open decks and at positions where they are exposed to a particularly high risk of mechanical damage shall be protected by pipes, covers or closed cable ducts.

4.2 Cables passing through decks shall be protected against damage by pipe sockets or casings extending to a height of about 200 mm. over deck.

5. Installation of Cables and Wires in Metallic Pipes, Conduits or Closed Metal Ducts

5.1 If cables are installed in pipes or ducts, attention shall be paid that the heat from the cables can be dissipated into the environment.

5.2 The inside of the pipes or ducts must be smooth, and their ends shaped in such a way as to avoid damage to the cable sheath.

They shall be effectively protected inside against corrosion. The accumulation of condensation water shall be avoided.

5.3 The clear width and any bends must be such that the cables can be drawn through without difficulty. The bending radius of the pipe must be equivalent to at least 9 times of the outer cable diameter.

5.4 Not more than 40 % of the clear cross-section of pipes and ducts shall be filled with cables. The total cross-section of the cables is deemed to be the sum of their individual cross-sections based on their outside diameters.

5.5 Pipes and ducts must be earthed.

5.6 Long cable ducts and pipes shall be provided with a sufficient number of inspection and pull boxes.

6. Installation in Non-Metallic Pipes and Ducts

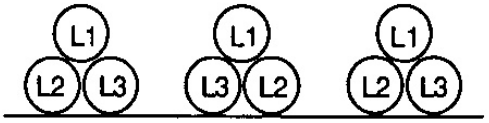
Non-metallic pipes or cable ducts must be made of flame-retardant material that is halogen-free or low in halogens.

7. Laying of Single-Core Cables and Wires in Single-Phase and Three-Phase AC Systems

7.1 In cases where use of multi-core cables is not possible, single-core cables and -wires may be permitted for installation if the following provisions are made and the requirements of IEC publication 60092-352 are observed:

7.2 The cables shall not be armoured or shrouded with magnetic material.

7.3 All conductors belonging to one circuit must be run together in the same pipe or duct, or clamped by common clamps, unless the clamps are made of non-magnetic materials or the cables are arranged in triangular configuration.



7.4 The cables forming a circuit must be laid immediately beside of each other and preferably in triangular configuration. If spacings cannot be avoided, the spacings shall not exceed one cable diameter.

7.5 No magnetic material shall be placed between single-core cables passing through steel walls. No magnetic materials shall be located between the cables of deck and bulkhead penetrations. Care shall be taken to ensure that the distance between the cables and the steel wall is at least 75 mm.

The measures are not required for single-core parallel cables if the cables are arranged in triangular configuration for penetration.

7.6 Single-core parallel cables must be of the same length and cross-section. Furthermore, to avoid unequal division of the current, the cables of one phase must be laid, as far as is practicable, alternatively with the cables of the other phases, e.g. in the case of two cables for each phase:

L1, L2, L3, L3, L2, L1		or	L1, L2, L3 L3, L2, L1
or	L3, L1, L2 L2, L1, L3	or	L2, L3, L1 L1, L3, L2

7.7 To balance the impedance of the circuit in single-core cables more than 30 m. long and with a cable cross-section of more than 150 mm^2 , the phases are to be alternated at intervals of not more than 15 m.

7.8 For single-core cables, metallic sheaths are to be insulated from each other and from the ship's hull for their entire length. They shall be earthed at one end only, except earthing is required at both ends for technical reasons, e.g. for medium voltage cables. In such cases, the cables shall be laid in triangular configuration along their entire length.

7.9 In 400 Hz networks, no single-core cables shall be used (except as protective earthing conductors). For this purpose, only cables with a core cross section of up to 35 mm^2 are permissible. For greater cross sections, parallel cables of the same number and cross sections must be used.

8. Bulkhead and Deck Penetrations

8.1 Cable penetrations must conform to the partition categories laid down by SOLAS, and shall not impair the mechanical strength or watertightness of the bulkhead.

8.2 Bulkhead and deck penetrations must have been type-tested. The TL Rules - Guidelines for the Performance of Type Approvals - Test Requirements for Sealing Systems of Bulkhead and Deck Penetrations shall be taken into consideration.

8.3 Where EMC measures are required, the shields and/or the coaxial outer conductors of cables routed through metallic bulkheads and decks separating EMC zones shall be connected conductively all around with the shielding at the point of penetration. For EMC measures, an electro-conductive casting compound (or, in the case of packing systems, conductive separating layers) must be used wherever necessary. The outer sheath that is to be removed must not protrude out of the penetration.

8.4 The cables shall not occupy more than 40 % of the cross-section of a penetration.

8.5 Vertical cable ducts shall be so constructed that a fire on one deck cannot spread through the duct to the next higher or lower deck.

9. Cables in the Vicinity of Radio-Communication and Navigation Equipment

9.1 Except where laid in metallic pipes or ducts, cables and wires with metal sheaths or metal braiding shall be used above the uppermost metallic deck and in positions where the cables and wires are not separated by metallic bulkheads or decks from aerials, aerial downloads, the radio room, direction finder or other radio navigation or receiving equipment. The metallic sheaths and shields are to be earthed.

9.2 Only cables required in the radio room shall be laid there. If cables without a braid shielding have to be run through a radio room, they shall be installed in a continuous metallic pipe or duct which is earthed at the entrance to and exit from the room.

9.3 Single-core cables are not permitted in the radio room.

9.4 If the radio equipment is installed on the bridge, the requirements stated above are to be complied with, as and where applicable.

10. Magnetic Compass Zone

All electrical cables, wires, machines and apparatuses must be laid, installed or magnetically shielded in order to avoid inadmissible interference, i.e. deviation of more than 0,5º with the magnetic compass.

11. Cable Installation in Refrigeration Spaces

11.1 Only cables with outer sheaths resistant to corrosion resistant and cold resistant shall be laid in refrigerated rooms.

11.2 Where cables are led through the thermal insulation, the requirements of shall be observed.

12. Earthing of the Braided Screens of Cable Network and Accessories

12.1 Metallic cable sheaths, armouring and shields in power installations shall be electrically connected to the ship's hull at each end; single-core cables shall be earthed at one end only.

In the case of cables and wires for electronic equipment, the manufacturer's recommendations shall be observed, earthing at one end only is recommended.

12.2 Electrical continuity of all metallic cable coverings must also be maintained inside of cable junction boxes and connection boxes.

12.3 Metallic cable sheaths, armouring and shields shall be earthed, preferably by the use of standard cable gland fittings designed for that purpose, or by suitable equivalent clips or joints.

12.4 Metallic cable sheaths, armourings and shields shall in no case be deemed to constitute earthing conductors for the protective earthing of the connected electrical equipment.

13. Cable Joints and Branches

13.1 Cables shall be extended only with the approval of TL. The used material must have been type tested.

13.2 Junction- and distribution boxes must be accessible and marked for identification.

13.3 Cables for safety low voltage shall not pass a junction box or distribution box together with cables for higher voltage systems.

13.4 The terminals for different types of systems, especially such of differently operating voltages, shall be separated.

14. Application of fire-resistant cables

14.1 Scope of installations

14.1.1 Cables for systems required to be operable under fire conditions, including those for their power supplies are recommended to be of a fire-resistant type, complying with Section 14, G.1.3 where they pass through high fire risk areas, fire zones or decks, other than those which they serve.

14.1.2. Systems that are self monitoring, fail safe or dublicated with cable runs as widely separated as is practicable may be exempted, provided their functionality can be maintained.

Notes

In case of cables for services required to be operable under fire conditions the fire resistant cables are to extend from the control/ monitoring panel to the nearest local distribution panel serving the relevant deck/area.

In case of power supply cables used for services required to be operable under fire conditions, the fire resistant cables are to extend from their distribution point within the space containing the emergency source of electrical power to the nearest local distribution panel serving the relevant deck/area.

14.1.3 Emergency services required to be operable under fire conditions include:

– Fire and general emergency alarm systems

– Fire extinguishing system and extinguishing medium alarms

– Fire detection system

– Control and power systems to power operated fire doors and status indication for all fire doors

– Control and power systems to power operated watertight doors and their status indication

– Emergency lighting

– Public address system

– Low location lighting, see UISC 135.

14.2 Installation

For installation of fire-resistant cables the following shall be observed:

14.2.1 The cables shall be arranged in such a way as to minimise the loss of operational availability as a result of a limited fire in any area.

14.2.2 The cables shall be installed as straight as possible and with strict observance of special installation requirements, e.g. permitted bending radii.

E. Requirements for Busbar Trunking Systems intended for the Electrical Supply of Distribution Panels and Single Consumers

1. Scope

The additional requirements below are valid for the design and the installation of busbar trunking systems that are installed outside of switchboards and are intended for the supply of distribution boards or single consumers.

Busbar systems shall not be used in areas potentially endangered by explosion or by explosive materials and on the open deck.

2. Components of the Busbar Trunking System

A busbar trunking system consists of the following components:

– Electrical conductors including neutral and protective conductors, their insulation and the encasement of the busbar trunking system

– Connecting elements

– Separation units

– Insulators and fixing elements

– Arc barriers

– Tap-off units

– Bulkhead and deck penetrations

– Protection devices.

3. Requirements

3.1 Basic requirements

The safety standard and availability of ship mains designed to include busbar trunking systems shall be at least equivalent to those of conventionally cables ship mains, even in case of failure.

Busbar trunking systems shall comply with the requirements of IEC publication 60439-1 and IEC publication 60439-2.

3.2 Requirements for components

3.2.1 Degree of protection

The design of the busbar trunking system shall comply with the following minimum degrees of protection:

– Dry spaces, e.g. accommodation, IP 54

– Wet spaces, e.g. engine rooms, IP 56

The operational readiness of the busbar trunking system shall be not impaired by condensed moisture. Where required means for automatic draining shall be provided.

Busbar trunking systems shall be protected against mechanical damage.

3.2.2 Bulkhead and deck penetrations, fire protection

The used materials shall be halogen-free and shall be flame-retardant according to IEC publication 60695-2.

With regard to flame spread, the whole busbar trunking system shall meet the test requirements of IEC publication 60332-3, category A/F.

Bulkhead and deck penetrations for busbar trunking systems shall not impair the mechanical strength and the watertightness of bulkheads and decks.

The propagation of smoke via the busbar trunking system must be effectively prevented.

3.3 System requirements

3.3.1 System configuration

The design of busbar trunking systems shall be such that in case of a single failure the supply to redundant essential equipment continues. Redundant essential equipment shall be supplied via separate busbar trunking systems.

Where a busbar trunking system is arranged below the uppermost continuous deck, the vessel's manoeuvrability and the operation of all installations necessary for the main purpose of the ship, as well as the safety of the crew shall not be impaired in the event of one or more watertight compartments outside the engine room being flooded.

Where busbar trunking systems are led through several watertight sections, means for separation at the supply-side of the transitions shall be provided. The units for separation shall be approachable, marked for identification and secured against unauthorized un-covering.

3.3.2 Protection devices

Busbar trunking systems shall be protected against overload and short-circuit.

Switchgear of the busbar trunking system shall be arranged with regard to selectivity.

The propagation of electric areas along the busbar trunking system shall be prevented by arc barriers or other means. If current limiting circuit breakers are used, those means are not required.

4. Tests

4.1 Tests on board

On the basis of approved documentation, a shipboard test of the completed installation shall be conducted. This includes the functional testing of the busbar trunking system and the check of settings for protection devices.

4.2 Type-approval

Busbar trunking systems are subject to mandatory type-testing.

F. Magnetic Self-Protection (Degaussing)

1. If the ship is equipped with an active degaussing system as follows, the Notation **DEG** is affixed to the Character of Classification, see also Chapter 101 - Classification and Surveys, Section 2, C.

2. General requirements

2.1 The number and orientation of the windings in the ship, the number of cables belonging to a winding, the cable type, the cross section as well as the number of cores shall be stipulated in the building specification.

2.2 Unless stipulated otherwise in the building specification, the orientation of windings in the ship is differentiated as follows:

2.2.1 **V windings**: windings laid horizontally, i.e. the effective magnetic direction is VERTICAL

2.2.2 **A windings**: windings laid parallel to the longitudinal direction of the ship, i.e. the effective magnetic direction is ATHWART

2.2.3 **L windings**: windings laid parallel to the transverse bulkheads, i.e. the effective magnetic direction is LONGITUDINAL

Notes

In each winding layer, there are I (induced) and P (permanent) windings, resulting in the following six winding circuits in total:

VI, AI, LI, VP, AP and LP.

As an alternative to the winding circuits mentioned, the winding circuits can be limited to the V, A and L circuits in the case of systems designed according to the net current principle. For the net current principle, there is no separation of the windings into P and I components.

The parameters for the required current components P and I are formed by summation in the control section (computer) of the system, so that only a net current flows for each winding.

3. Installation

3.1 The magnetic self-protection windings shall be run along separate cable trays or cable racks, the construction of which must be in compliance with D.

3.2 All cable routes should be selected so that the windings run precisely in the stipulated layer.

3.3 Partial lengths of adjacent A and V windings running athwartships or vertically shall be routed through a penetration only on one side of the corresponding bulkhead.

3.4 The smallest distance to the outer shell should be 70 mm, and the largest distance can be 160 mm.

3.5 In bunkers, tanks and cells, the magnetic self-protection windings shall be routed in continuous cable conduits. The ends of the conduits shall be run approx. 1 m above the bunker, tank or cell ceiling.

3.6 The cables should not be bundled, and must be laid in one layer, if possible with a spacing between each other. If two layers become necessary, the second layer shall be run on a separate cable tray with a spacing to the first layer.

Cables in pipes, if these are necessary for technical reasons, e.g. when passing through tanks, are excepted from this requirement.

Table 12.5 Current-carrying capacity of cables, max. permissible conductor operating temperature of 60 °C and 75 °C

Nominal cross-section		Current-carrying capacity of cables, max. Permissible conductor operating temperature					
		60 °C			75 °C		
mm^2	AWG/MCM	S1-Cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [A] maksimum	S1-Cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [A] maksimum
Single-core cables							
1,0	17	8	8	8	13	14	14
1,5	15	12	13	13	17	18	18
2,5	13	17	18	18	24	25	25
4	11	22	23	23	32	34	34
6	9	29	31	31	41	43	43
10	7	40	42	42	57	60	60
16	5	54	57	57	76	81	81
25	3	71	76	75	100	107	106
35	2	87	94	92	125	135	133
50	0	105	114	111	150	164	159
70	2/0	135	150	143	190	211	201
95	4/0	165	186	177	230	260	246
120	250	190	220	203	270	313	289
150	300	220	260	238	310	366	335
185	400	250	305	273	350	427	382
240	500	290	365	322	415	523	461
300	600	335	439	379	475	622	537
2 – core cables							
1,0	17	7	7	7	11	12	12
1,5	15	10	11	11	14	15	15
2,5	13	14	15	15	20	21	21
4	11	19	21	20	27	29	29
6	9	25	27	27	35	38	37
10	7	34	38	36	48	53	51
16	5	46	52	49	65	73	70
25	3	60	71	65	85	101	92
3 or 4 core cables							
1,0	17	6	6	6	9	10	10
1,5	15	8	9	8	12	13	13
2,5	13	12	13	13	17	18	18
4	11	15	16	16	22	24	23
6	9	20	22	21	29	32	31
10	7	28	31	30	40	45	42
16	5	38	43	41	53	60	57
25	3	50	60	55	70	84	76
35	2	61	76	67	87	108	96
50	0	73	95	82	105	137	118
70	2/0	94	129	108	133	182	153
95	4/0	115	165	137	161	232	192
120	250	133	200	162	189	284	231
Multi-core cables							
5 x 1,5	5 x 15	7			10		
7 x 1,5	7 x 15	6			9		
10 x 1,5	10 x 15	6			8		
12 x 1,5	12 x 15	5			7		
14 x 1,5	14 x 15	5			7		
16 x 1,5	16 x 15	5			7		
19 x 1.5	19 x 15	4			6		
24 x 1.5	24 x 15	4			6		

AWG: American Wire Gauge
MCM: Mille Circular Mil

Table 12.6 Current-carrying capacity of cables, max. permissible conductor operating temperature of 80 °C and 85 °C

Nominal cross-section		Current-carrying capacity of cables, max. Permissible conductor operating temperature					
		80 °C			85 °C		
mm^2	AWG/MCM	S1-Cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [A] maksimum	S1-Cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [A] maksimum
Single-core cables							
1,0	17	15	16	16	16	17	17
1,5	15	19	20	20	20	21	21
2,5	13	26	28	28	28	30	30
4	11	35	37	37	38	40	40
6	9	45	48	43	48	51	51
10	7	63	67	67	67	71	71
16	5	84	89	89	90	95	95
25	3	110	118	117	120	128	127
35	2	140	151	148	145	157	154
50	0	165	180	175	180	196	191
70	2/0	215	239	228	225	250	239
95	4/0	260	294	278	275	311	294
120	250	300	348	321	320	371	342
150	300	340	401	367	365	431	394
185	400	390	476	425	415	506	452
240	500	460	580	511	490	617	544
300	600	530	694	599	560	734	633
2 – core cables							
1,0	17	13	13	13	14	14	14
1,5	15	16	17	17	17	18	18
2,5	13	22	24	23	24	26	25
4	11	30	32	32	32	35	34
6	9	38	41	40	41	45	43
10	7	53	59	56	57	63	60
16	5	71	80	76	76	86	81
25	3	93	111	100	102	121	110
3 or 4 core cables							
1,0	17	10	11	11	11	12	12
1,5	15	13	14	14	14	15	15
2,5	13	18	19	19	20	22	21
4	11	24	26	25	27	29	29
6	9	31	34	33	34	37	36
10	7	44	49	47	47	53	50
16	5	59	67	63	63	72	67
25	3	77	92	84	84	101	92
35	2	98	122	108	101	125	111
50	0	115	150	129	126	164	141
70	2/0	150	206	173	157	215	181
95	4/0	182	262	217	192	276	228
120	250	210	315	256	224	336	273
Multi-core cables							
5 x 1,5	5 x 15	11			12		
7 x 1,5	7 x 15	11			10		
10 x 1,5	10 x 15	9			9		
12 x 1,5	12 x 15	8			9		
14 x 1,5	14 x 15	8			8		
16 x 1,5	16 x 15	7			8		
19 x 1,5	19 x 15	7			7		
24 x 1,5	24 x 15	7			7		

AWG: American Wire Gauge
MCM: Mille Circular Mil

Table 12.7 Current-carrying capacity of cables, max. permissible conductor operating temperature of 85 ºC (JIS)*

Nominal cross-section To JIS*	Current-carrying capacity based on a maximum conductor operating temperature of 85 °C		
	S1-cont. operation	S2-30 min	S2-60 min
mm^2	[A] maksimum	[A] maksimum	[A] maksimum
Single core cables			
1,25	18	19	19
2,0	25	26	26
3,5	35	37	37
5,5	46	49	49
8	59	63	63
14	83	88	88
22	110	117	117
30	135	144	143
38	155	167	164
50	185	202	196
60	205	228	217
80	245	277	262
100	285	331	305
125	325	384	351
150	365	445	398
200	440	554	488
250	505	662	571
2-core cables			
1,25	16	17	17
2	21	22	22
3,5	30	32	32
5,5	39	42	41
8	50	55	53
14	71	79	75
22	94	106	101
30	115	137	124
3-core cables			
1,25	13	14	14
2	17	18	18
3,5	25	27	27
5,5	32	35	34
8	41	45	43
14	58	65	61
22	77	88	82
30	94	113	102
38	110	136	121
50	130	169	146
60	145	199	167
80	175	252	208
100	200	300	244
Multi-core cables			
5 x 1,25	11		
7 x 1,25	10		
9 x 1,25	9		
12 x 1,25	8		
16 x 1,25	7		
19 x 1,25	6		
23 x 1,25	6		
27 x 1,25	6		

*JIS : Japan Industry Standards

Table 12.8 Current-carrying capacity of cables, max. permissible conductor operating temperature of 95 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature of 95 °C		
		S1-cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [A] maksimum
mm^2	AWG/MCM			
Single core cables				
1	17	20	21	21
1,5	15	24	25	25
2,5	13	32	34	34
4	11	42	45	45
6	9	55	58	58
10	7	75	80	80
16	5	100	106	106
25	3	135	144	143
35	2	165	178	175
50	0	200	218	212
70	2/0	255	283	270
95	4/0	310	350	332
120	250	360	418	385
150	300	410	484	443
185	400	470	573	512
2-core cables				
1	17	17	18	18
1,5	15	20	21	21
2,5	13	27	29	29
4	11	36	39	38
6	9	47	51	50
10	7	64	71	68
16	5	85	96	91
25	3	115	137	124
3-core cables				
1	17	14	15	15
1,5	15	17	18	18
2,5	13	22	24	23
4	11	29	32	31
6	9	38	42	40
10	7	52	58	55
16	5	70	80	75
25	3	94	113	102
35	2	115	143	127
50	0	140	182	157
70	2/0	178	244	205
95	4/0	217	312	258
120	250	252	378	307
Multi-core cables				
5 x 1,5	5 x 15	14		
7 x 1,5	7 x 15	13		
10 x 1,5	10 x 15	11		
12 x 1,5	12 x 15	10		
14 x 1,5	14 x 15	10		
16 x 1,5	16 x 15	9		
19 x 1,5	19 x 15	9		
24 x 1,5	24 x 15	8		

AWG: American Wire Gauge
MCM: Mille Circulare Mil

SECTION 13

ELECTRICAL PROPULSION PLANTS

A. General

1. Definitions, scope

1.1 A ship has an electrical main propulsion plant if the main drive to the propeller is provided by electrical propulsion motors.

1.2 Electrical auxiliary propulsion plants are additional propulsion systems that are functionally separated from the main drives.

1.3 The engines driving the generators for the electrical propulsion plant are main engines; the motors driving the propeller shaft are propulsion motors.

1.4 If electrical main propulsion plants are supplied from the ship's general mains, the Rules in this Section apply also to the generators and the associated switchgear. For auxiliary propulsion plants, the Rules of this Section shall be met correspondingly.

1.5 The IEC publication 60092-501: "Special features - Electric propulsion plant" shall be considered.

2. Special requirements for main propulsion plants

These requirements apply to ships with an electrical main propulsion system.

2.1 Basic requirement

The main propulsion plant must consist of at least two independent propulsion systems.

The design of the electrical propulsion system must ensure that at least 50 % of the propulsion power remains available after a single failure in the mechanical or electrical part of the main propulsion plant.

2.2 System configuration and arrangement

With regard to their function, the plants for propulsion of the ship are mechanically and electrically independent of each other.

2.3 Auxiliary systems

Auxiliary systems whose function has a direct influence on the propulsion plant must be available separately and independently for each propulsion plant.

2.4 Static converter installations

Static converter installations, their supply transformers, their protection and control equipment, and the associated power supply systems, cooling arrangements etc. must be designed in such a way that 50 % of the ship's propulsion power remains available after a single failure in the system.

2.5 Additional documents to be submitted

A failure mode and effects analysis (FMEA) shall be submitted for the propulsion plants and for their auxiliary and control systems.

This analysis must show that a single failure cannot lead to more than a 50 % loss in the propulsion power. In addition, the analysis must show that measures have been provided for fault detection and correction.

Furthermore, this analysis should investigate systematic faults and subsequent faults which could influence the system separation concept.

B. Drives

1. Basis for dimensioning

1.1 The electrical machinery and plants must, in accordance with their service and operating conditions, be designed for short periods of overload and for the effect of manoeuvres and the state of the sea.

1.2 The lubrication of machinery and shafting shall be designed to be adequate for the entire speed range of rotation in both directions, including towing operations.

2. Main engines

2.1 The main engines must also conform to the requirements of Chapter 104 - Propulsion Plants.

2.2 The diesel governors must allow safe operation over the whole speed range and under all running and

manoeuvring conditions, for both single operation and parallel operation.

3. Propulsion motors

3.1 The propulsion motors must also conform to sthe requirements of Section 14.

3.2 The effects of the harmonics of currents and voltages shall be taken into consideration for the design of the propulsion motors.

3.3 The winding insulation shall be designed to withstand the overvoltages which may arise from manoeuvres and switching operations.

3.4 Machines with forced ventilation shall be so dimensioned that in case of ventilation failure a limited operation is still possible. Versions deviating from this principle require approval.

Electrical machines with heat-exchangers must remain operable in the event of a failure of the heat exchanger. Here the degree of protection need not be preserved. If applicable, any reduction of the performance owing to higher coolant temperatures must be agreed with the customer.

3.5 The stator and rotor windings must be readily accessible for surveys, repairs and maintenance. Furthermore, it must be ensured that inspection of the air gap is possible.

3.6 Electrical propulsion motors must be able to withstand at their terminals and in the system under rated operating conditions a short circuit without damage until the protection devices respond.

C. Static Converter Installations

1. Power electronics equipment must also conform to the requirements of Section 6.

2. Static converters must be designed for the load to be expected under all operating and manoeuvring conditions, including overloads and short circuits.

3. If static converters are separately cooled, the plant must be capable to continue operation at a reduced power level if the cooling system fails, where no redundant static converter system is available.

4. The circuits for main power supply and exciter equipment must be supplied directly from the power station switchboards and shall be separate for each motor and each winding.

5. Exciter circuits, whose failure can endanger the operation, shall only be protected against short circuit.

6. The static converters must be easily accessible for inspection, repair and maintenance.

D. Control Stations

Control equipment must conform to Chapter 106 - Automation, as and where appropriate. Additionally, the following Rules apply:

1. Where the propulsion main control station is located on the bridge, provisions shall be made for the control of the propulsion plant also from the engine room and the machinery control centre.

2. For any arbitrary fault of the automatic remote control and the propulsion main control stations, local operation shall be possible from the local control station.

2.1 Change-over shall be possible within a reasonably short time. The local control station shall receive the highest priority, and it shall be possible to select this control station locally.

This control station shall be connected directly to the corresponding static converter.

It shall be ensured that control is only possible from one control station at any time. Transfer of command from one control station to another shall only be possible when the respective control levers are in the same position and when a signal to accept the transfer is given from the selected control station.

The loss of control at the concerned control station is to be signalled optically and audibly.

2.2 Ships with Class Notations **K50** and **K6** may, with the consent of **TL**, have only one propulsion main control station on the bridge and a local control station.

2.3 It shall be possible to acknowledge all malfunctions at the local control station.

2.4 At the propulsion main control station, it shall be possible to acknowledge at least all those malfunctions that are caused by the auxiliary services or by the supply network. After a black-out, it shall be possible to restart the propulsion at the propulsion main control station.

3. The propulsion main control stations on the bridge and in the machinery control centre as well as the local control station shall be provided with an emergency stop device that is independent of the main control system. The emergency stop device in the machinery control centre shall be provided even if only control positions according to 2.2 exists.

4. All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

5. A malfunction in a system for synchronizing or in a position equalisation device for controlling the operating levers of several control stations shall not result in the failure of the remote control from the main control position.

E. Ship's Mains

1. It must be possible to connect and disconnect generators without interrupting the propeller drive.

2. If a power management system is available, the automatic shutdown of main engines during manoeuvring shall be prevented.

3. If circuit breakers are power-driven, it is necessary to provide for additional manual operation or a second power drive which is independent of the first.

If a certain sequence must be observed when operating the switches, these elements must be coupled or inter locked electrically or mechanically so that their actuation during normal operation is only possible in the required order.

4. Main propulsion plants shall be supplied from each of the power station switchboards.

F. Control and Regulating

1. When computer systems are used, the requirements of Section 10 and Chapter 106 Automation shall be observed.

2. An automatic power limitation of the propulsion motors must ensure that the ship mains will not be overloaded.

3. The reverse power during reversing or speed reducing manoeuvres shall be limited to the maximum values acceptable for the main engines.

4. Malfunctions or failure of the arrangements for controlling and regulating the speed and voltage shall not lead to any damage of the associated machinery or units.

5. Electronic equipment for information processing in power installations shall be provided with short-circuit-proof outputs.

Arrangements containing power electronic equipment in power installations shall be constructed to be at least "conditionally short-circuit-proof".

G. Protection of the Plant

1. Automatic stop of the propulsion plant, which impairs the ship's manoeuvring capability, shall be limited to such failures which could result in serious damage within the plant. An override arrangement is permissible. Actuation of this arrangement shall be designed so that it can only be performed by authorized persons.

2. Protection devices must be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring, or in heavy seas.

3. Defects in reducing and stopping devices shall not impair the redundancy.

4. In the event of failure of an actual or reference value, it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will not be reversed and no dangerous operating conditions arise. The same applies to failure of the power supply for the control and regulating functions.

5. The following additional protection equipment shall be provided:

5.1 Where drives can be mechanically blocked in an uncontrolled manner, they must be provided with monitoring devices which prevent damage to the plant.

5.2 Overspeed protection

5.3 Protection against overcurrent and short circuit.

5.4 Differential protection and earth fault monitoring for propulsion motors with an output of more than 1500 kW.

6. The triggering of protection, reducing and alarm devices shall be indicated optically and acoustically. The alarm condition must remain recognizable even after switching off.

7. In the case of electrical main propulsion plants, an independent stopping and reducing device, as well as independent protection components, shall be provided for each drive.

H. Measuring, Indicating and Monitoring Equipment

1. Faults in measuring, monitoring and indicating equipment must not cause a failure of control and regulating. For main propulsion plants, independent systems shall be installed for each propulsion unit.

2. Measuring equipment and indicators

Main propulsion plants shall be provided with at least the following measuring equipment and indicators at control stations:

2.1 At local control stations

- Ammeter and voltmeter for each supply and each load component
- Ammeter and voltmeter for each exciter circuit
- Revolution indicator for each shaft
- Plant ready for switching on
- Plant ready for operation
- Plant disturbed
- Control from machinery control centre (MCC)
- Control from the bridge
- Control from the local control station
- Power reduced

2.2 At control stations in the machinery control centre (MCC)

- Power meter
- Revolution indicator for each shaft
- Plant ready for switching on
- Plant ready for operation
- Plant disturbed
- Power reduced
- Request to reduce
- Control from MCC
- Control from the bridge
- Control from the local control station
- Indication of the generators used for propulsion

2.3 At control stations on the bridge

- Revolution indicator for each shaft
- Indication of the power remaining available for the propulsion plant in relation to the total available ship's main power
- Plant ready for switching on
- Plant ready for operation
- Plant disturbed and power reduced
- Request to reduce
- Control from engine control room
- Control from the bridge
- Control from the local control station

2.4 At emergency control stations for multiple drives

In the case of multiple drives, an emergency control station must be set up at a central position for all drives instead of the local control station, and its instrumentation must comply with 2.1.

3. Monitoring equipment

The triggering of the following monitoring equipment shall be signalled optically and acoustically:

3.1 Monitoring of the ventilator and of the temperature of the cooling air for machines and static converters with forced ventilation.

3.2 Monitoring of the flow rate, the leakage and the temperature of the coolant for machines and static converters with closed cooling systems.

3.3 Temperature monitoring for the stator windings and the bearings.

3.4 Pressure or flow monitoring for the lubricating oil of friction bearings (except in the case of ring lubrication).

3.5 Power component fuses shall be monitored for failure.

3.6 Insulation resistance in the case of unearthed networks.

3.7 For local analogous indication and for automated monitoring, separate measurement transducers must be provided.

3.8 Each main propulsion plant shall be monitored by an independent alarm device.

I. Cable Installation

1. The cable network for electrical propulsion plants must comply with the requirements of Section 12. The cables of any one propulsion unit shall, as far as is practicable, be run over their entire length separately from the cables of the other units, in order to increase the combat survivability and resistance to fire.

2. Cables for measurement, control, regulating and indicating/alarm equipment for electrical propeller units must not be installed in one bundle together with the propulsion power cables.

J. Construction Supervision, Testing and Trials

1. Supervision during construction

Propulsion motors, generators, transformers, static converters and switchgear are subject to supervision during construction.

2. Tests

The following additional tests shall be carried out during fabrication and after the partial tests:

2.1 Tests of machines, static converters, switch-gear, equipment and cables shall be carried out at the manufacturer's works in accordance with Section 14.

2.2 Proof of compliance of the shaft material for generators and propulsion motors with Chapter 104 - Propulsion Plants, Section 5 must be provided.

2.3 The testing of other important forgings and castings for electrical main propulsion plants, e.g. rotors and pole shoe bolts, shall be agreed with TL.

2.4 TL reserve the right to request additional tests.

3. Tests after installation

3.1 Testing on board

Newly-constructed or enlarged plants require testing and trials on board. The scope of tests shall be agreed with TL.

3.2 Dock trial

Functioning of the propulsion plant shall be proved by a dock trial before the sea trials. At least the following trials/measurements shall be carried out in the presence of a TL Surveyor:

3.2.1 Start-up, loading and unloading of the main and propulsion motors in accordance with the design of the plant and a check of regulation, control and switchgear.

3.2.2 Verification of the propeller speed variation and all associated equipment.

3.2.3 Verification of the protection, monitoring and indicating/alarm equipment, including the interlocks, for faultless operation.

3.2.4 Verification of the insulation condition of the main-propulsion circuits.

3.2.5 TL reserve the right to request additional tests.

3.3 Sea trial

The trial programme at sea shall at least include:

3.3.1 Continuous operation of the ship at full propulsion load until the entire propulsion plant has reached steady-state temperatures.

The trials shall be carried out at rated engine speed and with an unchanged governor setting:

- at 100 % power output (rated power): at least 4 hours; and at the continuous power output normally used at sea: at least 2 hours

- with the propeller running astern during the dock test or during the sea trial at a minimum speed of at least 70 % of the rated propeller speed: 10 minutes

3.3.2 Reversal of the plant out of the steady-state condition from full power ahead to full power astern, and maintaining of this setting at least until the ship has lost all speed. Characteristic values such as speed, system currents and voltages, and the load sharing of the generators, shall be recorded. If necessary, oscillograms shall be made.

3.3.3 Performance of the manoeuvres typical for estuary navigation.

3.3.4 Checking of the machinery and plant in all operating conditions.

3.3.5 Checking of the network qualities in the ship's propulsion network and mains.

3.3.6 For main propulsion plants, it must be shown that the functional separation of the propulsion systems has been achieved.

3.3.7 It must be shown by fault simulation that fault events in the main propulsion system, its auxiliary systems, and in the monitoring and control circuits have the effects described in the FMEA which was submitted.

SECTION 14

ELECTRICAL EQUIPMENT

A. General

1. Depending on the application and deployment profile of the ship, additional environmental tests, e.g. shock resistance, vibration resistance and noise, must be determined and verified for electrical equipment and assemblies, see Section 1, E.

2. All electrical equipment and assemblies shall be tested in the manufacturer's works. The tests must be documented and the test reports submitted on request, see also Section 16.

B. Electrical Machinery

1. Generators and motors

1.1 General

Electrical machines shall conform to IEC publication 60034 or an equivalent standard.

For medium-voltage machines, see Section 8.

1.2 Materials

Materials for the construction of electrical machines must conform to the requirements set out in Section 1, I. For shaft materials, see 1.5.

1.3 Degree of protection

Protection against electric shock through accidental contact and against the entry of foreign bodies and water must conform to Section 1, J. The degree of required protection must be assured when the equipment is installed and in operation.

Electrical propulsion motors must have the degree of protection IP 56 up to the lower edge of the shaft bearing. The overall degree of protection of the machinery should be at least IP 23 for an open cooling circuit and at least IP 44 for a closed cooling circuit.

1.4 Ventilation and cooling

1.4.1 The construction of machines with coolants other than air is subject to approval, with due consideration of the operating conditions.

1.4.2 Draught ventilation

The supply air to draught-ventilated machines shall, as far as practicable, be free of moisture, oil vapours and dust. If required, filters shall be provided.

1.4.3 Enclosed air cooling circuit

Where heat exchangers are used in the air circuit, they must be designed and mounted in such a way that condensation or leakage water from the exchanger system is kept away from the machine windings.

Leakage monitoring is required. The water supply-lines and recirculating lines of each heat exchanger shall be fitted with shut-off valves. The air ducts must be provided with inspection holes for visual observation of the heat exchanger.

A failure of cooling (air filters, fan flaps, forced ventilation, recooling) must trigger an alarm, e.g. by monitoring of the cooling air temperature.

Electrical propulsion motors with heat-exchange arrangements must remain operable in the event of a failure of the heat exchanger. In this case the degree of protection need not be preserved.

Machines for electric propulsion plants shall be equipped with monitoring devices in accordance with Section 13.

Machines fitted with brushes shall be ventilated in such a direction that fines from the brushes do not enter the inside of the machine.

1.4.4 Surface cooling

Surface-cooled machines on the open deck shall have external fans only if they are fully protected against icing.

1.5 Construction of shafts

The materials for the shafts of:

1.5.1 motors of electric propulsion plants,

1.5.2 main generators supplying the motors of electric propulsion plants, and

1.5.3 shaft generators or supplementary electrical drives if their shafts form part of the ship's main shafting must conform to the Rules defined in Chapter 104 - Propulsion Plants, Section 5.

Proof shall take the form of an acceptance test certificate, similar to that for propeller shafts.

1.6 Bearings and bearing lubrication

1.6.1 Plain bearings

Bearing shells must be easily replaceable. Provision must be made for checking the bearing lubrication. Adequate lubrication must be assured even in inclined positions. No lubricant shall flow out and penetrate into the machine. In the case of bearings with forced lubrication, failure of the oil supply and the attainment of excessive bearing temperatures shall cause an alarm.

Two-part bearings shall be fitted with thermometers indicating, wherever possible, the temperature of the lower bearing shell.

Turbo generators and propulsion motors shall be equipped with devices which, in the event of a failure of the normal lubricant supply, provide adequate lubrication until the machine has come to standstill.

1.6.2 Prevention of bearing currents

To avoid damage to bearings, it is essential to ensure that no harmful currents can flow between bearing and shaft.

1.7 Standstill heating system

Generators and main propulsion motors with an output $\geq$ 500 kVA/kW and all bow thruster motors shall be equipped with an electric heating designed to maintain the temperature inside the machine at about 3 K above ambient temperature.

An indicator shall show when the standstill heating system is in operation.

1.8 Accessibility for inspection, repairs and maintnance

Commutators, slip rings, carbon brushes and regulators must be accessible for inspection, repairs and maintenance. For larger machines with plain bearings, provision must be made for the direct or indirect measurement of the air gap.

1.9 Windings

In interaction with the specified protection devices, machines must be able to withstand the dynamic and thermal stresses likely to result from a short circuit.

Machines shall be designed and rated in such a way that the permissible temperature rises listed in Table 14.3 are not exceeded.

All windings must be effectively protected against the effects of oil vapours and air laden with moisture or salt.

Main generators and propulsion motors/generators shall be fitted with sensors for monitoring the winding temperature.

1.10 Air gaps

Machines with only one internal bearing shall have a minimum air gap of 1,5 mm.

Where generators are intended for incorporation in the line shafting, the design of the generator and its foundations shall ensure faultless operation of the propulsion plant even in heavy seas, and regardless of the loading condition of the ship. In consideration of the special service conditions, the generator air gap shall not be less than 6 mm.

1.11 Brush rocker

The operation position of the brush rocker shall be clearly marked.

1.12 Terminal boxes

Terminal boxes shall be made of metallic materials.

They must be located in accessible positions.

Separate terminal boxes are required for terminals with service voltages above 1000 V AC or 1500 V DC. Terminals shall be clearly marked. The degree of protection for terminal boxes must correspond to that of the machine, but shall in no case be less than IP 44.

1.13 Voltage regulators

Regulators must withstand the loads expected at the place of installation, see Section 1.

The installation of regulators in terminal boxes is only permitted if the regulator units are mechanically separated so that they cannot be damaged during the mounting of the main cables.

Setpoint adjusters shall be so designed that it is impossible for them to shift by themselves, and they shall be adjustable from outside by use of a tool only.

1.14 Operation in networks with semiconductor converters

Electric machines operating in networks containing semiconductor converters shall be designed for the expected harmonics of the system. A sufficient reserve shall be considered for the temperature rise, related to a sinusoidal load, see Section 1 and 13.

1.15 Rating plate

Machines shall be fitted with durable corrosion resistant rating plates.

2. Magnetic brakes

The requirements stated in 1. shall be applied correspondingly.

The temperature rise of the windings shall not exceed the permitted values shown in Table 14.3. Where windings are located in the immediate vicinity of the brake linings, the heat generated during braking shall be considered.

3. Magnetic clutches

The requirements stated in 1. shall be applied correspondingly.

When engaged, the clutch must take over the drive smoothly and reliably. The clutch shall exert no axial thrust.

4. Testing of electrical machinery

4.1 Factory acceptance tests shall be performed in accordance with the provisions in 4.3. If necessary, additional tests may be stipulated in the case of new types of machines or where it is required for special reasons.

4.2 The machines listed below are subject to testing in the manufacturer's works in the presence of a TL Surveyor:

4.2.1 Generators and motors for essential equipment with outputs of 100 kW (kVA) and over.

4.2.2 Material test for the shafts of:

4.2.2.1 motors of electric propulsion plants,

4.2.2.2 main generators supplying the motors of electric propulsion plants, and,

4.2.2.3 shaft generators or supplementary electrical drives if their shafts form part of the ship's main shafting.

4.3 Extent of tests

Regarding the scope of factory acceptance tests, see Table 14.1. Depending on the application and deployment profile of the ship, additional environmental tests must be determined.

4.3.1 Documentation

The technical documentation shall be checked and a visual inspection be carried out.

4.3.2 Measurement of winding resistance

The winding resistances shall be measured and recorded.

4.3.3 Functional test

The fully assembled machines, including all control and supplementary elements, e.g. winding and bearing temperature sensors, current and voltage transformers, shall undergo functional tests. Generators shall be tested with their excitation systems.

4.3.4 Heat test

4.3.4.1 A heat test shall be performed until the steady-state temperature corresponding to the required mode of operation is reached.

The steady-state temperature is reached when the temperature rises by not more than 2 K per hour. Machines with separate cooling fans, air filters and heat exchangers shall be tested together with this equipment.

The heat run shall be completed with the determination of the temperature rise; the maximum permissible values shown in Table 14.3 shall not be exceeded.

4.3.4.2 An extrapolation of the measured values to the disconnection time (t = 0) is not necessary if the reading takes place within the periods listed in Table 14.2.

4.3.4.3 Heat tests on machines of identical construction made not more than 3 years previously can be recognized. The referenced temperature rise should be at least 10 % below the values shown in Table 14.3.

The following tests shall be carried out at approximately normal operating temperatures.

4.3.5 Load characteristics

For generators the voltage, and for motors the speed, shall be checked as a function of the load. The operating characteristics of generators must conform to the requirements stipulated in each case for the quality of supply of the consumers.

4.3.6 Overload/overcurrent test

The overload test shall be performed

4.3.6.1 for generators at 1,5 times the rated current for two minutes;

4.3.6.2 for shaft generators, which are arranged in the main shafting and - due to their construction -could not be tested in the manufacturer's works, at 1,1 times the rated current for 10 minutes;

4.3.6.3 for motors where no particular stipulations are made, at 1,6 times the rated torque for 15 seconds. During the test, the motor speeds shall not deviate substantially from their rated speed;

4.3.6.4 for anchor windlass motors, at 2 times the rated torque for two minutes. Overload tests already performed on motors of identical construction may be recognized.

The current of the operating stage corresponding to twice the rated torque shall be measured and indicated on the rating plate. The overload capability of generators with subsequent rectifiers must be specified in the building specification.

Table 14.1 Summary of tests to be carried out

No	Tests	AC generators		Motors	
		Type test **(1)**	Routine test **(2)**	Type test **(1)**	Routine test **(2)**
1	Technical documentation check, visual inspection	x	x	x	x
2	Winding resistance Measurement	x	x	x	x
3	Operational test	x	x	x	x
4	Heat run test	x		x	
5	Load test	x		x	
6	Overload, overcurrent test	x	x	x	x
7	Short circuit test	x			
8	Overspeed test	x	x	x	x
9	Winding test (High-voltage test)	x	x	x	x
10	Insulation resistance Measurement	x	x	x	x
11	Degree of protection check	x		x	
12	Bearing check	x	x	x	x
13	Test of voltage regulator, see Section 3, B. 2. **(3)**	x	x		

(1) *Test of the first machine of a series*

(2) *Test of all other machines of the series*

(3) *Test together with 5.*

Table 14.2 Time limits for data acquisition

Rated power [kW/kVA]	**Time elapsed after Disconnection [s]**
up to 50	30
over 50 up to 200	90
over 200 up to 5000	120
over 5000	by agreement

4.3.7 Short-circuit test

4.3.7.1 On all synchronous generators, the steady short-circuit current shall be determined with the exciter unit in operation. With a terminal short circuit on three phases, the steady short-circuit current shall not be less than three times the rated current. The generator and its exciter unit must be capable of withstanding the steady short-circuit current for a period of two seconds without suffering damage.

4.3.7.2 A short-circuit withstand test may be demanded

- to determine the reactances
- if there is any concern regarding mechanical and electrical strength

Synchronous generators which have undergone a short-circuit withstand test shall be thoroughly examined after the test for any damage.

4.3.8 Overspeed test

As proof of mechanical strength, a two-minute over-speed test shall be carried out as follows:

4.3.8.1 for generators with their own drive, at 1,2 times the rated speed;

Table 14.3 Permitted temperature-rises of air cooled machines at an ambient temperature of 45°C (differential values [°K])

No	Machinery component		Method of measurement **(3)**	Insulation class				
				A	E	B	F **(1)**	H **(1)**
1	AC windings of machines		R	55	70	75	100	120
2	Commutator windings		R	55	70	75	100	120
3	Field windings of AC and DC machines with DC excitation, other than those specified under 4		R	55	70	75	100	120
4	**a)** Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors		R	-	-	85	105	125
	b) Stationary field windings of DC machines having more than on layer		R	55	70	75	100	120
	c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer		R Th	55	70	75	95	115
	d) Single-layer field windings of AC and DC machines with exposed bare or varnished metal surfaces and single-layer compensation windings of DC machines		R Th	60	75	85	105	125
5	Permanently short-circuited, insulated windings		Th	55	70	75	95	115
6	Permanently short-circuited, uninsulated windings		The temperature rises of these parts shall in no case reach such values that there is a risk of injury to any insulation or other material on adjacent parts or to the item itself					
7	Iron cores and other parts not in contact with windings							
8	Iron cores and other parts in contact with windings		Th	55	70	75	95	115
9	Commutators and slip rings, open or enclosed		Th	55	65	75	85	105
10	Plain bearings	measured in the lower bearing shell or in the oil sump after shutdown		45				
11	Roller bearings Roller bearings with special grease	measured in the lubrication nipple bore or near the outer bearing seat		45 75				
12	Surface temperature			Reference 35 **(2)**				

(1) *These values may need correction in the case of high-voltage AC windings.*

(2) *Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidentally touched and there is a risk of burns (>80°C),* ***TL*** *reserves the right to request means of protection such as a handrail to prevent accidental contacts.*

(3) *R = resistance method, Th = thermometer method.*

4.3.8.2 for generators coupled to the main propulsion plant and not arranged in the main shafting, at 1,25 times the rated speed;

4.3.8.3 for shaft generators arranged in the main shafting and whose construction makes testing impracticable, proof by computation of mechanical strength is required;

4.3.8.4 for motors with one nominal speed, at 1,2 times the no-load speed;

4.3.8.5 for variable-speed motors, at 1,2 times the maximum no-load speed;

4.3.8.6 for motors with series characteristics, at 1,2 times the maximum speed shown on the rating plate, but at least at 1,5 times the rated speed.

4.3.8.7 The overspeed test may be dispensed with in the case of squirrel-cage machines.

4.3.9 Winding test (high-voltage test)

4.3.9.1 The test voltage shall be as shown in Table 14.4.

It shall be applied for one minute for each single test.

The voltage test shall be carried out between the windings and the machine housing, the machine housing being connected to the windings not involved in the test. This test shall be performed only on new, fully assembled machines fitted with all their working parts.

The test voltage shall be a practically sinusoidal AC voltage at system frequency. The maximum anticipated no-load voltage or the maximum system voltage shall be used as reference in determining the test voltage.

4.3.9.2 Any repetition of the voltage test which may be necessary shall be performed at only 80 % of the nominal test voltage specified in Table 14.4.

4.3.9.3 Electrical machines with voltage ratings according to Section 8 shall be subjected to an impulse withstand voltage test as per IEC publication 60034-15. The test shall be carried out for the coils as a random sample test.

4.3.10 Determination of insulation resistance

The insulation resistance measurement shall be carried out at the end of the test sequence, with the machine at operating temperature, if possible. Minimum values of the measuring voltage and the insulation resistance shall be taken from Table 14.5. The maximum anticipated no-load voltage or the maximum system voltage shall be taken for the rated voltage.

4.3.11 Test of degree of protection

For the test of the degree of protection see also Section 1, J.

If flooding insensitivity of the machine and windings is required, the test procedure shall be carried out with reference to the specified degree of protection.

4.3.12 Bearing check

Plain bearings shall be opened and examined after the test.

4.3.13 Test of voltage regulator

For the requirements for testing of voltage regulators see Section 3, B.3.

C. Transformers and Reactance Coils

1. General requirements

1.1 Coolant

Only dry-type transformers are approved for use on board ships. For separately cooled transformers, the cooling air shall be monitored; see also B.1.3.

1.2 Windings

All transformers shall have separate windings for primary and secondary coils, except for starting and ignition transformers, which may be of the autotransformer type.

Table 14.4 Test voltages for the winding test

No.	Machine or machinery component	Test voltage (r.m.s.) dependent on rated voltage U of the subject winding
1	Insulated windings of rotating machines of output less than 1 kW (kVA), and of rated voltages less than 100 V with the exception of those in items 4 to 8	2 U + 500 V
2	Insulated windings of rotating machines of size less than 10000 kW (kVA), with the exception of those in item 1 and items 4 to 8	U + 1000 V, with a minimum of 1500 V
3	Insulated windings of rotating machines of size 10000 kW (kVA) or more with the exception of those in items 4 to 8 rated voltage up to 11000 V	 2 U + 1000 V
4	Separately excited field windings of DC machines	1000 V + twice the maximum excitation voltage but not less than 1500 V
5	Field windings of synchronous generators, synchronous motors and rotary phase converters **a)** Rated field voltage up to 500 V over 500 V **b)** When a 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 the winding **c)** When the machine is intended to be started either with the field winding connected across a resistance of value equal to, or more than, ten times the resistance of the winding, or with the field windings on open-circuit with or without a field dividing switch	 10 times rated field voltage, with a minimum of 1500 V 4000 V + twice rated field voltage 10 times the rated field voltage, minimum 1500 V, maximum 3500 V 1000 V + twice the maximum value of the r.m.s. voltage, which can occur under the specified starting conditions, between the terminals of the field winding , or in the case of a sectionalized field winding between the terminals of any section, with a minimum of 1500 V
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 **b)** For motors to be reversed or braked by reversing the primary supply while the motor is running	 1000 V + twice the open-circuit standstill voltage as measured between slip rings or secondary terminals with rated voltage applied to the primary windings 1000 V + four times the open-circuit secondary voltage as defined in item (6a)

Table 14.4 Test voltages for the winding test (cont.)

No.	Machine or machinery component	Test voltage (r.m.s.) dependent on rated voltage U of the subject winding
7	Exciters (exception below) Exception 1: Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting Exception 2: Separately excited field windings of exciters	as for the windings to which they are connected twice rated exciter voltage + 1000 V, with a minimum of 1500 V as under item 4
8	Assembled group of machines and apparatus	A repetition of the tests in items 1 to 7 above should be avoided if possible, but if a test on an assembled group of several pieces of new machines, each one of which has previously passed its high-voltage test, is made, the test voltage to be applied to such assembled group shall be 80 % of the lowest test voltage appropriate for any part of the group. **(1)**
(1) *Where a number of windings belonging to one or more machines are connected together, the test voltage is dictated by the maximum voltage to earth which can occur.*		

Table 14.5 Minimum values for measurement voltage and insulation resistance

Rated voltage [V]	Measurement Voltage [V]	Insulation Resistance [MΩ]
$U_n \leq 250$	2 x U_n	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$\frac{U_n}{1000}+1$
$7200 < U_n \leq 15000$	5000	$\frac{U_n}{1000}+1$

2. Rating

2.1 Voltage variation during loading

Under resistive load, the voltage variation between no-load and full-load shall not exceed 5 %. This requirement does not apply to short-circuit-proof transformers.

2.2 Temperature rise

The temperature rise of windings shall not exceed the values listed in Table 14.6. Parts of casings with surface temperatures over 80°C shall be protected against unintentional contact.

2.3 Short-circuit resistance

Transformers, in conjunction with their protection devices, must be able to withstand without damage the effects of external short circuits.

3. Rating plate

Transformers must be provided with a durable, corrosion-resistant rating plate. If special designations are required, this must be stipulated by the Naval Authority.

4. Tests

4.1 Transformers rated at more than 50 kVA shall be tested at the manufacturer's works in the presence of a TL Surveyor and have to undergo the following tests.

4.2 Heat test

The test shall be performed to determine the temperature rise, which shall not exceed the maximum permissible values shown in Table 14.6. Temperature-rise tests on transformers of identical construction and carried out not more than 3 years previously may be recognized. The referenced temperature rise shall be 10 % below the values shown in Table 14.6. The following tests shall be performed at approximately operating temperature.

Table 14.6 Permissible temperature rise of transformer- and reactance coil windings with an ambient temperature of 45 °C

Insulation class	A	E	B	F	H
Temperature rise (K)	55	70	75	95	120

4.3 Induced overvoltage test

The windings shall be tested at twice the rated voltage and at increased frequency to verify that the insulation between turns is sufficient and satisfactory. The duration of the test shall be

$$120 \cdot \frac{\text{rated frequency}}{\text{test frequency}} \quad [\text{s}]$$

but not less than 15 s.

4.4 Short-circuit test

The short-circuit proof property in accordance with 2.3 shall be verified.

4.5 Winding test

The test voltage shown in Table 14.7 shall be applied between the winding parts to be tested and all other windings, which are to be connected to the core and the frame during the test. The test voltage shall be applied for one minute.

Table 14.7 Test voltage for transformers and reactance coil windings

Maximum operating voltage [V]	Alternating withstand voltage [V]
≤1100	3000
3600	10000
7200	20000
12000	28000
17500	38000

4.6 Determination of insulation resistance

The measurement of insulation resistance at low-voltage transformers shall be carried out at the end of the test sequence with a DC voltage of at least 500 V. The insulation resistance shall be at least:

- 5 MΩ between primary and secondary winding
- 2 MΩ for the remaining insulation

D. Capacitors

1. Application

The requirements of this Section apply to power capacitors with a reactive power of 0,5 kVA and above.

2. Construction

2.1 Capacitors must have gastight steel casings. The metal casings must have means for the connection of earthing conductors.

The dimensional design of capacitors shall be such that, if a casing is damaged, not more than 10 litres of impregnating agent can leak out.

2.2 Internal faults shall be limited by element fuses.

2.3 Discharge resistors must ensure the discharge of the capacitor down to a terminal voltage below 50 V within one minute after disconnection.

3. Testing

A type-test report shall be submitted for capacitors on request.

4. Selection and operation

4.1 The dissipation of heat by convection and radiation must be ensured. In locations with a high ambient temperature, capacitors of a higher temperature class shall be used.

4.2 The capacitor voltage rating shall be selected in accordance with the operating voltage of the power system, with due regard to a possible voltage increase caused by the capacitor and any inductances in series.

4.3 In systems with high levels of harmonics, capacitors must be protected against overloading.

4.4 To avoid self-excitation of individually compensated motors, the compensation power shall not exceed 90 % of the no-load reactive power of the motor.

E. Storage Batteries and Chargers

1. General requirements

1.1 These Rules apply to stationary storage batteries and chargers.

1.2 Rating of batteries

Storage batteries shall be so rated that they can supply the consumers for the required period, in accordance with the energy balance, when charged to 80 % of their rated capacity.

At the end of the supply period, the voltage at the battery or at the consumers shall conform as a minimum requirement to the values indicated in Section 1, F.

2. Storage batteries

2.1 The permissible types are lead-acid storage batteries with diluted sulphuric acid as electrolyte, and steel batteries with nickel-cadmium cells and diluted potassium hydroxide as electrolyte.

2.2 Other types of storage batteries such as silver/zinc batteries or sealed lead-acid batteries may be permitted, if their suitability for shipboard use is proven.

2.3 Storage batteries must be so designed that they retain their rated capacity at inclinations of up to 22,5°, and no electrolyte leaks out at inclinations of up to 40°. Cells without covers are not allowed.

2.4 The casing must be resistant to electrolytes, mineral oils, cleaning agents and to corrosion by saline mist. Glass and readily flammable materials shall not be used for battery casings.

2.5 For storage batteries containing liquid electrolyte, it must be possible to check the electrolyte level. The maximum permissible electrolyte level must be marked.

2.6 The weight of the greatest transportable unit shall not exceed 100 kg.

2.7 The nominal operating data of storage batteries shall be indicated on rating plates.

2.8 Storage batteries shall be maintained and operated in accordance with the manufacturer's instructions.

3. Chargers

3.1 Charging equipment must be so rated that discharged storage batteries can be charged to 80 % of their rated capacity within a period not greater than 10 hours without exceeding the maximum permissible charging currents.

Only automatic chargers shall be used with charging characteristics adapted to the type of batteries.

3.2 If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120 % of the rated voltage. The power demand of the consumers shall be considered for the selection of the chargers.

Chargers with a charging power above 2 kW shall be tested in the presence of a TL Surveyor.

F. Switchgear and Protection Devices

1. General requirements

1.1 Switchgear and protection devices shall conform to IEC publications or to another recognized standard.

1.2 For materials and insulation, see Section 1,I.

1.3 For equipment and components subject to mandatory type approval, see Section 5.

2. Medium-voltage switchgear

For details of medium-voltage switchgear, see Section 8.

3. Low-voltage switchgear

3.1 Circuit breakers

3.1.1 Drives

- Power-driven circuit breakers must be equipped with an additional emergency drive for hand-operation.

- Mechanical actuating elements on circuit breakers for generators and essential circuits must be so connected to the circuit breakers that they cannot be lost.

- Circuit breakers with a making capacity exceeding 10 kA shall be equipped with a drive which performs the closing operation independently of the actuating force and speed (by snap action).

- If the conditions for the closing operation are not fulfilled, e.g. undervoltage release not energized, switching-on shall not cause the contact pieces to come into contact.

3.1.2 Making and breaking capacity

The making and breaking capacity shall be tested in accordance with IEC publication 60947-2. Other standards may be recognized.

4. Protection devices

4.1 Short-circuit protection

Short-circuit protection devices must be independent of energy supplied from circuits other than those to be protected. In the event of a short circuit, the total breakdown of the supply voltage must be expected.

Short-circuit protection devices for generators shall be equipped with reclosing inhibitors, and shall be delayed for selective disconnection.

4.2 Overcurrent protection

The operation of overcurrent relays must not be influenced by the ambient temperature.

Overcurrent relays for motor protection must be adjustable and provided with a reclosing inhibitor.

4.3 Undervoltage protection

Undervoltage relays must cause the circuit breaker to open if the voltage drops to 70 % - 35 % of the rated voltage. Undervoltage relays of generator circuit-breakers shall have a delay up to 500 ms.

4.4 Shunt trips

Shunt trips must ensure the disconnection of the circuit breakers even if the voltage drops to 85 % of the rated voltage.

4.5 Reverse power protection

The reverse power protection device must respond to the active power regardless of the power factor, and shall operate only in the event of reverse power. The response value and pick up time must be adjustable.

The reverse power protection device must remain operative despite a voltage drop to 60 % of the rated value.

4.6 Phase failure protection

Protection devices for detection of a single-phase failure in three-phase circuits must operate instantaneously. Bimetallic relays with differential release do not constitute phase failure protection devices in the sense of these Rules.

4.7 Check synchronizers

Check synchronizers for the protection of an alternator against parallel connection at an unacceptable phase angle shall allow parallel switching only up to an (electrical) angular deviation of 45° and up to a frequency difference of 1 Hz.

The check synchronizer must ensure that parallel switching is impossible if the supply voltage or measuring voltage fails or in the event of failure of any component.

4.8 Insulation monitoring equipment

Devices for insulation monitoring of ships mains must continuously monitor the insulation resistance of the network, and must release an alarm should the insulation resistance of the system fall below 50 Ohm per volt of the operating voltage.

The measuring current shall not exceed 30 mA in the event of a dead short-circuit to earth.

G. Cables and Insulated Wires

1. General requirements

1.1 Only halogen-free materials are permitted. Exceptions can be made for special cables.

1.2 Cables and wires must be flame-retardant and self-extinguishing, also when laying in bundles. Cables and wires must have passed a bundle fire test in accordance with IEC publication 60332-3, category A/F.

1.3 Where fireproof cables are to be installed, it is permissible to use cables with a retention of insulating capability (e.g. for 3 hours) in accordance with IEC publication 60331 (see Section 12, D.14).

1.4 Cables and wires must conform to IEC publication 60092-3 or VG 95 218.

Other standards, even works specifications, may be recognized if proof is provided that they are equivalent.

2. Conductor material and structure

2.1 Electrolytic copper with a resistivity not exceeding 17,241 $\Omega \cdot mm^2/km$ at 20 °C shall be used as the material for the conductors of cables and wires.

2.2 The conductors of movable wires must be finely stranded. The conductors of permanently laid cables and wires shall be made of finely stranded copper or flexible stranded copper.

Unifilar (solid) conductors up to 4 mm^2 in cross-section are permitted for the final subcircuits of room lighting and space heating systems in the accommodation. For certain cable types, the common shielding of several cores or the inclusion of a second braid between the cable sheaths will be necessary. In such cases, separating layers must be provided between the braids.

3. Materials and wall thickness of insulating covers

The materials used for insulation must be of standardized types for which the maximum permissible temperatures at the conductors during undisturbed operation are specified.

4. Protective coverings, sheaths and braids

4.1 Single-core cables must have a suitable separating layer of filler material or foil over the core insulation.

4.2 Multicore cables must have a common core covering made of filler material or must have a wrapping and sheath.

4.3 Only materials of a standardized type shall be used for non-metallic sheaths. In all cases, the thermal stability of the compounds used must correspond to that of the insulating material.

4.4 Braids must be made of corrosion-resistant material such as copper or copper alloy or of material treated to prevent corrosion, e.g. galvanized steel.

4.5 Outer metallic wire braids are not permissible.

5. Electrical properties

The electrical properties of the cables must be derived from the corresponding functions of the installation, and are not specified here.

6. Identification

6.1 Each cable must be marked with the type and the name of the manufacturer.

6.2 The cores of multicore cables and wires shall have a permanent marking. In multicore cables and wires where the cores are arranged in a number of concentric layers, two adjacent cores in each layer shall be coloured differently from each other and from all other cores, unless the individual cores are otherwise unambiguously identified, e.g. by printed numbers.

6.3 Protective earth conductors must have a green/ yellow colour coding.

7. Approvals

7.1 Cables and wires for shipboard installation are subject to mandatory type-testing. Special cables and wires may be approved by individual tests.

7.2 Proof is required by the manufacturer through issue of workshop test reports stating that the continuous production is made in conformity to relevant standards and is verified by individual and sample tests for each production length of cables. These reports must record any deviations from the standards.

7.3 The utilization of cables and wires without type test is subject to agreement in every single case. Individual and sample tests performed at the manufacturer's works on each length delivered are required for these cables.

8. Tests

8.1 Type tests shall be carried out in accordance with the relevant standards at the manufacturer's works and in the presence of a TL Surveyor. The scope of the tests shall be agreed upon in advance.

8.2 If no ozone test is specified in the standard, this test shall be performed as follows:

Ozone tests on cable sheaths whose basic material consists of natural or synthetic rubber. The test conditions shall be:

- ozone concentration: 250 - 300 ppm
- temperature: (25 ± 2) °C
- duration: 24 h

The test shall be carried out in accordance with IEC publication 60811-2-1.

Other equivalent test methods are permissible.

The test is passed satisfactorily if no cracks are discovered which are visible to the naked eye.

8.3 Individual tests on non-type-tested cables and wires shall be performed at the manufacturer's works in the presence of a TL Surveyor.

The scope of the tests shall be agreed in advance. At least the following tests shall be carried out:

- Conductor resistance
- Dielectric strength
- Insulation resistance
- Dimensions and construction of samples
- Mechanical strength characteristics of samples

H. Bulkhead and Deck Penetrations

1. The sealing compounds and packing systems must be type-approved.

2. The type test shall be performed in the presence of a TL Surveyor at the manufacturer's works or at independent institutions, according to the TL Rules - Guidelines for the Performance of Type Approvals, - Test Requirements for Sealing Systems of Bulkhead and Deck Penetrations.

I. Installation Material

1. General requirements

1.1 The installation material shall conform to IEC publications. Other equivalent standards may be recognized.

1.2 Cable glands

If necessary because of the degree of protection or EMC requirements, cable glands should be fitted with standardized inserts (cones) for earthing the cable shields. In this way, the connection of the cable shields to the frame earth is made at the same time.

2. Cable distribution boxes, terminals

Cable distribution boxes shall be adapted to the corresponding installation situation with regard to the selection of the casing and the degree of protection.

Within the casing, sufficient space shall be provided between the terminals and the cable glands to permit proper connection of the cores.

It is necessary to ensure that terminals are suitable for the connection of stranded conductors. Exceptions are permitted for systems with solid conductors (e.g. lighting, socket-outlets and heating appliances in the accommodation area).

3. Cable lugs

For the connection of the conductors by means of terminal studs and terminal screws, cable lugs with crimp connections shall be used.

4. Fastening material for cables

4.1 For the fastening of the cables, metallic bindings shall be used wherever possible.

Metallic bindings must be shrouded with a flame-retardant and halogen-free (but at least low-halogen) plastic, or must only be used together with separating layers made of this plastic.

For the fastening of cables, plastic clips/straps may also be used, provided that metallic bindings are used additionally in the areas mentioned in Section 12, D.2.

4.2 For ship sections made of light alloys, special attention must be paid to proper selection of the fastening materials, particularly with regard to corrosion protection.

5. Plug-and-socket connections

Depending on their application, the design of plug-and-socket connections shall conform to the following standards:

- in the accommodation area, day rooms and service rooms (up to 16 A, 250 V AC) - IEC publication 60083 or 60320
- power circuits (up to 250 A, 690 V AC) - IEC publication 60309-1 and 60309-2
- electronic switchgear - IEC publications, e.g. 60130 and 60603
- containers, see Section 7, H.

J. Electrical Heating Equipment

1. General requirements

1.1 Electrical heating equipment and boilers shall conform to IEC publications, e.g. 60335, with particular attention to IEC publication 60092-307.

1.2 The connections of power supply cables shall be so arranged that temperatures higher than permitted for the terminals and supply cables do not arise.

1.3 Operating elements, such as switch knobs and handles, shall not attain temperatures higher than

- 55 °C for metal parts, or
- 65 °C for parts made of porcelain, glass, moulded plastics or wood.

A temperature of 5 °C higher is permissible for parts operated by brief pressing of a finger only.

1.4 Only heating elements with shrouding or ceramic-embedded heating coils shall be used. Infrared radiators are permitted, provided that they are mounted safely.

2. Design

2.1 Space heaters

2.1.1 The casing or enclosure of each heater shall be so designed that no objects can be placed on it, and the air can circulate freely around the heating elements.

2.1.2 Electrical space heaters shall be so designed that, based at an ambient temperature of 20°C, the temperature of the casing or enclosure and of the air flow from the heater does not exceed 95°C under defined test conditions.

2.1.3 To prevent unacceptable temperature rises due to heat accumulation, each heater shall be fitted with a safety temperature limiter. Automatic reconnection is not permitted. The safety temperature limiter may be dispensed with for watertight heaters in spaces without a substantial fire risk, e.g. in bathrooms and washing rooms.

2.1.4 The operating switches must disconnect all live conductors. The switch positions must be clearly marked at the switches.

2.2 Passage heaters and boilers

Passage heaters and boilers shall be equipped with two mutually independent thermal-protection devices, where one of them must be a permanently-set safety temperature limiter, and the other may be a thermostatic controller.

2.3 Electric ranges and cooking facilities

2.3.1 Only enclosed-type hot plates shall be used. It shall not be possible for liquids to penetrate into the electrical equipment.

2.3.2 The switches for the individual plates and heating elements must disconnect all live conductors. The switch steps must be clearly marked.

2.3.3 Internal connections must be made of heatproof terminals and wiring, and must be corrosion-resistant.

2.4 Deep-fat cooking equipment

Deep-fat cooking equipment shall be fitted with the following:

- an automatic or manual fire extinguishing system
- a primary or back up thermostat with an alarm in the event of failure of either thermostat
- arrangements for automatically shutting of the electric power upon activation of the fire extinguishing system
- controls for manual operation of the fire extinguishing system

K. Lighting Fixtures

1. General requirements

Luminaires, floodlights and searchlights shall conform to IEC publications 60598 and 60092-306. Other equivalent standards may be recognized.

The general requirements stated in I. shall be observed.

2. Design

2.1 The surface temperature of easily touchable parts of lighting fixtures shall not exceed 60°C.

2.2 High-power lights with higher surface temperatures shall be protected against unintentional contact by additional means.

2.3 The terminals and spaces for the connection of cables shall not reach a higher temperature than is permissible for the insulation of the wires or cables used. The temperature rise in the terminal box shall not exceed 40 K.

2.4 All metal parts of a lighting fixture must be conductively connected together.

2.5 Wiring inside lighting fixtures must have a minimum cross section of 0,75 mm^2. A cross-section of at least 1,5 mm^2 shall be used for through-wiring.

Heat-resistant wires shall be used for internal wiring.

2.6 Each lighting fixture must be durably marked with the following details:

- Maximum permitted lamp wattage
- Minimum mounting distance

SECTION 15

ADDITIONAL RULES FOR SHIPS FOR THE CARRIAGE OF MOTOR VEHICLES

A. Scope

These Rules apply additionally to areas for landing craft and other military vehicles as well as to electrical equipment on landing and amphibious warfare ships for the transportation of motor vehicles which are driven on and off the ship by their built-in drives and/or have fuel in their tanks.

B. Protection Areas

Protection areas (zone 1) are areas in which an explosive atmosphere can be expected to be present occasionally, see Fig. 15.1. Such zones include the following, when fuel with flash point not exceeding 60 °C is used:

1. Amphibious warfare ships

1.1 Closed vehicle decks above the bulkhead deck (at least 10 air changes/hour) up to a height of 450 mm. The spaces above grating vehicle decks with adequate permeability are not deemed to be protection areas.

1.2 Vehicle decks below the bulkhead deck extending to the full height.

1.3 Well decks for landing craft, vehicles, etc.

1.4 Holds for motor vehicles.

1.5 Exhaust ducts from holds and vehicle decks.

1.6 Hazardous areas, e.g. for refuelling, maintenance, storage of fuel, weapon or explosives.

2. Ships for flight operation

2.1 Hangar decks above the bulkhead deck up to a height of 450 mm (at least 10 air changes/hour).

2.2 Hangar decks below the bulkhead deck extending to the full height.

2.3 Exhaust ducts from hangar decks.

C. Ventilation

1. A forced-draught ventilation system is required to ensure a sufficient number of air changes during the loading, unloading and transportation of motor vehicles. For details, see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 11.

2. A fan failure **(1)** or failure related to the number of air changes specified for vehicle decks and holds shall be alarmed on the bridge.

3. It must be possible to switch ventilation systems on and off from a position outside the ventilated car decks or holds. Provision must be made for the immediate shutdown and closure of the systems in the event of fire.

D. Fire Alarm System

1. Unless enclosed car decks are under the supervision of a fire patrol during the transportation of vehicles, an automatic fire alarm system is required for these areas. The design of the system must comply with the requirements set out in Section 9, C. and Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9.

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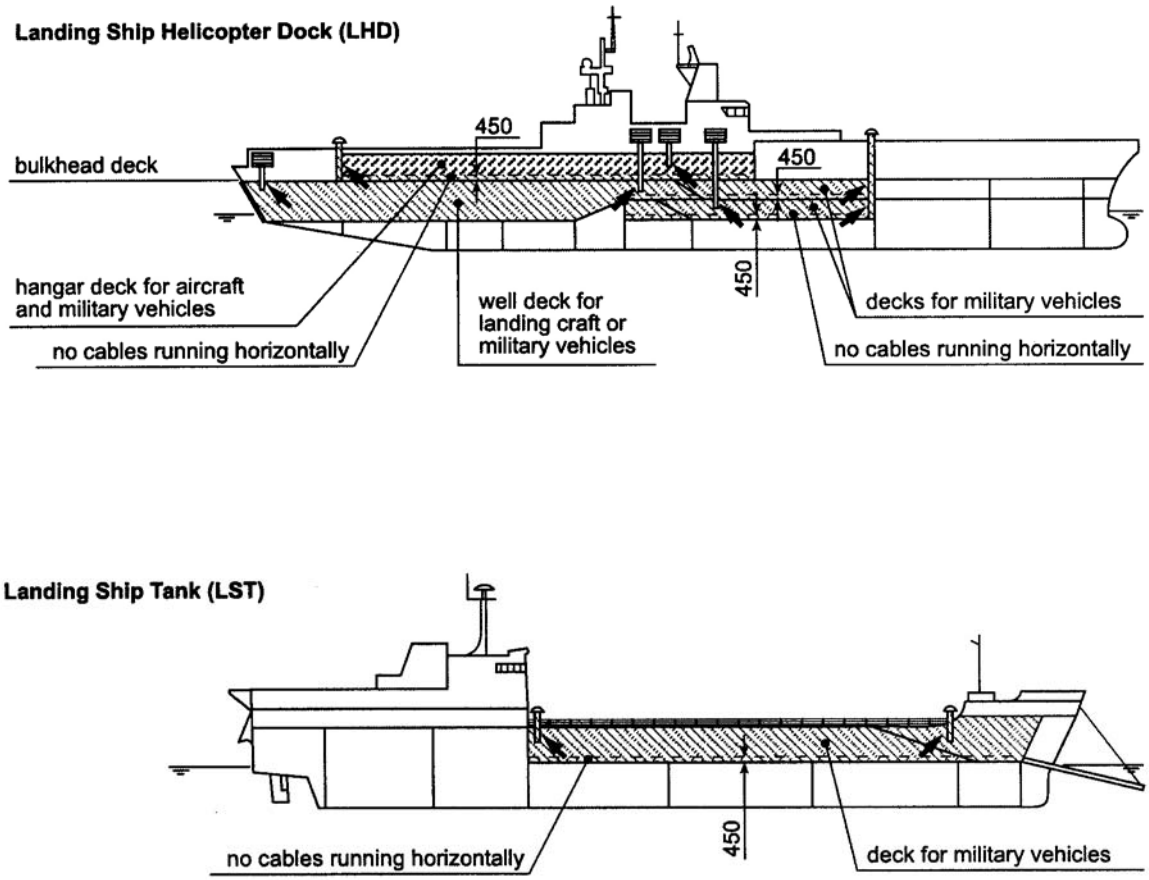
(1) *Monitoring of motor-fan switching devices is sufficient.*



Zones	Equipment design
above protection zone (zone 2)	IP 55 in conjunction with 10 changes of air per hour
protection zone (zone 1)	certified safe type equipment

Figure 15.1 Examples of protection areas at aircraft hangars, well decks and on vehicle decks for the carriage of military vehicles which are driven on and off the ship by their built-in drives and/or carry fuel in their tanks

2. A sufficient number of manually operated call points shall be installed in the areas mentioned above. One call point shall be located close to each exit.

E. Indicating and Monitoring Systems for Shell Doors

The following additional monitoring systems and indicators shall be provided on the bridge, see also Chapter 101 - Hull Structures and Ship Equipment, Section 22, B. and C.

1. Bow doors and inner doors

1.1 Bow doors and inner doors giving access to vehicle decks shall be equipped for remote operation from above the freeboard deck to enable the following for each door:

- Closing and opening of the door and
- Operation of the locking and securing devices

An indication of the open/closed position of each locking and securing device shall be provided at the remote-operating position. The operating consoles serving the doors shall be accessible only to authorised personnel. A notice drawing attention to the fact that all locking devices must be locked and secured before leaving harbour shall be fitted at every operating console. Furthermore appropriate warning indicator lights shall be provided.

1.2 Indicator lights shall be provided on the bridge and at the operating console for indication that the bow door and the inner door are closed and the locking and securing devices are in their correct positions. Deviations from the correct closed condition shall be indicated by optical and audible alarms.

A lamp test shall be provided for the indicating lights. Switching the indicating lights off is not permitted.

1.3 The indicating-system shall be self-monitored and shall provide optical and audible alarms if the doors are not completely closed and secured or the locking devices change to the open position or the securing devices become untight. The power supply to the indicating system must be independent of that for opening and closing the doors. The sensors of the indicating system must be protected against water, icing-up and mechanical damage (minimum degrees of protection IP 56).

1.4 The indicating equipment on the bridge must have a "Harbour/Sea" selector switch which initiates an alarm if the ship leaves the harbour with the bow or inner door not properly closed or with securing devices not in the correct position.

1.5 A leakage-water monitoring system with audible alarm and television supervision shall be provided which indicates on the bridge and in the machinery control centre (MCC) if water is leaking through the inner door.

1.6 The space between bow door and inner door shall be provided with television supervision and with monitors on the bridge and in the machinery control centre. This supervision must cover the position of the door and an adequate number of its locking and securing devices. Special attention shall be paid to the illumination and the contrasts of the objects to be monitored.

1.7 A drain system shall be provided between the bow door and the ramp. The same applies to the space between ramp and inner door with a corresponding arrangement. If the water level in this space reaches a height of 0,5 m above vehicle deck level, an audible alarm shall sound on the bridge.

2. Side shell doors and stern doors

2.1 These requirements apply to side doors behind the collision bulkhead and to stern doors giving access to enclosed areas.

2.2 The requirements set out in items 1.2, 1.3 and 1.4 also apply analogously to those doors which give access to special category areas and ro/ro areas, as defined in Chapter II-2, Regulation 3 of **SOLAS** 1974, as these areas could be flooded through these doors.

These requirements apply also for side shell doors, if the opening of a door exceeds 6 m^2 in size and for side shell doors below 6 m^2 in size where the sill of any side shell door is below the uppermost load line.

2.3 On landing ships a leakage monitoring system with an audible alarm and television supervision shall be provided which indicates on the bridge and in the machinery control centre any leakage through these doors.

2.4 Indicators for all closed fire doors leading to the vehicle decks shall be provided on the bridge.

2.5 Special category areas and ro/ro cargo rooms must be included in the fire-rounds or may be monitored by effective means such as television supervision, so that while the ship is under way any movement of the vehicles in heavy weather or unauthorized access by embarked troops can be watched.

F. Additional Requirements for the Illumination

1. Additional emergency luminaires

1.1 For emergency illumination in all rooms and holds intended for vehicles of embarked troops additional emergency luminaires with integral batteries shall be provided.

Should all other sources of electrical power fail, access to the escape routes shall be easily recognizable.

1.2 If all other sources of electrical power fail, these additional emergency luminaires shall remain operable for at least three hours regardless of their attitude. The power source for these luminaires must be a continuously-charged battery placed inside each luminaire.

The service life of the batteries, taking into account the respective operating conditions, shall be stated by the maker.

A failure of a luminaire must be immediately recognizable.

1.3 Low location lighting shall be provided, see Section 14.

G. Installation of Electrical Equipment in Protection Areas

1. On principle the amount of electrical equipment installed shall be restricted to installations necessary for operation.

2. All electrical equipment must be permanently installed.

3. Movable consumers or equipment supplied via flexible cables shall only be used with special permission or operated when there are no vehicles on board.

4. Cables shall be protected against mechanical damage by covers.

Cables running horizontally are not permitted in the protection area extending to 450 mm above the enclosed vehicle deck.

H. Permissible Electrical Equipment

1. Inside of the protection area (zone 1)

1.1 In areas, mentioned in B.1.1 to B.1.5 the electrical equipment must be of a certified safe type according to Explosion Group IIA and Temperature Class T3.

1.2 Areas, mentioned in B.1.6. and B.2. shall be equipped under consideration of the characteristic hazards.

1.3 Certified safe type equipment in accordance with Section 1, J. 3.1.3.2 is permitted.

2. Above the protection area (zone 2)

Equipment in accordance with Section 1, J.3.1.3.2 is permitted; the surface temperature must not exceed 200 °C.

SECTION 16

TESTS

A. General

1. The following Rules apply to the testing of electrical and electronic installations, equipment and components.

2. Within the framework of their general quality assurance programme, manufacturers must ensure that the products they manufacture conform to the specified requirements.

Records shall be made, containing quality assurance measures and tests and shall be handed over to TL on request.

3. For certain installations, equipment and components, testing in presence of a TL Surveyor is required according to these Rules, see C., D. and E.

The tests and items for testing specified below constitute minimum requirements.

TL reserve the right to demand that tests also be performed on other items, either on board or in the manufacturer's works.

4. For appliances of a new type or for equipment which is being used for the first time on ships with TL class, additional tests and trials are to be agreed between the manufacturer and TL, if the circumstances this require.

5. It is the aim of the tests to verify conformity with the requirements covered by the Rules for Construction, and to prove the suitability of equipment for its particular application.

6. Tests are divided into:

- Examinations of the technical documentation, see B.
- Tests in the manufacturer's factory (FAT), see C.
- Tests on board (HAT and SAT), see D.
- Tests for type approvals, see E.

The text procedures for FAT, HAT, SAT and type approvals are to be laid down in documents and are subject for approval by TL, see Section 1, C.2.11.

B. Examinations of Technical Documentation

1. The list of documents subject to approval is specified in Section 1, C.

2. The documents which have been examined and approved shall be presented to the TL Surveyor on request.

C. Tests in the Manufacturer's Factory (FAT) Tests in the presence of a TL Surveyor

1.1 The tests shall be carried out on the basis of these Rules and the approved documents. They shall be performed in accordance with a recognized standard.

1.2 Machines, appliances and installations subject to testing in accordance with 2 are to be tested in the presence of a TL Surveyor.

2. Machines, appliances and installations subject to testing

2.1 For scope of tests of electrical machines, see Section 14, B.

The following machines, appliances and installations are subject to testing:

- Generators and motors for electric propulsion plants, see Section 13, J.
- Generators and motors for essential equipment, P ≥ 50 kW/ kVA
- Transformers P ≥ 100 kVA
- Autotransformers P ≥ 100 kVA

2.2 Power electronics

For scope of tests, see Section 6, G.

- for electric propulsion plants, see Section 13, J.
- for essential equipment P ≥ 50 kW/ kVA
- for battery charging P ≥ 2 kW

2.3 Switchboards

For scope of tests, see Section 5, H. and Section 8, D. For the tests the form F 217 should be used, as far as suitable.

The following switchboards are subject for testing:

- Power stations
- Emergency supply
- Electric propulsion plants
- Main groups
- Groups
- Motors starters for essential equipment
- Motor control centre
- Fan groups
- Steering gear plants
- Boiler plants
- Chilled water plants
- Anchor capstan
- Warping winches
- Degaussing system

2.4 Electrical propulsion plants

For scope of tests, see Section 13, J.

2.5 Computer systems

For scope of tests, see Section 10, D.

2.6 Engine telegraph system, see Section 9, B.1.

2.7 Important voice communication, see Section 9, B.4.1

2.8 Public address system, see Section 9, C.2.

D. Tests on Board

1. General

The tests are divided into:

- Tests during construction/installation
- Tests during harbour trials (HAT)
- Tests during sea trials (SAT)

2. Tests during construction

2.1 During the period of construction of the ship, the installations shall be checked for conformity with the documents approved by TL and with these Rules.

2.2 Test certificates for tests which have already been performed shall be presented to the TL Surveyor on request.

2.3 Protective measures shall be checked:

- Protection against foreign bodies and water, see Section 1, J.
- Protection against electric shock, such as protective earthing, protective separation or other measures as listed in Section 1, J.
- Measures of explosion protection

  The design must conform to the details on form F 184 "Details about the construction of electrical equipment in hazardous areas", submitted by the shipyard for approval, see Section 1, J.

2.4 Testing of the cable network

Inspection and testing of cable installation and cable routing, see Section 12, with regard to:

- Acceptability of cable routing according to:
  - separation of cable routes
  - fire safety
  - the reliable supply of essential equipment
  - EMC measures
- Selection and fixation of cables
- Construction of watertight and fireproof bulkhead and deck penetrations
- Insulation resistance measurement

For testing of cable network for medium-voltage installations, see Section 8.

3. Tests during harbour trials (HAT)

3.1 General

Proofs are required of the satisfactory condition and proper operation of the main-, auxiliary-, uninterrupted and emergency power supply systems, the steering gear and the aids of manoeuvring, as well as of all the other installations specified in these Rules.

Unless already required in these Rules, the tests to be performed shall be agreed with the Surveyor to TL in accordance with the specific characteristics of the subject equipment.

3.2 Generators

A test run of the generator sets and as far as possible of the shaft generators shall be conducted under normal operating conditions. The tests shall be reported on form F 218.

3.3 Storage batteries

The following shall be tested:

- Installation of storage batteries
- Ventilation of battery rooms and boxes, and cross-sections of ventilation ducts including explosion proof equipment, if any
- Storage-battery charging equipment
- The required caution labels and information plates

3.4 Switchgear

The following items shall be tested under observance offormsF217andF218:

- Accessibility for operation and maintenance
- Protection against the ingress of water and oil from ducts and pipes in the vicinity of the switchboards, and sufficient ventilation
- Equipment of power station-, main groups- and emergency switchboards with insulated handrails, gratings and insulating floor coverings
- Correct settings and operation of protection devices and interlocks
- Independence of manual operation of generating sets from common external voltage and automation systems (manual operation means local start/stop and speed setting as well as voltage control, protection devices and synchronizing from switchboard)

TL reserve the right to demand the proof of selective arrangement of the ship supply system.

3.5 Power electronics

The following items shall be tested:

- Ventilation of the place of installation

- Function of the equipment and protection devices

3.6 Power plants

The following items shall be tested:

- Motor drives together with the driven machines, which shall, wherever possible, be subjected to the most severe anticipated operating conditions

  This test shall include a check of the settings of the motors' short-circuit and overcurrent protection devices.

- The emergency remote stops of equipment such as:

  - engine room fans

  - fuel pumps

  - separators

  - boiler blowers, etc.

- Closed loop controls, open loop controls and all electric safety devices

3.7 Control, monitoring and ship's safety systems

For these systems operational tests shall be performed.

3.8 Electrical propulsion plants

Regarding scope of tests, see Section 13, J.

3.9 Computer systems

Regarding scope of tests, see Section 10, D.

4. Tests during the sea trial (SAT)

4.1 Rating of the main, auxiliary, uninterruptible and emergency electrical power supplies

During the sea trial it shall be proved that the main- auxiliary - uninterruptible - and emergency electrical power supplies are adequately rated and conform to Section 3, A. and that all control and monitoring devices are functioning according to their assignments.

4.2 Operating reliability during navigation

4.2.1 Tests shall be carried out to determine whether all the machines, equipment etc. constituting the electrical installation including weapon and tactical command system operate satisfactorily at all operating conditions and revolutions of the main engine, particularly during engine and steering gear manoeuvres.

4.2.2 Tests shall be carried out on the restoration of the main and emergency electrical power supplies following a black-out during navigation.

4.2.3 Tests shall be made of network quality in distribution systems supplied by semiconductor converters and in distribution systems with prevailing load consumed by semiconductor converters.

4.2.4 Evidence for EMC measures are to be given.

4.2.5 Electrical propulsion plants

Regarding scope of tests, see Section 13.

E. Type Tests

1. The installations, equipment and assemblies listed in 5. are subject to mandatory type-testing.

2. Type tests shall be carried out in the presence of a Surveyor to TL Head Office either in the manufacturer's works or, by agreement, in suitable institutions.

3. Type tests are carried out according to the TL Rules - Guidelines for the Performance of Type Approvals, - Procedures and to defined standards.

Special consideration is given additional to shock stress.

4. Type tested installations, apparatuses and assemblies shall be used within the scope of valid Construction Rules only. The suitability for the subject application shall be ensured.

5. Equipment, apparatuses and assemblies subject to type testing

5.1 Electrical equipment

5.1.1 Cables and accessories, see Section 14, G. and H.

- Cables and insulated wires
- Sealing compounds and packing systems for bulkhead- and deck penetrations
- Connecting systems for cable repairs

5.1.2 Switchgear, see Section 5, H.

- Circuit-breakers, load switches, disconnect switches and fuses for direct connection to the main busbars or unfused distribution busbars of power station-, main groups-, emergency- and propulsion switchboards
- Standardized switchgear units manufactured in series with reduced clearance- and creepage distances, see Section 5, F.3.2

5.1.3 Generator protection devices, see Section 4, A.

- Short-circuit protection
- Overcurrent protection

  Reverse-power protection
- Check synchronizer
- Underfrequency protection
- Over- and undervoltage protection
- Differential protection

5.2 Steering gear and rudder-propeller systems

For steering gear and rudder-propeller systems, see Section 7, A.

5.2.1 Input devices such as: phase failure relays level sensors

- Phase failure relays
- Level sensors

5.2.2 Steering gear control systems with all components important for the function, e.g.

- Steering mode selector switch
- Follow up/ non follow up control devices

5.3 Variable pitch propeller controls

This includes all components important for the functioning.

5.4 Machinery control systems

For machinery control systems, see Section 9, B.

- Open and closed loop control for speed and power of internal combustion engines (main and auxiliary engine- and electrical actuators
- Safety devices
- Safety systems

5.5 Ship's control and safety systems

For ship's control and safety systems, see Section 9, B., C. and Section 7, G.

- Fire detection- and alarm systems
- Suction-type smoke-detection systems
- Wireless calling system (paging system)

- Control units for ship's safety relevant heel compensation systems

5.6 Computer systems

For computer systems, see Section 10, D.

6. Exceptions

6.1 Instead of the stipulated type tests in well-founded cases routine tests in the presence of a TL Surveyor may be carried out. An agreement with TL prior to testing is required.

6.2 Individual tests for cables and wires are specified in Section 14, G.

SECTION 17

SPARE PARTS

A. General Requirements

1. In order to be able to restore machinery operation and manoeuvring capability of the ship in the event of a damage at sea spare parts for the main propulsion plant and the essential equipment shall be available on board of each ship together with the necessary tools.

2. The detailed scope of the spare parts shall be defined between shipyard and Naval Authority considering the operational experience. In addition allowance is to be made for the manufacturer's recommendations.

3. The amount of spare parts shall be documented and a corresponding list shall be carried on board.