TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Chapter 105 - Electric
January 2022

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 as defined in TL- PR 29 is on or after 1st of January 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

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Chapter 105 – Electric

AMENDMENTS

Revision	RCS No.	EIF Date*
Section 02	03/2024	01.01.2025
Section 17	03/2024	01.01.2025
Section 05	01/2024	01.07.2024
Section 10	01/2024	01.07.2024
Section 14	01/2024	01.07.2024
Section 04	04/2023	01.01.2024
Section 05	04/2023	01.01.2024
Section 13	04/2023	01.01.2024
Section 14	04/2023	01.01.2024
Section 06	02/2023	01.07.2023
Section 07	02/2023	01.07.2023
Section 17	02/2023	01.07.2023
Section 02	05/2022	01.01.2023
Section 03	05/2022	01.01.2023
Section 08	05/2022	01.01.2023
Section 13	05/2022	01.01.2023

* Entry into Force (EIF) Date is provided for general guidance only, EIF dates given in Rule Change Summary (RCS) are considered valid. In addition to the above stated changes, editorial corrections may have been made.

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 military sensors, weapon systems and tactical command systems are not subject of these Rules.

1.1 Versions deviating from these Naval Rules may be approved if they have been tested for suitability and accepted as equivalent by **TL.**

1.2 **TL** reserves the right to specify additional requirements to these Rules where these are related to new systems or installations or where they are necessary because of new knowledge or operating experience.

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

2.4 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

2.5 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 generation plant. See also Section 2, A.1.2 and Section 3, B.2.1.2.

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 One failure principle

The single failure concept assumes that only one (single) failure is the initiating event for an undesired occurrence. The simultaneous occurrence of independent failures is not considered.

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. Alarms

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

2. 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

3. 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.*

4. Areas Potentially Endangered By Explosive Materials

Areas potentially endangered by explosive materials are differentiated as follows:

- Ammunition storage rooms (see 3.)
- Ammunition handling rooms (see 2.)

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 an electrical power generating plant.

6. Black-Out Condition

Black-out condition means that the complete machinery plant including the sources of electrical power are out of operation, but auxiliary energy as compressed air, starting current from batteries, etc. is still available for restoration of power supply.

7. Cable Bundles

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

8. Category A Machinery Spaces

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.

9. Dead Ship Condition

"Dead ship" condition means that the complete machinery plant including the sources of electrical power are out of operation and auxiliary energy as compressed air, starting current from batteries, etc. are NOT available for the restoration of the main power supply, for the restart of the auxiliaries and for the start-up of the propulsion plant. It is however assumed that special mobile or fixed equipment for start-up will be available on board of a naval ship.

10. Direct Consumers

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

11. Dry Operating Spaces

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

12. Electrical Distribution

12.1 Main groups are distribution switchboards that are fed alternatively from at least two power station switchboards.

12.2 Groups are distribution switchboards which are fed from either a main group or from a power plant switchboard.

12.3 Subgroups are distribution switchboards which are fed from a main group or a group.

13. Electrical Network

13.1 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.

13.2 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.

13.3 Electrical network with earthed neutral

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

14. Electrical Power Generation Plant

Electrical power generation plant is the grouping of generators, switchboard, auxiliary machinery, etc. to form an independent functional unit as part of the main source of electrical power.

15. Electrical Power Supply

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

16. Emergency Consumers

As far as requested by the Naval Ship Code, emergency consumers are mandatory consumers which, after breakdown of the main energy supply, must be fed by the emergency electrical power supply.

17. Emergency Electrical Power Supply

Emergency electric power supply is to be provided, if it is requested by the Naval Ship Code.

18. 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.

19. Essential Equipment

19.1 Essential for ship operation are all main propulsion plants.

19.2 Essential are the following auxiliary machinery and plants, which:

- Are necessary for the propulsion and manoeuvrability of the ship
- Are necessary for the navigation of the ship
- Are required for maintaining ship’s safety
- Are required to maintain the safety of human life at sea as well as
- Equipment according to special Characters of Classification and Class Notations

19.3 Essential equipment is subdivided into:

- Primary essential equipment
- Secondary essential equipment

19.3.1 Primary essential equipment

Primary essential equipment is equipment according to 19.2 which has to be in uninterrupted operation.

It comprises e.g.:

- Generator units supplying primary essential equipment
- Steering gear plant
- Fuel oil supply units
- Lubricating oil pumps
- Cooling water/cooling media pumps
- Charging air blowers
- Hydraulic pumps for primary essential equipment
- Controllable pitch propeller installation
- Electrical main propulsion plants
- Adjusting, control and safety devices/systems for primary essential equipment
- Monitoring equipment for primary essential equipment
- Azimuth drives as sole propulsion equipment
- Internal and external communication equipment
- Weapon systems (effectors and sensors)
- Tactical command system

19.3.2 Secondary essential equipment

Secondary essential equipment is equipment according to 19.2 which has not to be in uninterrupted operation for a short time. It comprises e.g.:

- Anchor windlasses and capstans
- Azimuth and transverse 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 installations for auxiliary and main engines
- Starting-air and control-air compressors
- Bilge, ballast and heel-compensating installations
- Hot and warm water generation plants
- Chilled water units
- Seawater pump
- Fire pumps and other fire fighting equipment
- Ventilation fans for engine and boiler rooms
- Ventilation fans for hazardous areas
- Turning gear for main engines
- Generators supplying secondary essential equipment, but only if this equipment is not supplied by generators
- Navigation lights and navy-specific signal lights
- Navigational appliances and systems

- Main lighting system
- Fire detection and alarm systems
- Internal safety communication equipment
- Bulkhead door closing equipment
- Bow and stern ramps as well as shell openings, if applicable
- Adjusting, control and safety devices/systems for secondary essential equipment
- Monitoring equipment for secondary essential equipment
- Parts of the shipboard aircraft installations
- NBC fans
- NBC passage heaters
- Decontamination equipment
- Magnetic self-protection (degaussing)

20. 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.

21. 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.

22. 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.

23. Fire Zones

23.1 Main vertical fire zone

Fire zones (main vertical) are those sections into which the hull, superstructure and deckhouses are divided by fire-resisting divisions, the mean length and width of which on any deck does not in general exceed 40 m.

23.2 Fire-resisting divisions

Fire-resisting divisions are those divisions formed by bulkheads and decks which comply with the following:

23.2.1 They shall be constructed of non-combustible or fire-restricting materials which by insulation or inherent fire-resisting properties satisfy the following requirements.

23.2.2 They shall be suitably stiffened.

23.2.3 They shall be so constructed as to be capable of preventing the passage of smoke and flame up to the end of the appropriate fire protection time.

23.2.4 Where required they shall maintain load carrying capabilities up to the end of the appropriate fire protection time.

23.2.5 They shall have thermal properties such that the average temperature on the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature during the appropriate fire protection time.

23.2.6 A prototype bulkhead or deck shall be required to ensure that the above requirements are met in accordance with approval by **TL**.

24. Hazardous Areas

24.1 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.

24.2 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)

25. 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 switch-gear, transformers etc. They have to be constructed as dry spaces.

26. 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.

27. 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).

28. 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.

29. Non-Essential Equipment

Non-essential equipment is equipment which is not listed in 19. respectively does not fit into the definition according to 19.

30. Power Supply Installations

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

31. Power Electronics

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

32. 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.

33. 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.

34. 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.

35. Safety Devices

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

36. Safety Extra-Low 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.

37. Safety Systems

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

38. 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.

39. 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.

40. Wet Operating Spaces

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

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 in Table 1.1 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. 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:

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

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

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

Table 1.1 Documents subject to approval relating to electrical equipment, if applicable

No	Designation of documents	Basic documents	Additional documents		
		General	Motor vehicles	Flight ops	Azimuthing propulsors
1.	**Power supply equipment**				
1.1	Electical plant, power generating and distribution (general layout drawing)	I			
1.2	Generators, UPS equipment, converters, mains power supply units, batteries with maintenance schedule, transformers	I			
1.3	Spaces with explosion hazards, with specification on the equipment installed there		A	A	
1.4	Short-circuit calculation, where total generator's output > 500 kVA	I			
1.5	Electrical power balance (main networks and sub networks	A			
1.6	Switchboards of electrical power generation plants (circuit diagrams, plans of the busbar systems , pictorial drawing and parts list)	A			
1.7	Emergency switchboard (circuit diagrams, plans of the busbar systems, pictorial drawings and parts list)	A			
1.8	Main groups, subgroups, groups circuit diagram, pictorial drawing and parts list	A			
1.9	Groups for the lighting, with specification of the circuits and rooms supplied	A			
1.10	Incoming feeders for sensors, weapons and tactical command systems	A			
1.11	Concept to avoid radiation hazards	I			
1.12	Main cable ways for all voltage systems	I			
1.13	Bulkhead/deck penetrations A 60	I			
1.14	Cable layout and cable list	I			
1.15	Protection coordination concept with total generator's output > 500 kVA	I			
1.16	Harmonic distortion calculations, if applicable	I			
2.	**Manoeuvring equipment**				
2.1	Steering gear, control and monitoring system	A			
2.2	Azimuthing propulsors and lateral thruster system	A			
2.3	CP propeller installation	A			
2.4	Dynamic positioning system, where applicable	A			
3.	**Lighting**				
3.1	Arrangement of the lighting fixtures and socket outlets of all primary, secondary, transitional, portable and operational lighting installations	I			
3.2	Documentation on light fittings and sockets used	I			
3.3	Electric operated escape, evacuation and rescue lighting system	A			
3.4	Supply and consumer protection for navigation, signal and navy specific lights	A			
3.5	Supply and consumer protection for aircraft operation lights	A		A	

Table 1.1 Documents subject to approval relating to electrical equipment, if applicable (cont.)

No	Designation of documents	Basic documents	Additional documents		
		General	Motor vehicles	Flight ops	Azimuthing propulsors
4.	**Starting, control and monitoring equipment**				
4.1	Monitoring systems for machinery	A			
4.2	Safety devices/safety systems for machinery	A			
4.3	Electrical starting arrangements for auxiliary and main engines	A			
4.4	Controls and adjustments for essential equipment/drive installations	A			
5.	**Ship's safety devices**				
5.1	General alarm system (quarter bill)	A			
5.2	Position and navigation lights, signaling lights switchboard	A			
5.3	Drawing/general arrangement plan (side view and top view of ship, with key) for the navigation lights and navy-specific signalling lights and signal control, with details on their arrangement	A			
5.4	Fire detection system	A			
5.5	CO_2 alarm system	A			
5.6	Watertight door control system and indicators, if applicable	A			
5.7	Fire door control system and indicators, if applicable	A			
5.8	Control and monitoring systems for shell doors, gates and ro-ro decks	A	A		
5.9	Emergency shut-off facilities	A			
5.10	Tank level indicators, alarm, shut-off facilities	A			
5.11	Gas and NBC (nuclear biological chemical) detection systems	A			
5.12	Fixed water-based local application firefighting systems (FWBLAFFS)	A			
5.13	Water ingress detection system				A
5.14	Earthing system for aircraft			A	
5.15	Power supply and safety measures for hangar doors			A	
5.16	Power supply and safety arrangements for aircraft lifts			A	
5.17	Power supply and safety arrangements for helicopter and drone handling systems			A	
6.	**Control stations**				
6.1	Machinery Control Centre (MCC) consoles	A			
6.2	Damage Control Centre (DCC) consoles	A			
6.3	Auxiliary control positions	A			

Table 1.1 Documents subject to approval relating to electrical equipment, if applicable (cont.)

No	Designation of documents	Basic documents	Additional documents		
		General	Motor vehicles	Flight ops	Azimuthing propulsors
7.	**Communication equipment**				
7.1	Public address system	A			
7.2	Essetial inter communication systems	A			
8.	**Computer systems**				
8.1	System configuration		A		
8.2	Software version				
9.	**Electrical propulsion plants**				
9.1	Propulsion motors		A		
9.2	Software version		A		
9.3	Control, adjustment, monitoring		A		
9.4	Functional description of class notation RP %, if applicable		A		
9.5	FMEA (Failure Mode and Effect Analysis) for class notation RP %, if applicable		A		
9.6	Converter transformers		A		
9.7	Propulsion switchgear		A		
9.8	Listing of special alarms and indicator				A
9.9	Functional description		A		
9.10	Trial program		A		
10	**Medium voltage installation**				
10.1	Test schedule		A		
Notes : *A : For Approval, I : For Information*					

3. Modifications

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 independently from each other. The standard requirements and the requirements for Class Notation **AC1** are defined in Table 1.2.

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 **AC1** are defined in Table 1.3.

1.4 Products are classed according to their applications into the environmental categories, as stated in Table 1.4. Reference is made in the type approval Certificates.

1.5 Care has to be taken of the effects on the electrical installations caused by distortions of the ship's hull.

1.6 For ships intended for operation only in specified zones, **TL** may approve deviating ambient conditions.

1.7 Ambient temperatures for electrical equipment in areas other than machinery spaces

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

- The equipment is not for use for emergency power supply (see Section 3, C.) and is located outside of the machinery space(s)

  Temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature

- The equipment is able to be initially set to work safely within a 45 °C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45 °C ambient temperature

- Audible and visual alarms are provided, at a continually manned control station, to indicate any malfunction of the cooling units

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

1.7.3 The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, in accordance with B.19.2.

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.

2.1.3 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

2.1.3 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.

2.1.4 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 Chapter 104 – Propulsion Plants, Section 1,D.2. 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 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 (0,7 g). 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.

Table 1.2 Design conditions for ship inclination 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°
	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, e.g. emergency power installations, emergency fire pump and their device, 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*

Table 1.3 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 **ICE - 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.*

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				For general applications, except category B, C, D, F, G, H.
B	0 °C to + 45 °C	to 100 %	4 g				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				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				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				For use in air-conditioned areas. With **TL**'s special consent only.
F				– 25 °C to + 45 °C	to 100 %	0,7 g	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.

2.2.5 If an electrical machine or equipment generates mechanical vibrations when in service (e.g. because 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.

2.2.6 In positions exposed to particularly severe stresses, electrical machines and appliances may be loaded outside area A (0,7 g). 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 (4 g) shall, however, not be exceeded. Lower design parameters can be accepted subject to proof of lower vibration loading in service.

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

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.

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 If not otherwise stated, the following requirements shall be observed:

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 1.5 Voltage and frequency variations for AC distribution systems

Quantity in operation	Variations	
	continuous	transient
Frequency	± 5 %	± 10 % (5 s)
Voltage	+ 6 %, - 10 %	± 20 % (1,5 s)

1.3 Unless otherwise stated in national or international standards, all equipment shall operate satisfactorily with the variations from it's rated value shown in Tables 1.5 to 1.7 on the following conditions:

a) For alternative current components, voltage and frequency variations shown in the Table 1.5 are to be assumed.

b) For direct current components supplied by d.c. generators or converted by rectifiers, voltage variations shown in the Table 1.6 are to be assumed.

c) For direct current components supplied by electrical batteries, voltage variations shown in the Table 1.7 are to be assumed.

1.4 Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits shown in the Table shall not be supplied directly from the system but by alternative means, e.g. through stabilized supply.

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 STANAG 1008.

2.2 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. 1.1 apply for single harmonics as continuous values. The total harmonic distortion shall not exceed 8 %.

Table 1.6 Voltage variations for DC distribution systems

Parameters	Variations
Voltage tolerance (continuous)	± 10 %
Voltage cyclic variation deviation	5 %
Voltage ripple (AC rms over steady DC voltage)	10 %

Table 1.7 Voltage variation for battery system

System	Variations
Components connected to the battery during charging (see note)	+ 30 %, - 25 %
Components not connected to the battery during charging (see note)	+ 20 %. – 25 %
Note *Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.*	

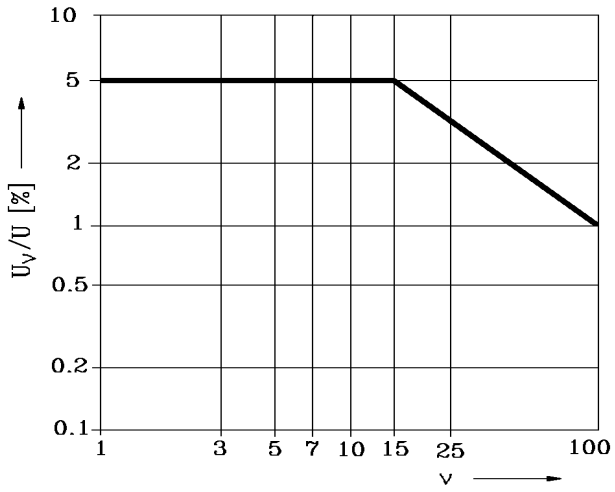

Fig. 1.1 Limit values for the single harmonics in the supply voltage. U_v is the RMS value of the v-th order harmonic voltage

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 excempted from this requirement. The maximum permissible rated mains voltages are given in Table 1.8.

Hull return is not permitted.

1.2 Main networks (primary networks)

In general the following network parameters should be applied. If other parameters are intended to be used, they have to be agreed by **TL.**

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

Three-phase current (AC)

Rated output voltage: 120 V, 240 V, 450 V
Rated consumer voltage: 115 V, 230 V, 440 V
Number of phases: 3
Number of conductors: 3
Rated frequency: 60 Hz or 400 Hz

Direct current (DC)

Rated rectifier output voltage: 24 - 28 V
Rated consumer voltage: 24 V
Number of conductors: 2

2. Medium-Voltage Systems

See Section 8.

3. Systems with Non-Earthed Neutral

3.1 In non-earthed systems, the generator neutral points shall not be connected together.

3.2 The insulation resistance of a distribution system without earthing of the system is to be monitored and displayed.

H. Visual and Acoustical Signalling Devices

1. The colours used for visual signalling devices shall in general conform to Table 1.9.

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.1021 (26) "Code on Alerts and Indicators", 2009.

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, e.g. IEC publications 60695-11-10 or UL 94. Cables shall correspond to IEC publication 60332-1.

1.3 In areas attended by the crew during action stations only halogen-free cables shall be used for permanent installations. Cable trays/protective casing made of plastic materials as well as mounting materials shall be halogen-free as well.

Exceptions for individual cables for special purposes have to be agreed with **TL.**

For all other areas of the ship, the use of halogen-free cables is recommended.

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
- Pollution degree 3
- Insulation material group IIIa.

Table 1.8 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

Table 1.9 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 1.10. 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 to the indications in Table 1.10.

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.

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

1.2.6 Spaces subject to an explosion or fire hazard shall additionally comply with the provisions of 3. and Section 15.

1.3 Pipe work and air ducts shall be so arranged that the electrical systems are not endangered.

1.4 If the installation of pipes and ducts close to the electrical systems are unavoidable, the pipes shall not have any flanged or screwed connections in this area.

1.5 Are flanged or screwed connections installed, if e.g. heat exchangers as integrated components of the electrical equipment are used, the flanged or screwed connections shall be protected with a shield or screen against leakage and condensed water.

1.6 The water supply lines and recirculating lines shall be fitted with shut-off valves.

1.7 Heat exchangers are preferably to be installed outside rooms containing major electrical equipment such as switchboards, transformer, etc.

1.8 If possible, the piping for cooler and heat exchangers shall be installed through the deck under the heat exchanger.

1.9 The flow rate and leakage of coolants of machines and static converters with closed cooling systems in electric cabinet rooms shall be monitored and alarmed. The air ducts shall be provided with inspection holes for visual observation of the heat exchanger.

1.10 A failure of cooling shall be alarmed.

1.11 It is to ensure that leakage or condensation of water does not cause an electrical failure to the liquid cooled power equipment. Leakage and condensation of water shall be monitored. The cooling medium of direct cooled systems shall be monitored regarding their insulating capacity.

1.12 Further requirements in Section 2, E.1.4, Section 6, D., Section 13, H.2. and Section 14, B.1.4.3 are to be observed.

Table 1.10 Minimum degrees of protection against foreign bodies and water (in conformity with IEC 60529)

Equipment / Location	Switchboards, Distribution Boards, Motor Control Centers and Controllers	Generators	Motors	Transformers, Converters	Lighting Fixtures	Heating Appliances	Accessories (**)
Dry accommodation space	IP20	-	IP20	IP20	IP20	IP20	IP20
Dry control rooms	IP20	-	IP20	IP20	IP20	IP20	IP20
Control rooms	IP22	-	IP22	IP22	IP22	IP22	IP22
Machinery spaces above floor plates	IP22	IP 22	IP22	IP22	IP22	IP22	IP44
Steering gear rooms	IP22	IP 22	IP22	IP22	IP22	IP22	IP44
Emergency machinery rooms	IP22	IP22	IP22	IP22	IP22	IP22	IP44
General store rooms	IP22	-	IP22	IP22	IP22	IP22	IP44
Pantries	IP22	-	IP22	IP22	IP22	IP22	IP44
Provision rooms	IP22	-	IP22	IP22	IP22	IP22	IP44
Bathrooms and showers	-	-	-	-	IP34	IP44	IP55
Machinery spaces below floor plates	-	-	IP44	-	IP34	IP44	IP55
Closed fuel oil or lubricating oil separator rooms	IP44	-	IP44	-	IP34	IP44	IP55
Ballast pump rooms	IP44	-	IP44	IP44	IP34	IP44	IP55
Refrigerated rooms	-	-	IP44	-	IP34	IP44	IP55
Galleys and laundries	IP44	-	IP44	IP44	IP34	IP44	IP44
Shaft or pipe tunnels in double bottom	IP55	-	IP55	IP55	IP55	IP55	IP56
Hold for general cargo	-	-	IP55	-	IP55	IP55	IP55
Open decks	IP56	-	IP56	-	IP56	IP56	IP56
Bilge wells	-	-	-	-	-	-	IP68
Ventilation trunks/ducts	-	-	IP22 **(*)**	-	-	-	-

Notes:

(1) *Empty spaces shown with "-" indicate installation of electrical equipment is not recommended.*

(*) *If there is danger of liquid spraying, presence of cargo dust, serious mechanical damage, aggressive fumes, IP55 would be required.*

(**) *In case of installing communication equipment, display, input units, signalling equipment, etc. higher protection degrees would be required*

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.

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 Protection by extra-low voltage, or

2.2.3 Protection by electrical separation for supplying one consuming device only (voltage not exceeding 250 V) or

2.2.4 Protective insulation (double insulation)

2.2.5 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 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.

2.3.3 The protective conductors and earthing conductors must be made of copper. If other materials are prescribed for reasons of electro magnetic compatibility (EMC), the separated protective conductor can be dispensed with, provided that the strips are of equivalent construction.

2.3.4 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. 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 The cross-section of the earthing conductor shall at least conform to the values indicated in Table 1.11.

2.4.1.4 Insulated mounted 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.

2.4.1.5 Machines and devices which are insulated mounted are to be earthed by flexible cables, wires or stranded copper straps.

2.4.1.6 The connection of the earthing conductor to the ship’s hull shall be located at a point where it can easily be checked. Connections of earthing conductors shall be protected against corrosion.

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 Cu Sn 8 F45 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.

3.1 Hazardous areas

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

3.1.1 General

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.

3.1.2 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 ocur occasionally. Zone 2 comprises areas in which a dangerous explosive atmosphere is liable to ocur only rarely, and then only for a brief period (extended hazardous areas).

Table 1.11 Cross-sections for earthing conductors

<table>
<tr><th rowspan="2">Cross-section of outer conductor
[mm²]</th><th colspan="3">Minimum cross-section of earthing conductor</th></tr>
<tr><th>in insulated cables
[mm²]</th><th>separately laid
[mm²]</th><th>flexible cables and wires
[mm²]</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 con-ductor 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 con-ductor 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>

3.2 Hazardous areas, Zone 0

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

3.2.2 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

3.2.3 Cables for above mentioned equipment may be installed and shall be armoured or screened or run inside metal tubes.

3.3 Hazardous areas, Zone 1

3.3.1 These areas include e.g.:

- Paint rooms
- Storage battery rooms (see Section 2)
- Acetylene and oxygen bottle rooms
- Ventillation ducts belonging to above mentioned areas
- 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.
- See also 3.5 to 3.11-

3.3.2 The following types of explosion-protected equipment are permissible:

- Equipment, permitted for zone 0, see 3.2.2.
- 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
- Hermetically enclosed echo-sounders

3.3.3 Cables in hazardous areas Zone 0 and 1

- must be armoured or screened

or

- run inside a metal tube.

– for echo sounders and cathodic protection systems are to be installed in thick-walled steel pipes with gastight joints up to above the main deck

3.4 Extended hazardous areas, Zone 2

3.4.1 These areas include e.g.:

- Areas directly adjoining Zone 1 lacking gastight separation from one another
- Areas inside an airlock
- Areas on open deck 1 m surrounding openings for natural ventilation or 3 m surrounding openings for forced ventilation for rooms
- Closed helicopter hangars and closed stowage places for other vehicles containing fuel in their tanks with a flash point < 60 °C
- See also 3.9 to 3.10
- Enclosed areas with access to zone 1 areas may be considered as safe, if the access door is gastight and fitted with self-closing devices without holding back arrangements (watertight door may be considered as adequately gastight) and the area is ventilated from a safe area by an independent natural ventilation system (have overpressure ventilation with at least 6 changes of air per hour); or the adjacent area is naturally ventilated protected by airlocks.

3.4.2 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 3.2 and 3.3
- Use of facilities with type Ex n protection
- 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
- Equipment with a degree of protection of IP 55 at least and whose surfaces do not attain any unacceptable temperatures.

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

3.5.1 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.

3.5.2 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.

3.5.3 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 gastight and fitted with self-closing devices and without arresting devices; a watertight door may be considered as being gastight
- 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.

3.6 Electrical equipment in acetylene and oxygen bottle rooms

Electrical equipment in acetylene and oxygen bottle room shall be of certified safe type with explosion protection of IIC T2.

3.7 Electrical equipment in battery rooms

Electrical equipment in battery rooms shall be of certified safe type with explosion protection of IIC T1 at least.

Arrangements and further requirements, see Section 2, B.

3.8 Electrical equipment in fuel stores, flash point ≤ 60 °C

Electrical equipment in fuel stores shall be of certified safe type with explosion protection of IIA T3 at least.

3.9 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 15.

3.10 Explosion protection in 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 3.3.2 (zone 1).

3.11 Areas potentially endangered by explosive materials

3.11.1 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.

3.11.2 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.

3.11.3 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

3.11.4 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.

3.12 Permitted electrical equipment

3.12.1 Electrical equipment shall not be installed in hazardous areas zones 0, 1 and 2, unless it is necessary for ships operation or safety. All electrical equipment, necessary to install in hazardous areas zone 0 and 1 shall be either manufactured according to a recognised standard such as IEC 60079 and certified by an authority recognised by **TL** or of a simple type belonging to an intrinsically safe circuit. Certificates for electrical equipment installed in zone 2 may be requested by **TL.** Special conditions, mentioned in the certificates or in their instruction manuals have to be observed.

3.12.2 Where electrical equipment is liable to suffer damage due to characteristics of supply goods, measures shall be taken to protect such equipment.

3.13 Portable electrical equipment

Portable electrical equipment, important for aboard operation and used in hazardous areas or stipulated for such use by regulations shall be of a certified safe type.

3.14 Earthing/ equipotential bonding/static electricity

3.14.1 All electrical equipment in hazardous areas shall be earthed regardless of the operating voltage.

3.14.2 To prevent static charges, all cargo tanks, processing plants, piping etc. shall be durably bonded by electrical conductors and/or connected to the hull, unless they are electrically connected to the hull by welds or bolting. Not permanently installed tanks, piping systems and equipment may be connected by bonding straps. Such straps shall be designed and located that they are protected against corrosion and mechanical damages. These connections shall be accessible for inspection.

3.14.3 To prevent the accumulation of static electricity the discharge resistance has to be less than 1 MΩ.

3.15 Aerials / Electromagnetic radiation

3.15.1 Aerials and their riggings shall be placed outside hazardous areas.

3.15.2 If aerials shall be placed in hazardous areas owing important reasons of ship construction or radio technology, the level of radiated power or field strength shall be limited to safe values acceptable to the appropriate authority.

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 result from the military sensors, weapons and tactical command systems, are to be stipulated in the building specification and are not subject of these rules.

5.5 If class notation EMC is assigned, see also Section 12, A.7 and C.6.

6. Radiation Hazard (RADHAZ)

6.1 General

The radio and radar equipment of a naval ship develops an electromagnetic frequency radiation environment which may cause hazards to

- Personnel (significant internal heating occurs)
- Ammunition and weapon systems embodying electro-explosive devices
- Fuels, flammables
- Safety critical electronic devices

The radiation will be created by the own ship, but can also be influenced by incoming aircraft or other ships operating nearby, e.g. during Replenishment at Sea (RAS) or in port.

An exposure level of electromagnetic radiation that personnel and equipment can withstand without RADHAZ risk (Permissible Exposure Level - PEL) is to be evaluated.

6.2 Procedures to ensure RADHAZ safety

Depending on the type and size of the installed equipment, the following measures to avoid hazards may be considered by the Naval Authority:

6.2.1 The required minimum safe distance if the radiation source and its antennas are in operation, is to be evaluated. This distance shall be shown by red lines on deck and/or superstructures and installation of warning signs, e.g. according to STANAG 1379.

Preferably the access to areas of the ship within to the minimum safe distance from the antennas should be blocked-off by movable railings, etc.

If passageways or working places have to be situated near to sources of radiation, such areas are to be shielded-off by suitable metal structures and walls.

6.2.2 If work within the minimum safe distance has to be done for a limited time and the performance of the radiation source cannot be reduced, the working personnel is to be equipped with rubber or PVC gloves, protective clothing, etc.

6.2.3 During maintenance, etc. on radiating equipment the RADHAZ source shall be connected to a dummy load, which absorbs the power output of the source.

6.2.4 Only flammables with flashpoints above 60 °C may be exposed to RADHAZ. Other flammables have to be located and transported in shielded, closed containers.

During fuelling, defueling of aircraft, vehicles or water craft no radar main beams and radiations from other directional aerials shall illuminate fuelling points and such operations have to be done outside the minimum safe distance.

6.2.5 A minimum separation distance between fixed shipboard transmitting antennas or aircraft structures

and ammunition is to be maintained. Within a RADHAZ area all ammunition shall be carried in completely enclosed metal containers.

Other measures according to the type of ammunitions and safety critical electronic devices are to be defined by the Naval Authority.

6.2.6 At least for naval ships with considerable radio and radar equipment it is recommended to:

- Summarize all necessary procedures to avoid hazards in a RADHAZ manual

- Assign a RADHAZ Responsible Officer (RRO) within the crew

6.3 Further information

Only the fixed installed equipment and safety measures are subject to Classification by **TL**, but further information may be gained from the following standards:

- STANAG 1379: NATO RADHAZ Warning Sign

- STANAG 1397: RADHAZ Classification of Munitions and Weapon Systems Embodying Electro-Explosive Devices

- STANAG 2345: Evaluation and Control of Personnel Exposure to Radio Frequency Fields 3 kHz to 300 GHz

- NATO/PfP AECP-2 (B): NATO Naval Radio and Radar Radiation Hazards Manual. Recommendations to ensure RADHAZ Safety

- DIN VDE 0848: Safety in electrical, magnetic and electromagnetic fields

SECTION 2

INSTALLATION OF ELECTRICAL EQUIPMENT

A. Electrical Power Generation Plants

1. Arrangement

1.1 Unless specified otherwise in the building specification, electrical power generation plant shall be arranged below the main deck, preferably in a particular auxiliary machinery room, e.g. within the space bounded by watertight main bulkheads.

Location forward of the collision bulkhead is not permitted.

1.2 The generating sets shall be grouped into at least two electrical power generation plants.

If only three generating sets are provided, they must also be grouped into at least two electrical power generation plants. See also Section 1, A.3.1 and Section 3, B.2.1.2.

1.3 The electrical power generation plants 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 The installation shall ensure faultless operation, even in heavy weather, particularly with regard to the supply of fresh air and the removal of exhaust air.

1.6 The aggregates shall be capable of being started, connected, disconnected and monitored from the switchboard of the electrical power generation plant.

2. Switchboards

The relevant switchboards shall be located as close as practicable to the generator sets, within the same machinery room and the same vertical and horizontal A 60 boundaries.

3. Generators Driven by the Main Propulsion Plant

3.1 Where generators are to be incorporated in the propeller shafting, the generators and their foundations are to be suitably designed to ensure satisfactory operation of the propulsion plants even in heavy seas, regardless of the loading condition of the ship.

3.2 In view of the special operating conditions, the generator air gap shall, if possible, not be less than 6 mm. In the event of damage to the generator, separation of the rotor from the stator shall be possible with the means available on board, e.g. by shifting the stator.

4. Emergency Generators

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

4.1 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.

4.2 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.

4.3 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. General

1.1 Typical storage batteries are lead-acid and nickel-cadmium batteries.

1.2 Further types of batteries, e.g. lithium-ion batteries, may be approved under consideration of the following points:

- Resistance to short-circuits
- Fuse elements at occurring short-circuits
- Electrical monitoring elements
- Fire risk/fire behaviour including consequences on adjacent cells or components
- Special requirements for the installation location
- Suitability of the used electrical components
- Integration in the electrical plant including switch gears
- Charging devices and battery management system

Refer to **TL** Rules “Additional Rules for Certification, Installation and Testing of Lithium Batteries” for further requirements.

1.3 At the end of the supply period the voltage in the storage battery resp. in the consumers shall at least reach the values quoted in Section 1, F.

2. Installation

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

Storage batteries for essential equipment and the associated power supply unit/battery charger and distribution switchboards are to be installed in the same watertight compartment.

2.2 Storage batteries shall be so installed as to ensure accessibility for the changing of cells, inspection, testing, 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 portable lighting, where charging does not result in the development of harmful gases.

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

2.4 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 **TL**, the calculation of the charging capacity need not be based on the maximum current. For the typical automatic IU-charging the calculation is stated under 3.

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

2.6 Applied materials shall comply with Section 1, H.

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

3. Battery Systems

A battery system is an interconnection of storage batteries wired in series, parallel or as a combination of both connections. These systems are installed in cabinets or battery rooms.

For comprehensive battery systems further measures have to be agreed with **TL.**

3.1 Only storage batteries of same electrochemical characteristics, type, brand and year of construction shall be connected to a battery system. The selected configuration of a battery system shall not be changed.

3.2 The maximum permitted voltage of a battery system is 1500 V DC.

3.3 Only authorised personal shall have access to locked cabinets or battery rooms. Safety measures are to be taken against electric shock.

3.4 Storage batteries shall withstand internal- and external short circuits. The level of expected short circuit current shall be considered for the DC network design and its switching and protection devices.

3.5 Disconnecting devices shall be provided to isolate all conductors of battery systems from circuits.

3.6 Battery systems for redundant installations shall not be installed in the same cabinet or battery room. The requirements of redundancy shall be applied to the auxiliary systems and cooling systems as well.

3.7 Battery systems for emergency supply shall not be installed in the same cabinet or battery room as storage batteries for other consumers.

3.8 Battery systems shall be labelled. At access hatches or other openings to cabinets or battery rooms instructions to personnel safety shall be displayed.

3.9 Heating and Cooling

3.9.1 No additional heat sources shall be installed in spaces of storage batteries. Cabinets or battery rooms shall be equipped with controlled heating systems, if applicable.

3.9.2 Redundant cooling or ventilation systems shall be provided including monitoring and alarm in case of abnormal operation.

3.9.3 Preferably air- or liquid flow monitoring devices shall be provided. Differential pressure indicators are not recommended.

3.10 Protection

3.10.1 A ground fault detection system shall be provided for the DC network.

3.10.2 Management-, monitoring- and protection systems shall be provided. These systems are subject to **TL** type approval and shall include the following functions at least:

- Control and monitoring during charging, discharging and operation

- Protection against overcharging, discharging and against deep discharge

3.10.3 An independent temperature monitoring system shall be provided. This monitoring shall give an alarm if temperature difference between the interior of cabinets or battery rooms and the environment is too large.

3.10.4 A documentation shall be submitted to verify safe operation of the battery system including personal protection.

3.11 Installation and maintenance

3.11.1 The manufacturer instructions regarding installation, maintenance, operation and cooling of the battery system are to be observed.

3.11.2 Positive (+) and negative (-) wiring shall have equal wire length.

3.11.3 It is recommended to check periodically cable connections and to use e.g. an infrared (IR) camera to detect hot spots in the battery system if any.

4. Equipment in Cabinets and Battery Rooms

4.1 During charging, discharging or internal failures storage batteries could generate and release explosive gases.

4.2 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.

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

4.4 Other electrical equipment shall be installed in cabinets or battery rooms only when it is unavoidable for operational reasons.

4.5 In case of gastight batteries, such as NiCd-, NiMH- or Li-batteries, alternative measures have to be agreed with **TL.**

5. Ventilation of Spaces Containing Batteries

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

For ventilation of lithium batteries, refer to **TL** rules "Additional Rules for Certification, Installation and Testing of Lithium Batteries".

5.2 Batteries installed in switchboards with charging power up to 0,2 kW

Lead batteries with a charging power up to 0,2 kW may be installed in switchboards without separation to switchgear and without any additional ventilation, if:

a) the batteries are valve regulated (VRLA), provided with solid electrolyte

b) the battery cases are not closed completely (IP 2X is suitable)

c) the charger is regulated automatically by an IU-controller with a maximum continuous charging voltage of 2,3 V/cell and rated power of the charger is limited to 0,2 kW

5.3 Ventilated spaces with battery charging power up to 2 kW

Batteries may be installed in ventilated cabinets and containers arranged in ventilated spaces.

The unenclosed installation (IP 12) in well ventilated positions in machinery spaces is permitted.

Otherwise batteries shall be installed in ventilated battery cabinets or containers.

The charging power for automatic IU-charging shall be calculated as follows:

$$P = U \cdot I$$

$I = 8 \cdot K / 100$ for Pb-batteriers

$I = 16 \cdot K / 100$ for NiCd batteries

P = Charging power [W]

U = Rated battery voltage [V]

I = Charging current [A]

K = Battery capacity [Ah]

The gassing voltage shall not be exceeded. If several battery sets would be used, the sum of charging power has to be calculated.

The free air volume in the room shall be calculated depending on battery size as follows:

$$V = 2,5 \cdot Q \; ; \quad Q = f \cdot 0,25 \cdot I \cdot n$$

V = Free air volume in the room [m^3]

Q = Air quantity [m^3/h]

n = Number of battery- cells in series connection

f = 0,03 for lead batteries with solid electrolyte

f = 0,11 for batteries with fluid electrolyte

If several battery sets would be installed in one room, the sum of air quantity shall be calculated.

Where the room volume or the ventilation is not sufficient, enclosed battery cabinets or containers with natural ventilation into suitable rooms or areas shall be used.

The air ducts for natural ventilation shall have a cross section as follows, assuming an air speed of 0,5 m/s:

$$A = 5{,}6 \cdot Q$$

A = Cross-section [cm^2]

The required minimum cross-sections of ventilation ducts are shown in Table 2.1.

Small air ducts and dimensions of air inlet and outlet openings shall be calculated based on lower air speed.

Table 2.1 Cross-section of ventilation ducts

Calculation based on battery charging power (automatic IU-charging)			
Battery charging power [W]	**Cross-section [cm^2]**		
	Lead battery solid electrolyte VRLA	**Lead battery fluid electrolyte**	**Nickel-Cadmium battery**
< 500	40	60	80
500 < 1000	60	80	120
1000 < 1500	80	120	180
1500 < 2000	80	160	240
2000 < 3000	80	240	Forced ventilation
> 3000	Forced ventilation		

5.4 Ventilated rooms with battery charging power more than 2 kW

Batteries exceeding charging power of 2 kW shall be installed in closed cabinets, containers or battery rooms forced ventilated to open deck area. Lead batteries up to 3 kW may be ventilated by natural means.

Battery rooms shall be arranged according to 3.

The ventilation arrangements for installation of vented type batteries which have charging power higher than 2 kW are to be such that the quantity of air expelled is at least equal to:

$Q = 110 \cdot n \cdot I$ where

n = Number of cells in series

I = Maximum current delivered by the charging equipment during gas formation, but not less than 25 per cent of the maximum obtainable charging current in amperes

Q = Quantity of air expelled in litres/hr.

The ventilation rate for compartments containing valve-regulated batteries may be reduced to 25 per cent of that given above.

5.5 Ventilation requirements

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

The air inlet openings shall be arranged below and air outlet openings shall be arranged above.

If batteries are installed in several floors, the free distance between them shall be at least 50 mm.

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

Air ducts for natural ventilation shall lead to the open deck directly.

Openings shall be at least 0,9 m above the cupboard/ boxes. The inclination of air ducts shall not exceed 45° from vertical.

Battery room ventilators are to be fitted with a means of closing whenever:

- The battery room does not open directly onto an exposed deck, or

- The ventilation opening for the battery room is required to be fitted with a closing device according to the Load Line Convention (i.e. the height of the opening does not extend to more than 4,5 m (14.8 feet) above the deck for position 1 or to more than 2,3 m (7.5 feet) above the deck in position 2), or

- The battery room is fitted with a fixed gas fire extinguishing system.

Where a battery room ventilator is fitted with a closing device, then a warning notice stating, for example "This closing device is to be kept open and only closed in the event of fire or other emergency – EXPLOSIVE GAS", is to be provided at the closing device to mitigate the possibility of inadvertent closing.

5.6 Forced ventilation

If natural ventilation is not sufficient or required cross-sections of ducts according to Table 2.1 are too big, forced ventilation shall be provided.

The air quantity Q shall be calculated according to 5.3.

The air speed shall not exceed 4 m/s.

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

Wherever possible, forced ventilation exhaust fans shall be used.

The fan motors shall be either certified safe type with a degree of protection IIC T1 and resistant to electrolyte or, preferably, located outside of the endangered area.

Fans are to be of non-sparking construction.

The ventilation systems shall be independent of the ventilation systems serving other rooms. Air ducts for forced ventilation shall be resistant to electrolyte and shall lead to the open deck.

6. Emergency Storage Batteries

The location in which storage batteries for the emergency power supply are installed shall fulfil the same conditions as required for the installation of the emergency generator.

7. Batteries for Starting of Internal Combustion Engines

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

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

8. 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.

9. Recording of the Type, Location and Maintenance Cycle of Batteries

9.1 Where batteries are fitted for use for essential services a schedule of such batteries is to be compiled and maintained. The schedule, which is to be approved by **TL,** during plan approval or the newbuilding survey, is to include at least the following information regarding the battery(ies):

- Type and manufacturer's type designation

- Voltage and ampere-hour rating

- Location

- Equipment and/or system(s) served

- Maintenance/replacement cycle dates

- Date(s) of last maintenance and/or replacement

- For replacement batteries in storage, the date of manufacture and shelf life **(1)**

9.2 Procedures are to be put in place to ensure that where batteries are replaced that they are of an equivalent performance type.

9.3 Where vented **(2)** type batteries replace valve-regulated sealed **(3)** types, it is to be ensured that there is adequate ventilation **(4)** and that the **TL** requirements relevant to the location and installation of vented types batteries are complied with.

C. Power Transformers

1. Transformers 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 electrical power generation plants, or these transformers must be located in the watertight compartments which they supply.

3. The location of centrally arranged converters for the sub-networks must fulfill the same conditions as those applying to the installation of the electrical power generation plants

4. For medium-voltage transformers, see F.

(1) *Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specific performance.*

(2) *A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.*

(3) *A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.*

(4) *For the ventilation arrangements for installation of vented type batteries which have charging power higher than 2kW, Item B.5.4 shall be applied.*

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. Switchboards of Electrical Power Generation Plants

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 main switchboards electrical power generation plants (separately for each electrical power generation plants) 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 switchboard 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 switchboard 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 appropriately insulating covering, or insulating gratings or mats (according to IEC 61111) 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 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.

2.3 Where the emergency source of electrical power is a accumulator battery it shall not be installed in the same space as the emergency switchboard.

3. Main Group Switchboard

The requirements set out in 1.3, 1.5 and 1.8 for switchboards of electrical power generation plants also apply to main group switchboards.

4. Group and Sub-group Switchboards

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. Medium Voltage Equipment

Appliances for medium voltage are designed for the range greater 1 kV to 15 kV AC.

1. General

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.

1.2.1 Electrical equipment which only ensures the lowest required protection against contact according to Section 8, Table 8.3 shall be installed in a locked electrical operational compartment.

1.2.2 If the lowest required protection against contact according to Section 8, Table 8.3 is not ensured, the equipment shall be installed in rooms whose access doors shall be locked in such a way that they can only be opened after isolation and earthing of the supply circuits and a suitable marking is to be placed which indicates danger of high-voltage.

1.3 If during operation the protection against accidental arcing at the place of installation or in their vicinity is not ensured, the hazardous areas are to be blocked off by appropriate means and are to be marked with warning labels. The continuous stay of personal in the hazarded areas shall be avoided. Therefore control panels, devices for vocal communication, etc. may not be installed in this area.

1.4 The place of installation of switchgear without valid arc test shall be interlocked that access shall be given only when the equipment is isolated. Other components, for which an arc test is required, shall be considered accordingly.

An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/ deck-head above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200.

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.

Accidental arc gases shall be vented in a way, that the hazard of persons and equipment is minimised.

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.

Note

Compartments subjected to arc gases, shall be equipped with sufficient exhaust ventilation, where necessary supplied from two different switchboards.

3.2 SF6 Switchgear

3.2.1 SF6 switchgear shall only be installed in spaces which are adequately ventilated. An exhaust fan is to be provided. 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 mating (e.g. according to IEC 61111).

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.

3.4 Auxiliaries for main switchboards

Auxiliaries necessary for the operation of the main switchboard have to be installed so that their function is only affected by fire or other incidents within the same compartment.

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. Ship Service Transformers

Ship service transformers with a degree of protection lower than the minimum required degree of protection according to Section 8, Table 8.3 shall be installed in separate compartments.

6. 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 according to IEC 61230, together with insulated fitting tools
- an insulating mating (mat for repair/ maintenance)
- a sufficient number of warning labels bearing the words "Do not operate switch"
- safety instructions for gas insulated switchboards

7. 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 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
- 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 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.

If a special port generator is provided, electric power may be produced by the ship itself, see F.

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 auxiliary systems, 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.

Main electric power source may be generator or a static storage device such as fuel cell or battery. For installation and safety requirements of lithium batteries, refer to the **TL** rules "Additional Rules for Certification, Installation and Testing of Lithium Batteries".

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 generators, compare the power management system, see Chapter 106 - Automation, Section 7, E.

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. Simultaneously connection of the different generators and/or power supplies to main busbar without synchronization shall be prevented.

1.2.4 Where several generators 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 electric power generation plant fails, the main groups must automatically be changed over to the remaining electric power generation plant, see also Section 4, H.4.

1.3 The arrangements of the ship's source of electrical power shall be such that operation in accordance with Section 1, A.3. can be maintained regardless of the speed and direction of rotation of the main propulsion machinery or shafting.

The use of generators driven by the main propulsion plant is subject to the requirements mentioned in item 5.

1.4 The ship machinery installations shall be so designed, that in the event of total failure of the electrical power supply, they can be brought to operation from this dead ship condition; compare also the definition of dead ship condition in Section 1, B.

The equipment to start from dead ship condition is defined in the **TL** Rules for Ship Operation Installations and Auxiliary Systems, Section 6, A.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 power management system 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 electric power generation plant.

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 1½ times the highest power demand determined by the electrical power balance (including NBC 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 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. Other modes of parallel operation are to be agreed with **TL.**

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 A.2.

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 type 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, TS HD 60364-7-710 respectively IEC 60364-7-710 shall be applied.

3. Rating and Control of Alternating and Three-Phase Current Generators of the Electrical Power Supply

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. Where a number of generators operate in parallel, this condition shall continue to be met when the largest generator is not in operation.

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.

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

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.

On ships with shaft driven generators the range of speeds of main generator and auxiliary diesel which can be set is to be so designed that even at the minimum operating speed acceptable for shaft driven generator operation, correct synchronisation of and entering by the auxiliary units is possible in all weather conditions.

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 permissible cyclic irregularity is to be agreed between the manufacturers of the prime movers and the generators.

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.

5. Generators Driven by the Main Propulsion Plant (E.G. Shaft-Driven Generators)

5.1 Generators driven by the main propulsion plant may be deemed to constitute part of the main electrical power supply in accordance with 1. Provided they can

be operated under all weather-, navigating and manoeuvring conditions, including stopped ship by supplying sufficient load. The operating conditions for frequency stated in Section 1, F.1. shall be fulfilled. Voltage and load sharing shall be in the limits acc. to 3.2, 3.3, 3.5.1, 3.5.2 and 3.6 (only to be observed in case of parallel operation).

5.1.1 It is an essential requirement that, should any generator or its prime mover fail, the conditions stated in 1.2 shall be satisfied, and it shall also be possible to start the main propulsion plant in accordance with 1.4 and C.1.2.

5.1.2 Provision shall be made for decoupling generators not lying in the line of the propeller shaft.

5.1.3 The generators shall be protected in such a way that a short-circuit in the main busbars will not cause a damage in the generator system and a subsequent restoration of normal generator function will be possible.

5.2 Generators which are driven by the main propulsion plant but which fail to conform to the conditions stated in 5.1 are not considered to constitute part of the main electrical power supply, although they may be used as additional generators and on occasion maintain the entire power supply function provided the following conditions are met:

- Where main propulsion plants are not driven at constant speed, regulators should be fitted enabling the generator plant to deliver an adequate output over a speed range of the main engine from at least 75 % to 100 %.

- Frequencies are to be kept within the limits stated in Section 1, F.1. For voltage and load sharing (only in case of parallel operation) furthermore the conditions stated in 3.2, 3.5.1, 3.5.2 and 3.6 are to be fulfilled.

- On ships with remote control of the main engine from the bridge, it is necessary to ensure that, when manoeuvres preventing the continued operation of the shaftdriven generator plant are initiated, the supply to essential equipment is maintained from the shaft-driven generator plant until the load has been shifted to a stand-by generator.

5.3 For the selectivity demands of the distribution system the short-circuit current shall be sufficient.

5.4 In case of frequency deviations exceeding 10 %, the generator is to be disconnected within 10-30 seconds.

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/19;
- 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. Transitional Electric Power Supply

1. General Requirements

1.1 If the electrical power fails, the transitional power supply (UPS) must automatically supply the consumers mentioned below**.**

1.2 This source of power shall be installed locally at the consumers or centralised for each watertight compartment. Further detailed requirements are defined in Section 14, E.4.

2. UPS Consumers

The transitional power supply (UPS) shall be capable of simultaneously supplying at least the following services with at least the defined duration:

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 with a duration of at least 30 minutes.

2.2 Services with a duration of at least 3 hours:

2.2.1 General emergency alarm as per Section 9, D.1.

2.2.2. Public address system as per Section 9, D.2.

2.2.3 Fire detection and fire alarm system as per Section 9, D.3.

2.2.4 Voyage data recorder (VDR) as per Section 9, D.7.

2.2.5 VHF radio installation

2.2.6 GPS receiver and gyro-compass

2.3 For any other equipment and systems requiring uninterrupted transition of power the duration of power supply shall be at least 15 minutes.

2.4 Other, higher values for the transition duration may be defined in the building specification.

2.5 Permissible time for changeover of weapon systems and tactical command systems are to be specified by the maker or in the building specification

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 may be an option to supply 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 electrical power generation plants.

1.2 Depending on the size of the ship, on the spatial separation between the electrical power generation plants and on measures taken to increase combat survivability, the supply will be taken from the remaining 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.

F. Operation of a Port Generator

1. General

The port generator may be used during lay time in the harbour for the main power supply, provided the requirements mentioned in the following are complied with.

2. Requirements

2.1 The location where the port generator set and the relevant switchboard are installed shall be covered by means of a fire detections system similar to those required for unattended main and auxiliary machinery spaces, see Section 9, D.3.5.

2.2 The prime mover shall be designed for continuous operation and the gen set shall be directly connected to a main switchboard or a special port generator switchboard. For port service it shall normally be blocked against simultaneous operation with other generator sets. Otherwise the gen set has to be equipped for parallel operation with the main gen sets.

2.3 The prime mover and the generator shall be provided with monitoring, protective and safety devices as required for auxiliary engines and main generators intended for unattended operation, e.g. stop at lubrication oil pressure too low. Also the other requirements defined in these Rules for generator sets have to be fulfilled, as far as applicable.

2.4 It is recommended that the prime mover shall be equipped with switch-over filters (2 or more filter chambers, e.g. Duplex-filter) for fuel oil and lubrication oil which enable cleaning during operation.

2.5 The fuel oil supply tank to the port diesel generator set shall be provided with a low level alarm arranged at a level of fuel sufficient for a defined remaining duration of operation.

SECTION 4

INSTALLATION PROTECTION AND POWER DISTRIBUTION

A. Three-Phase Main Generators

1. General

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

1.1 Single operation

Single operation means that each generator supplies its own switchboard at the electrical power generation plant and also, when the interconnection feeder is activated, another electrical power generation plant switchboard.

1.2 Parallel operation

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

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 (preferably 2,8 x In). It must have a short time delay compatible with the selectivity of the system (from 300 up to about 500 ms).

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

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 exceeded, causes 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 70 % - 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.34.

2.7 Under frequency protection

2.7.1 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.

2.7.2 For shaft driven generator plants protection shall be provided in accordance with Section 3, B.5. for disconnecting the generators in the event of under frequency.

2.8 Testing

Generator protection devices are subject to mandatory type tests.

3. Switchgear

3.1 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. The use of thermal bi-metallic release for generators used to supply essential consumers is not permitted.

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

3.1.4 In the design of the contactor to supply primary essential consumers the low voltage switching devices shall be dimensioned in accordance with IEC 60947-4-1 “type 2”.

3.1.5 If the personnel safety ensured and the selective protection of the electrical system by devices in series guaranteed, in this case the low voltage switching devices for supplying secondary essential and less important consumers could be dimensioned in accordance with IEC 60947-4-4 “type 1”.

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.

3.3.3 A single fault in the synchronization circuit or in the black-out monitoring shall not lead to any synchronous connection.

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. 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.

C. Power Transformers

1. Transformers intended for parallel operation shall be so designed that over the whole load range 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.

Each transformer required is to be located as a separate unit with separate enclosure of equivalent, and is to be served by separate circuits on the primary and secondary sides.

Each primary circuit is to be provided with switch-gear and protection devices in each phase.

Each of the secondary circuits is to be provided with a multipole isolating switch. Transformers supplying bow thruster are excluded

2. Power transformers are to be provided with overload and short circuit protection.When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

In installations where feedback is possible, transformers shall be switchable at both the primary and secondary side.

D. 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.

E. Power Electronics

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

F. 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 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 " 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 protection against overload and short-circuit in the switchboard of the electrical power generation plant.

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 electrical power generation plant, 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 switchboards of the electrical power generation plant, 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 box shall be protected at least against short circuit.

2.7 All equipment operated from the shore connection must be so constructed as to ensure trouble free 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.

2.8 Facilities shall be provided to compare the polarity (in case of direct current) and the phase sequence (in case of three phase alternating current) of the shore supply with those of the ship’s mains.

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.

G. 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 shall be proved.

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.

H. Power Distribution

1. General Requirements

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

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. Electrical Power Generation Plant / Interconnection Feeders

2.1 The generators and the shore connections belonging to a electrical power generation plant 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 electrical power

generation plant, they shall be linked by an interconnection feeder which must be designed for half the power of one electrical power generation plant. If, however, the electrical power generation plant 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 switchboard of the electrical power generation plant.

3. Supply of the Consumers

3.1 The consumers are supplied either directly from the switchboards of the electrical power generation plant 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 electrical power generation plant 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 electrical power generation plant switchboard or through a main group.

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

3.1.3 Sub-groups

Sub-groups are to be supplied from a group and may 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 electrical power generation plant switchboards via the main groups is prevented.

An uninterrupted change-over with the interconnection feeder activated between the electrical power generation plant 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 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. by transitional electric power (UPS), shall be provided.

5. Load Balancing in Three-Phase Systems

Where, in three-phase systems, AC consumers are connected between outer conductors, 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.

6. Essential Supply Cables

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

6.2 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 electrical power generation plant switchboards or from the main group(s) or group(s).

7. Supply of Lighting Systems

For supply of lighting systems see Section 11,B.

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 electrical power generation plant, this switchboard shall be given two incoming feeders from different main groups or from groups of different electrical power generation plant.

In exceptional cases if ships have only one electrical power generation plant, this switchboard shall be given one incoming feeder from the main source of electrical power and one from the emergency source of electrical power.

An automatic switch over to the alternative source of power is permitted and to be alarmed.

8.3 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.

The masthead light(s), sidelights and stern lights shall be dublicated or be fitted with dublicate lamps.

8.4 A navigation lights controller should facilitate ON/OFF controls of individual navigation lights.

8.5 An navigation lights controller should provide visual indications of “ON”/”OFF” status of navigation lights.

8.6 Pre-programmed navigation lights group settings may be provided.

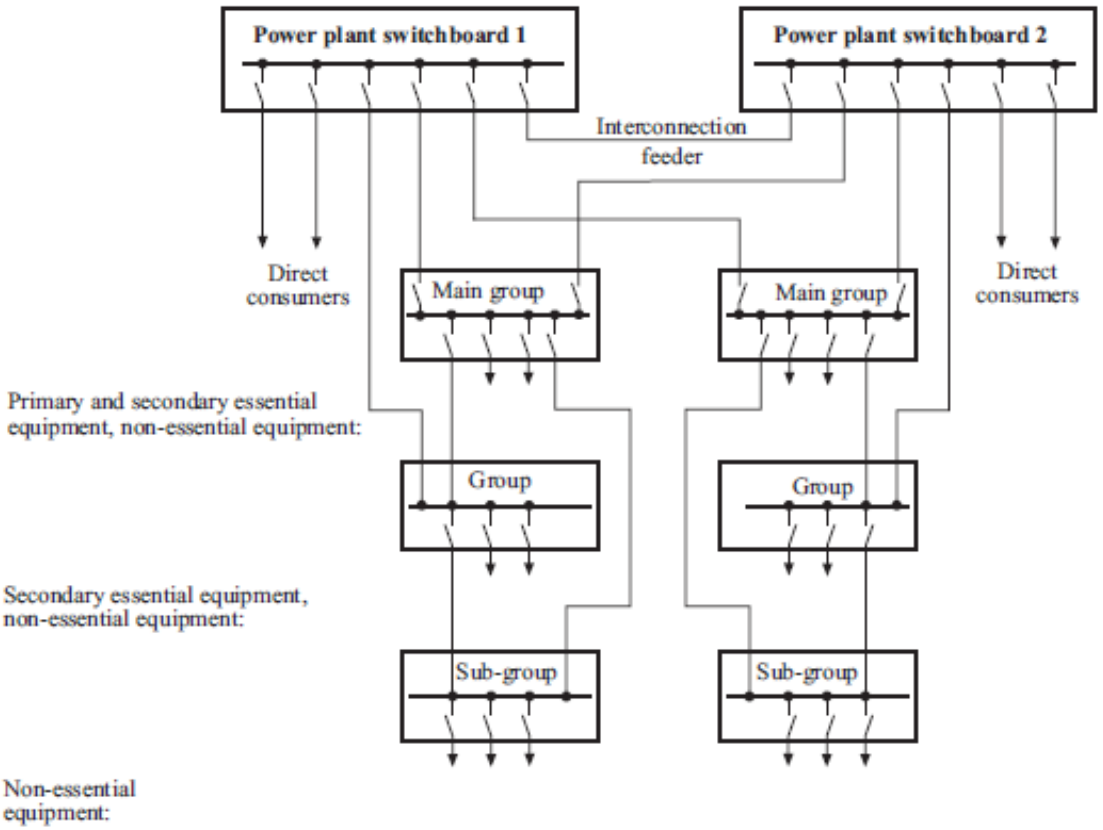

Figure 4.1 Example for the supply of equipment from switchboards of two electrical power generation plants

8.7 The navigation lights controller shall be provided with a device for each light which gives optical and acoustical alarm if the light disappears.

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

8.8 On request of the Naval Authority, the navigation lights may be fitted with a range adjustment device for common and continuous range reduction from 100 % to 5 %.

8.9 A navigation lights controller shall present the status of all navigation lights in a logical present tion, meeting the requirements set out in IMO Resolution MSC.191(79).

8.10 All indicators of an navigation lights controller shall be dimmable. The brightness of a display, if fitted, shall be controllable.

8.11 To prevent shortage of luminous intensity of LEDs (Light Emitting Diodes) an alarm function should be activated to notify the Officer of the Watch that the luminous intensity of the light reduces below the level required by COLREGs or LEDs shall only be used within the lifespan (practical term of validity) specified by the manufacturer to maintain the necessary luminous intensity of LEDs. The specifications in the certificate of conformity for navigation lights are to be observed.

8.12 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. 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.

9.1 A common distribution network with an uninterruptible source of power may be used to supply systems which are required to remain operative even if the other sources of electrical power fails. For this network, there must be two supply possibilities from different electrical power generation plant 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.

For emergency shutdown facility that is generally de-energized (i.e., normally open circuits), a wiring break monitoring device is to be supplied.

The design of the emergency shutdown system is to be such that no single failure will cause loss of essential equipment such as fuel and lubricating oil pumps which may cause loss of main power generation or main propulsion.

Emergency shutdown facilities shall be provided for e.g.

- Fuel pumps
- Lubrication oil 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 (electrical power generation plant) 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 Power supply for radio equipment

11.2.1 Two 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 transitional electric power supply at all times.

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

12. Navigational Equipment

Where radio equipment requires an uninterrupted input of information from the ship's navigational equipment, it will be necessary for the equipment providing the data to be supplied from the same distribution board bus bar serving the radio equipment.

13. Sound Signalling System

The ship's sound signalling system shall remain operative if one of the electrical power supplies fail.

14. Harmonic Distortion for Ship Electrical Distribution System Including Harmonic Filters (1)

14.1 Scope

The requirements of this item apply to ships where harmonic filters are installed on main busbars of electrical distribution system, other than those installed for single application frequency drives such as pump motors.

14.2 General

The total harmonic distortion (THD) of electrical distribution systems is not to exceed 8 %.

This limit may be exceeded where all installed equipment and systems have been designed for a higher specified limit and this relaxation on limits is to be documented (harmonic distortion calculation report) and made available on board as a reference for the surveyor at each periodical survey.

14.3 Monitoring of harmonic distortion levels for a ship including harmonic filters

The ships are to be fitted with facilities to continuously monitor the levels of harmonic distortion experienced on the main busbar as well as alerting the crew should the level of harmonic distortion exceed the acceptable limits.

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(1) *Aligned with TL- R E 24.*

Where the engine room is provided with automation systems, this reading should be logged electronically, otherwise it is to be recorded in the engine log book for future inspection by the surveyor..

14.4 Mitigation of the effects of harmonic filter failure on a ship's operation

Where the electrical distribution system on board a ship includes harmonic filters the system integrator of the distribution system is to show, by calculation, the effect of a failure of a harmonic filter on the level of harmonic distortion experienced.

The system integrator of the distribution system is to provide the ship owner with guidance documenting permitted modes of operation of the electrical distribution system while maintaining harmonic distortion levels within acceptable limits during normal operation as well as following the failure of any combination of harmonic filters.

The calculation results and validity of the guidance provided are to be verified by the surveyor during sea trials.

14.5 Protection arrangements for harmonic filters

Arrangements are to be provided to alert the crew in the event of activation of the protection of a harmonic filter circuit.

A harmonic filter should be arranged as a three phase unit with individual protection of each phase. The activation of the protection arrangement in a single phase shall result in automatic disconnection of the complete filter. Additionally, there shall be installed a current unbalance detection system independent of the overcurrent protection alerting the crew in case of current unbalance.

Consideration is to be given to additional protection for the individual capacitor element as e.g. relief valve or overpressure disconnector in order to protect against damage from rupturing. This consideration should take into account the type of capacitors used.

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 60092-302-2.

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 61363-1. Equivalent standards may be approved.

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 ,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 60092-302-2 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, operating devices and electrical cables 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 be marked 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 Switchboards of electrical power generation plants, 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 Hinged doors in switchboards 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 switchboards of electrical power generation plants 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. for class notations SHOCK or VIBR, the shock or vibration resistance, shall be determined for the switchgear.

1.14 Cable ducts and covers for contact protection shall be made of halogen-free material.

Exceptions for individual cables for special purposes and for specific areas have to be agreed with **TL.**

1.15 Swit**c**hboards of electrical power generation plants, main group switchboards and other switchboards with more than 1 control section or 5 total indication lamps, starter panels with more than 3 lamps or starter panel cabinet which contains more than one control section (i.e. 2 pumps etc.) shall have lamp test option. Switchboards with HMI (Human Machine Interface) panels with visual and audible alarm functionality may be exempt from the lamp test option.

2. Switchboards of Electrical Power Generation Plants

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 switchboards of electrical power generation plants shall be constructed as follows:

2.2.1 For ships with only one electrical power generation plants:

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 electrical power generation plants:

The main busbars of each switchboard of electrical power generation plants 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 switchboard of electrical power generation plants. 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 100 kVA AC/100 kW DC, 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 In plants where electrical power is necessary for the propulsion of the ship, the main busbar shall be capable to be subdivided into at least two parts which shall normally be connected by circuit breakers or other approved means.

Other approved means can be achieved by:

- Circuit breaker or
- Disconnecting link or
- Switch

by which bus bars can be split easily and safely. Common bolted links between single busbar or switchboard sections (e.g. for transportation) do not fulfil these requirements.

2.6 A single disconnecting device is sufficient if this device is provided within a separate switchboard panel without other installations or in an equivalent bounded section, see Fig. 5.1. Otherwise two disconnecting devices are required in different switchboard panels, see Fig. 5.2.

2.7 In case of removable or movable links, these devices shall be easily accessible and simple to

handle. Tools for operating shall be located nearby.

2.8 As far as is practicable, the connection of generating sets and duplicated consumers shall be equally divided between the main bus bar sections.

2.9 The consumers may, for instance, be grouped as follows:

Consumers 1	Consumers 2
Lubricating oil pump 1	Lubricating oil pump 2
Cooling water pump 1	Cooling water pump 2
Lighting 1	Lighting 2
etc.	etc.

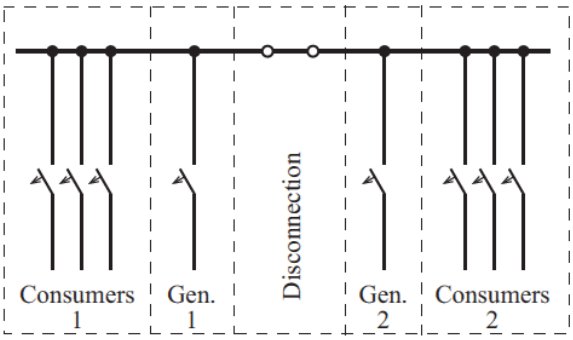

Fig. 5.1 Example for arrangement of a main busbar disconnection and division of consumers

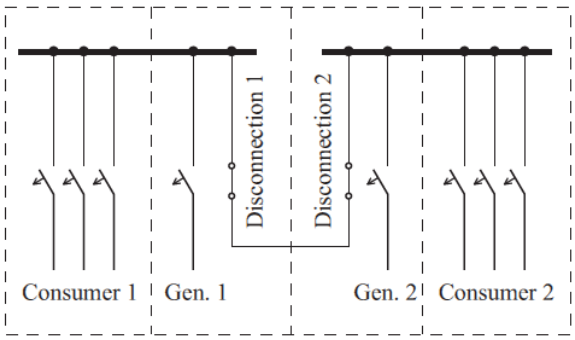

Fig. 5.2 Example for arrangement of two disconnecting devices and division of consumers

2.10 Switchgear and synchronizing equipment for generators

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

2.11 Measuring and monitoring devices for generators

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

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

2.11.2 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

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

- 1 voltmeter and 1 ammeter

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

- Generator protection devices and the undervoltage trip of the generator circuit breaker,
- Measuring instruments,
- Indicating lights,
- Diesel-engine speed-adjusting equipment,
- Motor drive for circuit breaker.

2.11.5 A manual operation is to provide for generator circuit breaker. It shall be independent, see Section 17, D.3.4.

2.12 Switchgear and fuses for equipment

2.12.1 Each supply line run from the switchboards of electrical power generation plants 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 may be provided for the supply cables of main groups in agreement with **TL.**

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.

2.12.2 For steering gear, see Section 7, A.

2.13 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.

3. Main Group, Groups and Subgroups

3.1 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.

3.2 Supply lines 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.

3.3 For navigation lights panels, see Section 4, H.8.

4. Motor Starters

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

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

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

4.4 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

4.5 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 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.

2.2.3 Additional requirement for circuit breakers in IT systems:

- Testing as described in Annex H of IEC 60947- 2 is required.

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 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 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.

2.5 Circuit breakers are to be selected on the basis of their rated service short circuit breaking capacities I_{cs} as follows:

- All circuit breakers which are directly connected to switchboards of electrical power generating plants
- All circuit breakers which are installed in the feeder lines for essential services or emergency consumers

Equivalent protection schemes require special approval by **TL**.

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 Determined 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 cu$_r$rent.

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, H.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.

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.

Excepted are indicating lamps with operating voltage ≤ 24 V or if measures are taken to prevent an influence on control and power circuits in the case of short circuit .

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.4.9.

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

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. In special cases if requested by **TL**, 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

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.

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.

Table 5.1 Permissible loading of copper main busbars and section busbars of rectangular cross-section at 45 °C 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
160 x 10	3348	5121	6646	7836	2752	4451	5803	6857
200 x 10	4079	6162	7973	9287	3335	5344	6956	8109

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.

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

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	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
[mm²]	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℃ and an ambient temperature of 45℃. For conductors with a maximum permissible operating temperature [T] deviating from 70℃, 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

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-Approvals

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

- 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:

- Electric power generation plants
- Emergency power 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, if applicable

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, as far as is feasible.

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 60146-1 and 60146-2 "Semiconductor 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. and I.

2. Rectifier systems must guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see Section 1, E. In the event of unacceptable large frequency and/or voltage variations in the supply voltage, the system 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 volt-age 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 The safety of operation shall be proved for liquid cooling and forced cooling.

1.2 Natural cooling is preferred.

1.3 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 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.

Or alternatively performance may be reduced e.g. by load shedding.

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

2. Monitoring

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

2.2 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 It is assumed that the requirements for environmental conditions defined in Section 1, E. and also especially for electro-magnetic compatibility are fulfilled. **TL** is entitled to request proof of the relevant parameters, if applicable.

2. Routine Tests

2.1 Voltage test

Prior to the start of the functional tests, a high-voltage test shall be carried out.

For equipment directly connected to the low voltage mains, a.c. or d.c. test voltage values given in Table 14 of IEC 60146-1-1:2009 is to be used. With U being the rated insulation voltage, the a.c. test voltage equals U + 1200 [V].

For equipment above 1 000 V a.c. and directly connected to high voltage mains, a.c. or d.c. test voltage values given in Table 15 of IEC 60146-1-1:2009 is to be used.

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 demonstrated.

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 full 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, D.

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, H.

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 – same as steering gear control system – and shall be made for its disconnection without any accessories. 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 electro-hydraulic 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 starter except from driven by frequency converter must have an ammeter mounted in the respective switchboards, as applicable, or in the contactor cabinets.

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. Steering gear motor circuits obtaining their power supply via an electronic converter and which are limited to full load current are exempt from above requirement to provide protection against excess current, including starting current, of not less than twice the full load current of the motor. The required overload alarm is to be set to a value not greater than the normal load of the electronic converter.

Note:
Normal load is the load in normal mode of operation that approximates as close as possible to the most severe conditions of normal use in accordance with the manufacturer's operating instructions

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.

If a follow-up control system is installed on the bridge wing, then the follow-up tiller shall be fitted with a retaining spring to midship position, or a take-over system/button shall be installed on bridge wings.

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 switchboards of electrical power generation plants.

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 On ships where an automatic control system like heading or track control system is installed, an override facility shall be installed close to the operator unit of the automatic steering system. The Override facility shall be so designed that self-induced return to

automatic control is not possible except where the course preselection of the automatic system is automatically kept in line. The switch-over from automatic- to manual control by "Override" is to be indicated optically and audibly at the steering position.
The override facility shall be independent of the automatic control system or follow-up control mode.

6.8 Different steering modes including steering gear control positions on the bridge wings shall be changed over all poles, when it cannot be verified that it is free of reactive effects. 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.

From the main steering station on the bridge, it must be possible to isolate / disconnect completely any additional steering control positions on the open deck and any portable steering consoles with flexible cables.

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.

6.10 Failure detection (1)

6.10.1 The most probable failures that may cause reduced or erroneous system performance shall be automatically detected and at least the following failure scenarios shall be considered:

(a) Power supply failure

(b) Earth fault on AC and DC circuits

(c) Loop failures in closed loop systems, both command and feedback loops (normally short circuit, broken connections and earth faults)

(d) Data communication errors

(e) Programmable system failures (Hardware and software failures)

(f) Deviation between rudder order and feedback*

* Deviation alarm shall be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g. follow-up control and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures.

6.10.2 All failures detected shall initiate audible and individual visual alarm on the navigation bridge.

6.11 System response upon failure (1)

6.11.1 The failures (as defined but not limited to those in 6.10.1) likely to cause uncontrolled movements of rudder are detected, the rudder is to stop in the current position without manual intervention or, subject to the discretion of TL, is to return to the midship/neutral position. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not mandatory, and the operator can follow instructions on the signboard in case of such failures, in accordance with TL-R M42.13.

Note: *For hydraulic locking failure, refer also to TL- R M 42.12.2 and 42.13.*

7. Alarms and Indicators

7.1 Alarms and indicators for steering gears and controls are given in Table 7.1.

7.2 Depending on the rudder characteristic, critical deviations between rudder order and response shall be indicated visually and audibly as actual steering mode failure alarm on the navigating bridge. The following parameters shall be monitored:

- Direction: actual rudder position follows the set value;
- Delay: rudder´s actual position reaches set position within defined time limits;
- Accuracy: the end actual position shall correspond to the set value within the design offset tolerances.

(1) *Aligned with TL- R E 25*

7.3 The alarms/indicators listed in Table 7.1 shall be signalled visually and audibly irrespective from the automation equipment.

Alarms on the bridge shall be announced at a position close to the main steering station.

7.4 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.

7.5 The energy supply for the alarms and indicators shall be in accordance with A.2.

8. Rudder-Angle Indicator

For the rudder-angle indicator in its particulars see Section 9, C.4.

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-approval, 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 Control of the direction of thrust

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, C.4. apply as and where appropriate

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	⊗
7	Failure actual steering mode	x	⊗
8	Earth fault on AC and DC circuit	x	
9	Loop failures in closed loop systems, both command and feedback loops (normally short circuit, broken connections and earth faults)	x	
10	Data communication errors	x	
11	Programmable system failures (hardware and software failures)	x	
12	Deviation between rudder order and feedback	x	

Note : x = *Single indication, see also 7.3*
⊗ = *Group indication*

B. Lateral Thrust Propellers and Manoeuvring Aids

These Rules apply to equipment with electrical drive.

For azimuthing propulsors see Section 13 and the **TL** Rules for Propulsion Plants, Section 7B.

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.

3.4 There shall be an emergency stop at every control station, which affects the feeder breaker in the switchboard.

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 7A.

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

1.1.1 The power supply to the motors and the fire-pump control systems shall be so arranged with regard to the assignment to electric power generation plants, 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.

1.1.2 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. Regarding remote starting of fire pumps on ships with unattended engine room see the **TL** Rules for Automation, Section 2, A.

1.1.3 A bypass shall be provided, if fire pumps have a soft starter.

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 at least two switchboards of electric power generation plants or main groups is required.

1.2.2 The design of the fire detection system shall meet the requirements set out in Section 9, D.3.

1.2.3 The switches at the switchboards of electric power generation plants 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, H.10 must be observed.

2.2 It is recommended that one of the engine room fans should be supplied from two sources of electrical power to enable the extraction of fire extinguishing gases, should the need rise. Due to this recommendation the requirements of Section 5, C.2.8 are to be observed.

2.3 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.

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. Alarming of fault conditions is to be provided.

6.2 Main engines

If main engines are started electrically, two starter batteries mutually independent are to be provided. They shall be so arranged that they cannot be connected in parallel. Each battery shall be capable of starting the main engine from cold condition.

The total capacity of the starter batteries shall be sufficient for the following number of starting operations to be carried out within 30 minutes without recharging:

– non-reversible main engines:
6 starting operations

6.3 Auxiliary engines

6.3.1 Main generator sets

If several auxiliary engines are started electrically, at least two mutually independent batteries shall be provided. The use of the main engine starter batteries, are not permitted.

The capacity of the batteries shall be sufficient for at least three starting operations per engine.

If only one of the auxiliary engines is started electrically, one battery is sufficient.

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. General

1.1 Type of enclosure

The degree of protection for motors and switchgear shall be selected in accordance with Section 1, I.1. and Table 1.10.

1.2 Emergency shut-down

Deck machinery shall be equipped with an emergency switch which allows to stop the drive immediately, should the control system fail. Brakes shall be released automatically if the power supply fails.

1.3 Control equipment

Levers and handwheels for the control of lifting equipment shall return automatically to the zero position when released. Exceptions may be allowed for special purpose drives.

2. Anchor Windlasses and Capstans

2.1 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.

2.2 Overload protection

To prevent excessive overloading of the motors and, as far as possible, the gears, electrical overload protection shall be provided as follows:

2.2.1 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.

2.2.2 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.

2.2.3 The electromagnetic release is not required in electrohydraulic drives where the maximum torque is limited by a safety valve.

3. Lifting Gear

Reference is made to the **TL** Rules, Chapter 107, Ship Operation Installations and Auxiliary Systems, Section 3 and the Guidelines for the Construction and Survey of Lifting Appliances.

3.1 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 operated automatically if the ship's power supply fails.

3.2 Control equipment

Levers and hand wheels for the control of lifting equipment must return automatically to the zero position when released.

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, K.

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. 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 ensure that, when the pushbutton is pressed or the circuit is interrupted, the power circuit of the containers is switched off automatically.

9.2 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 15 kV, and rated frequencies of 50 Hz or 60 Hz.

Note:
Where necessary for special application, higher voltages may be accepted by ***TL***

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

Equipment with voltage above about 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

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3. Clearances and Creepage Distances

3.1 Clearances

In general, for Non Type Tested equipment phase-to-phase air clearances and phase to-earth air clearances between non-insulated parts are to be not less than those specified in Table 8.1.

Intermediate values may be accepted for nominal voltages provided that the next higher air clearance is observed. In the case of smaller distances, appropriate voltage impulse test must be applied.

3.2 Creepage distances

Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system, the nature of the insulating material and the transient developed by switch and fault conditions.

3.2.1 Insulators shall conform to IEC 60168 and 60273.

Table 8.1 Minimum clearances for voltage installations

Nominal Voltage [kV]	Minimum clearance [mm]
3 (3,3)	55
6 (6,6)	90
10 (11)	120
15	160

4. Degrees of Protection

4.1 Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC 60092-201 and Table 8.2 are to be complied with, in addition to the provisions of Section 1, Table 1.10

4.1.1 Rotating machines

The degree of protection of enclosures of rotating electrical machines is to be at least IP 23.

The degree of protection of terminals is to be at least IP44. For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP4X is required.

4.1.2 Transformers

The degree of protection of enclosures of transformers is to be at least IP23. For transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required.

4.1.3 Switchgear, controlgear assemblies and converters

The degree of protection of metal enclosed switchgear, controlgear assemblies and static convertors is to be at least IP32. For switchgear, control gear assemblies and

static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP4X is required.

4.2 If the required degree of protection is not fulfilled by the unit itself, adequate protection shall 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 For switchgear installations it shall be proved that an internal arc test according to IEC publication 62271-200, Annex A had been passed. The criteria 1 to 5 shall be fulfilled see also Section 2, F.1.4.

4.3.3 Terminal boxes shall be equipped with a device for the calculated expansion of the accidental arc gases. Evidence shall be given to prove the effectiveness of the chosen design.

5. Equipotential Bonding

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 shall be earthed if, in the event of a fault, there is a possibility to get 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.

Such earthing conductors shall have a minimum cross section of 16 mm^2.

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.

Evidence shall be given to prove down stream selectivity of the complete grid (low- and medium-voltage) under all operating conditions.

This applies to short-circuit, overcurrent and earth fault tripping. Other protection equipment, also those not required by **TL,** may not interfere with this selectivity concept.

8. Isolating and Earthing Devices

A sufficient number of isolating links and earthing and short-circuit devices shall be provided to enable maintenance work to be performed safely on plant sections.

9. Control of Generator and Bus Tie Circuit Breakers

A single-fault event in the synchronization circuit or in the black-out monitoring shall not lead to an asynchronous connection.

C. Network Design and Protection Equipment

1. Electrical Operating Systems

1.1 Essentially, the following arrangements are permitted:

- 3 conductors, with earthed star point,
- 3 conductors, insulated from the hull.

Table 8.2 Minimum degrees of protection against foreign bodies and water (in conformity with IEC 60529)

Equipment / Location	Switchboards, Distribution Boards, Motor Control Centers and controllers	Generators	Motors	Transformers, Converters	Junction/connection Boxes
Dry control rooms Authorized personnel only	IP32	-	-	IP23	IP44
Dry control rooms	IP42	-	-	IP44	IP44
Control rooms Authorized personnel only	IP32	-	-	IP23	IP44
Control rooms	IP42	-	-	IP44	IP44
Above floor plates in machinery spaces Authorized personnel only	IP32	IP23	IP23	IP23	IP44
Emergency machinery rooms Authorized personnel only	IP32	IP23	IP23	IP23	IP44
Below floor plates in machinery spaces Authorized personnel only	-	-	-	-	IP44
Below floor plates in machinery spaces	-	-	-	-	IP44
Ballast pump rooms Authorized personnel only	IP44	-	IP44	IP44	IP44
Ballast pump rooms	IP44	-	IP44	IP44	IP44
Holds for general cargo	-	-	-	-	IP55

Notes:

(1) *Empty spaces shown with "-" indicate installation of electrical equipment is not recommended.*

1.2 Medium-voltage systems are permitted only for fixed installed electrical equipment.

2. Systems with Earthed Star Point

2.1 The star 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.7, measures shall be taken for installations with current-limited star point earths to ensure selective disconnection outputs, in which an earth fault has occurred.

2.1.2 Electrical equipment must be designed to withstand a single-pole short-circuit up to the activation of the protective device.

2.2 Highly resistive earthed mains, in which the 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 star point connection

For each star point, isolating links are to be provided for the purposes of maintenance and measurement.

2.5 Design of the star 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 star point. For each isolatable busbar section directly supplied by generators, a separate star point connection shall be provided.

2.5.3 Earthing resistors shall be dimensioned for twice of the tripping time and shall be protected against overload and short-circuit.

Short-circuit protection is sufficient if the earthing resistor is dimensioned for continuous duty.

2.6 In the systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

3. Systems with Isolated Star Point

3.1 Since intermittent earth-faults can cause transient overvoltages in networks with an isolated star point, endangered equipment shall be fitted with overvoltage protection. For this overvoltages of at least 3,3 times U_N shall be considered.

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.

4.1 Faults on the generator side of circuit-breakers

Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically 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 service transformers and transformers supplying the power section of a main propulsion drive 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 filling level falls below the permissible limit.

4.3.5 Power transformers are to be provided with overload and short circuit protection. When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

4.4 Voltage transformers for control and measuring purposes

4.4.1 Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

4.5 Fuses

Fuses are not to be used for overload protection.

5. Low-Voltage Networks

Low-voltage networks fed via transformers from a medium-voltage network are to be protected against the overvoltages. This may be achieved by;

- Direct earthing of the lower voltage system,
- Appropriate neutral voltage limiters,
- Earthed screen between the primary and secondary windings of transformers.

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

Switchgear and controlgear assemblies are to be constructed according to the IEC 62271-200 and the following additional requirements

2.1 Construction

Switchgear accessible for authorized persons only shall at least comply with accessibility type “A” of IEC 62271-200; Annex AA; AA 2.2 .

In accessible spaces by non-authorized persons, switchgear of accessibility type “B” shall be used. Besides this measures against unauthorized operation shall be provided.

Installation and location of the switchgear and controlgear shall correspond with its internal arc classification and classified sides (front, left and right).

2.1.1 Switchgear is to be of metal - enclosed type in accordance with IEC 62271-200 or of the insulation - enclosed type in accordance with the IEC 62271-201.

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.

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 Switchboards supplying primary essential consumers shall have the service continuity LSC 2 according to IEC publication 62271-200.

2.1.5 Evidence shall be provided that mediumvoltage switchboards have passed a type test according to IEC 62271-200. A modification of the construction of a switchboard requires re-testing. The same applies to modifications of the exhaust gas system.

2.1.6 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.

- Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

- Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

- The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

- Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colours or lables.

2.1.7 Doors which give access to medium voltage are to be interlocked in such a way that they can be opened only after closing the earthing switch.

At the entrance of the spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed which indicates danger of high-voltage. As regard the high-voltage electrical equipment installed

out-side a.m. spaces, the similar marking is to be provided. An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/deckhead above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200 (see 2.1).

2.1.8 For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked upon with safety.

Duplicated consumers shall be divided up amongst the dividable switchboard sections.

Note

It is recommended that two different, spatiall separated main switchboards, coupled via a transfer line, are used.

2.1.9 The partitioning of a gas insulated switchboard supplying primary essential equipment shall correspond with the requirements of an air insulated switchboard. Each gas volume shall be monitored.

A pressure drop shall be alarmed. Measures according to manufacturer's instruction shall be initiated.

2.1.10 The corresponding safety instructions shall be displayed at the switchboard.

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.

If shunt trip coils are used, the continuity of the tripping circuit has to be monitored. This does not preclude shunt tripping provided that alarms are activated upon lack of continuity in the release circuits and power supply failures.

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 sections. The switch-over to the other source of energy shall be automatic and shall actuate an alarm. Uninterruptible power supply shall be fed from different electrical power generating plants.

2.3 Tests

2.3.1 An individual test in accordance with IEC 60271-200 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 60271-200, Annex B, if organic insulating materials or gas-insulated busbar penetrations are used.

2.3.3 High-voltage test

A power-frequency voltage test is to be carried out on any switchgear and control gear assemblies. The test procedure and voltages are to be according to the IEC 62271-200 section 7/ routine test.

2.4 Low voltage switchgear design

2.4.1 If the ship's main switchboard is supplied from the medium-voltage system a circuit breaker for the longitudinal separation of the main busbar shall be provided.

The busbar section shall be supplied by circuit breakers suitable for isolation.

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.

2.4.5 Parallel operation of transformers supplying the main switchgear (service transformers) is only permissible for short-term load transfer, if also the medium voltage sides of the transformers are connected.

A forced splitting, independent of the automation system shall be provided.

2.4.6 After black out of the supply of the main switchboard or a partial black-out of busbar sections in the low-voltage main switchgear, the recovery of the power supply shall be performed automatically.

2.4.7 If the black out of the supply is caused by a short-circuit in the low-voltage switchboard no automatic recovery shall be carried out.

2.4.8 The manual connecting of the stand by supply shall be possible after the acknowledgement of short-circuit trip.

2.4.9 A stand by alarm shall be triggered, if components, necessary for the automatic recovery, are not available.

2.4.10 A switching off of the medium-voltage circuit breaker shall cause the opening of the low-voltage circuit breaker.

2.4.11 The supply panels shall meet the requirements for generator panels of this Chapter analogously.

2.4.12 The low-voltage supply panels shall be equipped with a voltmeter and an ampere-meter. It shall be possible to display the currents and voltages of all three phases. Where instrumentation switches for voltage or ampere-meter are used it shall be ensured that a failure in measuring circuit doesn't impair or disable any protection function of this circuit.

2.4.13 The operation modes On, Off, Tripped and Ready shall be indicated by signal lights.

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

It shall be possible to operate the mechanical off of the circuit breaker having the doors closed.

It is to prove that the circuit breaker fulfils the requirements of Section 14, F.3.1.1 d also when actuating the mechanical on button

Circuit breakers are to conform to IEC 62271-100.

3.2.1 For drawout circuit breakers, see 2.1.6.

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 62271-102/103.

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 62271-106.

Medium-voltage power contactor fuse combinations shall be dimensioned according to IEC 62271-106 subclause 4.107.3 damage classification “type c”.

If the safety of the staff and the selective protection of the ships grid ensured by connected upstream devices, medium-voltage contactors supplying secondary or unessential consumers may be dimensioned according to “damage classification type a” of IEC 62271-106.

3.6 Current and voltage transformers

3.6.1 Transformers shall conform to the following IEC publications:

- Current transformers, IEC 61869-2,
- Voltage transformers, IEC 61869-3.

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 60255.

4. Electrical machines

4.1 Design

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 above 1000 V shall be provided with their own terminal boxes. Terminals shall be marked clearly.

4.3 Tests

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

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 60076-11. 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°.

5.1.6 Oil immersed transformers are to be provided with the following alarms and protections:

- Liquid level (Low) - alarm
- Liquid temperature (High) - alarm
- Liquid level (Low) - trip or load reduction
- Liquid temperature (High) - trip or load reduction
- Gas pressure relay (High) – trip

5.2 Ship service transformers

5.2.1 If the ship's low-voltage network is supplied from the medium-voltage network, at least two independent ship service transformers shall be installed. The supply shall be taken from the associated medium voltage switchboards of the electrical power generating plants.

For each electrical power generating plant, an independent low voltage switchboard shall be provided.

Control and protection shall comply correspondingly with the requirements of Section 4 and 5 for the electrical power supply.

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. and in the relevant IEC standards.

5.3.2 The test voltages are to be selected in accordance with Section 14, Table 14.8.

6. Cables

6.1 General

6.1.1 Medium-voltage cables shall conform to IEC 60092-354 and 60092-353 or other equivalent standard. 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 8.3.

E. Installation

1. General

For installation see also Section 2, F.1.

2. Cable Installation

2.1 Cable routes

Medium-voltage cables are to be run through the accommodation area in enclosed metallic cable conduits. 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 of cables

2.2.1 Medium-voltage cables operating at different voltages are to be segregated from each other; in particular, they are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box. Where medium-voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between the cables is not to be less than the minimum air clearance for the higher voltage side shown in Table 8.1.

2.2.2 Medium-voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less.

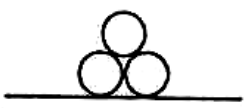
Other means of separation are to be agreed by **TL.**

2.3 Construction 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.

2.7 Assembly

The manufacturer's assembly instructions shall be observed.

3. Tests

3.1 Tests following installation

When the installation work has been completed, high-voltage cables and its accesories are to undergo

voltage withstand tests in the presence of a **TL** Surveyor.

The test is to be carried out after an insulation resistance test.

Note:
Compliance with the safety regulations for tests at high voltage is the responsibility of the testing body.

3.2 Voltage withstand tests can be made using an a.c. or a d.c. voltage.

3.2.1 For cables with rated voltage (U0/U) above 1.8/3 kV (Um=3.6 kV) an a.c. voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test methods to be used:

3.2.1.1 Test using the rated (phase-to-phase) voltage/frequency between conductor and the metallic screen/ shield for a period of 5 minutes.

3.2.1.2 Test using the operating voltage of the system for a period of 24 hours.

3.2.2 D.C. voltage tests are divided according their rated voltage (U_0/U) above and up to the value of 1,8/3 kV (U_m = 3,6 kV) as below:

3.2.2.1 For cable with rated voltage above 1,8/3 kV (U_m = 3,6 kV), d.c. test voltage equal to 4 U_0 may be applied for 15 minutes.

3.2.2.2 For cable with rated voltage up to 1,8/3 kV (U_m = 3,6 kV), d.c. voltage equal to 4 U_0 shall be applied for 15 minutes

3.3 The insulation resistance is to be measured before and after the high-voltage test (500 V /200 MΩ).

Table 8.3 Test voltages for medium-voltage cables

Max. system voltage U_m	kV	1,2	3,6	7,2	12	17,5
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
AC test voltage	kV	3,5	6,5	11,0	15,0	22,0
DC test voltage	kV	8,4	15,6	26,4	36,0	52,8

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.

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 is not covered by this section.

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 malfunctions 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.

2.9 In case of special tasks for a naval ship the possibility of switching-off all audible alarms in advance for a certain time may be provided, if requested by the Naval Authority. This "silent ship condition" has to be specially indicated by signal lights, announcements on monitors, etc.

2.10 Systems have to be intelligible and user-friendly and have to follow ergonomic principles.

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 function directly involved. 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.15.

4. Application of Computer Systems

If computer systems 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 For maintenance purposes all remote and automation functions for a machinery or system shall be safely disabled by hardware switching.

5.2 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.

5.3 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

5.4 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.

5.5 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. Machinery Control and Monitoring Installations

1. Safety Devices

1.1 The design of safety devices shall be as simple as possible and shall be reliable and inevitable in operation. Proven safety devices which are not depending on a power source are to be preferred.

1.2 The suitability and function of safety devices shall be demonstrated in the given application.

1.3 Safety devices shall be designed so that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, ship or machinery. These faults and also the tripping of safety devices shall be signalled by an alarm.

1.4 For preference, safety devices shall be designed in conventional technology (hard wired). Alternative technical solutions shall be agreed with **TL.**

1.5 The adjustment facilities for safety devices shall be designed so that the last setting can be detected.

1.6 Where auxiliary energy is needed for the function of safety devices, this has to be monitored and a failure has to be alarmed.

1.7 Security equipment like short circuit monitoring of generators as well as overspeed monitoring of diesel engines shall run independently from automatic power

control system, to ensure that the equipment can continue operating manually in case of a breakdown.

1.8 Safety devices are subject to mandatory type approval.

2. Safety Systems

2.1 Safety systems shall be independent of openand closed-loop control and alarm systems. Faults in one system shall not affect other systems.

Deviations from this requirement may be allowed for redundant equipment with the agreement of **TL** where this would entail no risk to human life and where ship safety would not be compromised.

2.2 Safety systems shall be assigned to systems which need protection.

2.3 Where safety systems are provided with overriding arrangements, these shall be protected against unintentional operation. Provision to override a safety system shall only be fitted when approved by the Naval Authority that the loss of the equipment avoids a greater hazard for ship and crew. The actuation of overriding arrangements shall be indicated and recorded.

2.4 The monitored open-circuit principle shall be used for safety systems. Alternatively, the closed circuit principle shall be applied where the provisions of national regulations demand it. (e.g. boiler and oilfired systems). Equivalent monitoring principles are permitted. Faults, and also the tripping of safety systems shall be indicated by an alarm and recorded.

2.5 Safety systems shall be designed for preference using conventional technology (hard wired). Alternative technical solutions shall be agreed with **TL.**

2.6 The power supply shall be monitored and loss of power shall be indicated by an alarm and recorded.

2.7 Safety systems are subject to mandatory type approval.

3. Manual Emergency Stop

3.1 Manual emergency stops are to be protected against unintentional activation.

3.2 The manual emergency stop shall not be automatically cancelled.

3.3 It shall be recognizable which manual emergency stop has been activated.

3.4 Manual emergency stops shall be designed according to the monitored open-circuit principle.

4. Open-Loop Control

4.1 Main engines and essential equipment shall be provided with effective means for the control of its operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems, see also A.2.4, B.8. and B.9.

4.2 Control equipment shall have built-in protection features where incorrect operation would result in serious damage or in the loss of essential functions.

4.3 The consequences of control commands shall be indicated at the respective control station.

4.4 Controls shall correspond with regard to their position and direction of operation to the system being controlled resp. to the direction of motion of the ship.

4.5 It shall be possible to control the essential equipment at or near to the equipment concerned.

4.6 Where controls are possible from several control stations, the following shall be observed:

- Competitive commands shall be prevented by suitable interlocks. The control station in operation shall be recognizable as such.

- Taking over of command shall only be possible with the authorization of the user of the control station which is in operation.

- Precautions shall be taken to prevent changes to desired values due to a change-over in control station.

- Open-loop control for speed and power of internal combustion engines (main and auxiliary engines) and electrical actuators are subject to mandatory type approval.

5. Closed-Loop Control

5.1 Closed-loop control shall keep the process variables under normal conditions within the specified limits.

5.2 Closed-loop controls shall maintain the specified reaction over the full control range. Anticipated variations of the parameters shall be considered during the planning.

5.3 Defects in a control loop shall not impair the function of operationally essential control loops.

5.4 The power supply of operationally essential control loops shall be monitored and power failure shall be signalled by an alarm.

5.5 Closed-loop control for speed and power of internal combustion engines (main and auxiliary engines) and electrical actuators are subject to mandatory type approval.

6. Alarm Systems

6.1 Alarm systems shall indicate unacceptable deviations from operating figures optically and audibly.

6.2 Alarm delays shall be kept within such time limits that any risk to the monitored system is prevented if the limit value is exceeded.

6.3 Optical signals shall be individually indicated. The meaning of the individual indications shall be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal shall remain visible until the fault has been eliminated. It shall be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

6.4 It shall be possible to acknowledge audible signals.

The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes.

Alarms shall be discernible under all operating conditions. Where this cannot be achieved, for example due to the noise level, additional optical signals, e.g. flashing lights shall be installed.

6.5 In individual cases, **TL** may approve collective alarms from essential, stand-alone systems which are signalled to the machinery alarm system.

6.5.1 Each new single alarm, which will not lead to stop, has to retrigger the collective alarm.

6.5.2 The individual alarms have to be recognizable at the concerned system.

6.6 Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

6.7 Alarm systems shall be designed according to the closed-circuit principle or the monitored open-circuit principle. Equivalent monitoring principles are permitted.

6.8 The power supply shall be monitored and a failure shall cause an alarm.

7. Operational Devices for Main- and Auxiliary Engines

Operational devices required for local machinery control stations in accordance with the **TL** Rules for Propulsion Plants, Chapter 104, Section 3, H. for:

- Speed/direction of rotation of main engine/ propeller shafting

- Lubricating oil pressure

- Starting air pressure, if applicable
- Control air pressure, if applicable
- Fuel pressure

shall be electrically independent of other systems, like remote control.

8. Speed/Output Controls of Diesel Engines

8.1 General

8.1.1 The governor and the actuator shall be suitable for controlling the engine under the operating conditions laid down in the Rules for Construction and shall be also in line with the requirements specified by the engine manufacturer, see **TL** Rules for Propulsion Plants, Chapter 104, Section 3, F.

8.1.2 Electrical governors and the associated actuators are subject to mandatory type approval.

8.1.3 In the event of faults in the governor system, the operating condition of the engine shall not become dangerous.

Faults in the governor system shall cause an alarm.

In the case of main propulsion engines, engine speed and power shall not increase.

In the case of auxiliary engines, in the event of faults in the governor system, the fuel admission in the injection pumps shall be set to "0".

8.2 Power supply to the control systems of main propulsion engines

8.2.1 Control systems with an independent back-up system shall be supplied from the same source of electrical power.

8.2.2 Where main propulsion engines can be operated without a supply of electrical power (pumps driven from the main engine), their control systems (if they have no back-up system) shall be supplied from the same source of electrical power with battery backup for at least 30 minutes. The automation battery, if of sufficient capacity, may be used for this purpose.

8.2.3 Where main propulsion engines can only be operated with a supply of electrical power (electrically driven pumps), their control systems shall be fed from the main source of electrical power.

8.2.4 Dedicated power supplies shall be provided for each control system of plants comprising a number of main propulsion engines.

8.2.5 Batteries shall not be discharged by the control system following an engine shut-down.

8.3 Power supply to the control systems of generator sets

8.3.1 Each control system shall be provided with a separate supply from the respective source of electrical power with battery back-up for at least 30 minutes.

8.3.2 If there are more than two auxiliary engines, a total of two back-up batteries is sufficient.

8.3.3 If the auxiliary engines are started electrically, a combination of the back-up battery with the starter battery is permissible.

The automation battery may be used as a second backup battery to boost the input voltage.

8.3.4 No supply or battery back-up is required for a control system with its own power source.

8.3.5 No battery back-up is needed if a back-up system is provided.

8.3.6 Batteries shall not be discharged by the control system following an engine shut-down.

9. Integration of Systems for Essential Equipment

9.1 The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

9.2 A defect in one of the subsystems (individual module, unit or subsystem) of the integrated system shall not affect the function of other subsystems.

9.3 Any failure in the transfer of data of autonomous Subsystems which are linked together shall not impair their independent function.

9.4 Essential equipment shall also be capable of being operated independently of integrated systems.

C. Ship Control Systems

1. Remote Control of the Main Engine

Where the remote control of the main engine from the bridge is envisaged, the requirements according to the **TL** Rules for Automation, Chapter 106, Section 5, A. shall be observed.

2. Engine Telegraph Systems

2.1 General requirements

2.1.1 Two independent means shall be provided for communicating orders from the navigation bridge to the position in the machinery space or in the control centre from which main propulsion is normally controlled.

One of these means shall be an engine telegraph. A further means according to 2.3 or 5.1 could be provided.

2.1.2 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.

2.1.3 In the case of installations with several control positions the acknowledged command shall be indicated at all control positions. Where control positions are selected by switching, additionally indication shall be provided of which one is in use.

2.1.4 Transmitters and receivers shall be equipped with call-up devices which remain activated from the start of the command transmission until it is correctly acknowledged.

2.1.5 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.

2.1.6 Power supply shall be provided from the main source of electrical power.

2.2 Main engine telegraph system

2.2.1 The controls of the transmitters and receivers must be safeguarded by suitable means, e.g. notching, against inadvertent move.

2.2.2 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.

2.2.3 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.

2.2.4 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.

2.2.5 Power supply must be provided from the at least one source of electrical power.

2.3 Emergency engine telegraph system

2.3.1 The function of the emergency engine telegraph system shall conform to that of the main system in accordance with 2.2.1 and 2.2.2.

Power supply must be provided from the transitional source of electrical power.

2.3.2 Instead of the emergency engine telegraph system, a further means according to 5.1 could be provided.

3. Indicators on the Bridge

3.1 All instruments and indicators important to the navigate of the ship must be legible at all times.

3.2 All indicators and illuminations for instruments must be provided with dimmers.

3.3 All illumination and lighting of instruments shall be adjustable down to zero, except the lighting of warning and alarm indicators and the control of the dimmers which shall remain readable.

3.4 Each instrument shall be fitted with an individual light adjustment. In addition, groups of instruments normally working together may be equipped with common light adjustment.

4. Rudder Angle Indicators

4.1 The ship's main control station must be equipped with a rudder angle indicator whose transmitter is actuated by the rudderstock.

4.2 All the equipment forming part of the rudder angle indicator system must be independent of the steering gear control.

4.3 The rudder angle indicator must be legible from all control stations on the bridge. The display must be continuous.

4.4 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.

4.5 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.

4.6 The electrical supply to the indicators shall be the same as for the steering gear, see Section 7, A.2.2.

5. Voice Communication and Signalling Systems

5.1 Important voice communications (intercommunication systems and talkback systems)

5.1.1 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.

5.1.2 The following voice communications are required:

This may be a telephone system, an intercommunication system or a public address system, provided that the bridge can in any event cut into existing communications.

5.1.2.1 Bridge-Radio room,

This link is not required if communications can be made without recourse to equipment.

5.1.2.2 Bridge-machinery control centre (MCC)

5.1.2.3 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. Additional optical means may be used for this purpose.

This voice communication is not required if a main and emergency telegraph is available, see 2.1

5.1.2.4 Bridge-Steering gear compartment,

An intercommunication system is required between the bridge and the steering gear control position in the steering gear compartment.

5.1.2.5 Bridge -combat information centre (CIC)

5.1.2.6 Communications from CIC and MCC to other important locations, like damage control centre (DCC), etc. should be considered.

5.1.3 If the voice communication system requires an electrical power supply, this supply shall be from at least two independent source of electrical power.

5.2 Voice communications in an emergency

5.2.1 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.

5.2.2 This system may comprise portable or permanently installed devices and shall also be operable in the event of the failure of the electrical power generating plants.

5.3 Technical officer's alarm (Engineers' call)

From the engine room or from the machinery control centre it shall be possible to transmit an alarm into the accommodation area of the technical officers or the crew members responsible for the machinery.

For ships with automated machinery, the **TL** Rules for Automation, Chapter 106, Section 4, B. is to be observed additionally.

5.4 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.

5.4.1 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 by means of a mechanical timer.

The emission of audible and optical alarms shall continue as long as the flooding valves are open.

The automatic actuation of the CO_2 alarm in the protected space may be realized by e.g. opening the door of the release station.

An automatically trip of emergency shut-down facilities by the CO_2 alarm is not permitted.

5.4.2 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**.**

5.4.3 Audible and optical alarms (pre-discharge alarms as defined in 5.4.1) are also to be provided in ro-ro cargo spaces, spaces for the transport of special containers and spaces to which personnel normally have access and where the access is therefore facilitated by doors and manway hatches. In small spaces, e.g. small compressor rooms, paint stores, etc., alarms may be dispensed.

5.4.4 If the alarm is operated pneumatically, a permanent supply of compressed air for the alarm system is to be ensured.

5.4.5 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.

5.5 Lift alarm

5.5.1 Lifts for military vehicles, aircraft, supplies, etc. with internal controls shall be equipped with an

audible emergency calling device which can be actuated from the lift cabin. The alarm shall be transferred to a permanently manned location.

5.5.2 The emergency calling system and the telephone shall be supplied from the transitional source of electrical power and shall be independent of the power and control system.

5.6 Refrigerating compartment closure alarm

A closure alarm shall be provided to a permanently manned location. The system shall initiate an alarm immediately. Illuminated switches situated near the access doors of each refrigerated space shall be installed.

5.7 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
- NBC alarm

D. 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.

Note :

Regarding the required sound pressure level the IMO LSA Code (resolution MSC.48(66), as amended) may be observed.

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 respective source of electrical power fails, the general emergency alarm system must be powered by the transitional power supply of electrical power, see Section 3, D.

1.6 Cables for general emergency alarm installations and for loudspeaker systems shall be according to Section 12, D.15.

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 The system shall be so arranged to minimize the effect of a single failure, by the use of at least 2 amplifiers, segregated supply with fuse protection, segregated cable routes and segregated arrangement.

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.

2.2.9 The loudspeaker system shall be designed under observance of the minimum required sound level.
In case of an emergency the announcements in all areas shall be understandable and above the ambient noise.
Announcement via microphone shall be free of acoustic feedback and other distortions.

3. Fire Detection and Fire Alarm Systems

3.1 General requirements

3.1.1 For general requirements see Chapter 107 - Ship Operation Installations and Auxiliary Systems, Section 9 and for scope of use also Chapter 106 - Automation.

3.1.2 Fire detection and fire alarm systems are subject to mandatory type approval.

3.2 System design and indication

3.2.1 The central fire alarm panel shall be located on the bridge or in the main fire control station.

One indicating unit shall be placed on the bridge if the central fire alarm panel is not located there.

3.2.2 Identificating devices, central fire alarm panel or fire indicator board shall indicate the section in which a fire detector has been activated. At least one indicating unit shall be so located that it is at all times accessible to responsible crew members.

3.2.3 On the fire indicating units or on the central fire alarm panel, clear information shall be provided showing which rooms are monitored, and where the individual sections are located.

3.2.4 The fire detection system shall be self-monitored. Faults, such as a supply failure, short circuit or wire break in detection loops, the removal of a detector from its base and earth fault in detection loops with all-pole insulation shall be optically and audibly signalled at the central fire alarm panel. Fault alarms shall be acknowledgeable and distinguishable from a fire alarm.

3.2.5 Short-circuit or disconnection of the signal transfer between the fire detection system and the controller of fire safety systems, fire alarm systems or alarm devices shall be provided.

3.2.6 The emission of audible and optical alarms shall continue until they are acknowledged at the central fire alarm panel. If only a repeater installed on the bridge, the acknowledgement of the audible alarm on the fire indicating unit shall be independent from the central fire alarm panel. Acknowledgement shall not disconnect the detection loop, nor shall it suppress further alarm signals in other detection loops. The control panel shall clearly distinguish between normal, alarm, acknowledged alarm, fault and silenced conditions.

3.2.7 The fixed fire detection and fire alarm systems shall be arranged to automatically reset to the normal operating condition after alarm and fault conditions are cleared.

3.2.8 The central station shall be provided with means for testing and disconnecting of individual detectors or detector loops. When a particular detector/ detector loop is disconnected, this shall be clearly recognizable.

Means for such recognition shall be provided for each loop.

The failure or disconnection of one detector loop shall not affect the operation of another detector loop.

The simultaneous response of detectors shall not impair the operation of the system.

3.2.9 The fire alarm shall be audible and optical recognized on the fire control panel, on the indicating units and by a responsible engineer officer without any time delay. If a fire alarm is not acknowledged within two minutes, an audible alarm shall be automatically released in all crew accommodation areas, service rooms, control stations and category A 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.

3.2.10 Fire detection systems shall not be used for other purposes, except for the automatic closure of fire doors, shut-off fans, closure of fire dampers, sprinkler systems, smoke extraction systems, low-location lighting systems, fixed local application fire-extinguishing systems, CCTV systems, paging systems, fire alarm, public address systems or other fire safety systems. Automatic stopping of engine room fans and appropriate flaps is not permitted.

3.3 Fire detectors

3.3.1 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 factors may be approved, provided they are not less sensitive than the aforementioned detectors.

3.3.2 Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12,5 % obscuration per metre, but not until the smoke density exceeds 2 % obscuration per metre.

3.3.3 Heat detectors shall be actuated at a temperature of between 54 □C and 78 □C when the temperature rises to those limits at a rate of rise less than 1 □C per minute. In case of a faster temperature rise a higher threshold value may be permitted by agreement with **TL.**

3.3.4 In rooms with specially high ambient temperatures (e.g. drying rooms), the operation temperature of heat detectors may be up to 130 °C, and up to 140 °C in saunas.

3.3.5 If the fire detection system is not designed for remote and individual identification of detectors, it is not permitted that one zone may monitor more than one deck within the accommodation, service rooms and control stations, except of a zone which monitors closed staircases. To avoid delay to locate the fire, the number of closed rooms monitored in any one zone is limited to a maximum of 50.

If the fire detection system is designed for remote and individual identification of detectors, the zones may monitor several decks and any number of closed rooms.

3.3.6 A section of fire detectors and manually operated call points shall not be situated in more than one main vertical zone.

3.3.7 Smoke detectors shall be used in passageways, stairways and escape routes.

Detectors in stairways shall be located at least at the top level of the stair and at every second level beneath.

3.3.8 Heat detectors shall be used as the sole detector only in accommodation areas.

3.3.9 Flame detectors shall only be used in addition to the mandatory detectors.

3.3.10 All fire detectors must be so designed that they remain serviceable, without the replacement of components, on having passed regular testing.

3.3.11 If it is not recognizable at the central fire alarm panel which detector has responded, an optical indication shall be provided on each detector itself. This indication shall remain displayed until the loop has been reset on the central fire alarm panel.

3.3.12 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, except in corridors, lockers and stairways.

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

3.3.13 Manually operated call points shall be provided in the accommodation area, the service areas, control station.

A manually operated call point shall be fitted at every exit. Manually operated call points are not required to be installed for each exit at the navigation bridge, in case, where the fire alarm panel is located at the navigation bridge.

Manually operated call points shall be readily accessible on every deck in the passageways, i.e. no part of the passageway shall be more than 20 m far from a manually operated call point. Service spaces and control stations which have only one access, leading directly to the open deck, shall have a manually operated call point not more than 20 m (measured along the access route using the deck, stairs and/or corridors) from the exit.

3.3.14 A section of fire detectors which covers a control station, a service space or an accommodation space shall not simultaneously include a machinery space of category A or a ro-ro space. A section of fire detectors which covers a ro-ro space shall not include a machinery space of category A.

3.3.15 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.

3.3.16 Fire detectors for use in critical environments, 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.

3.5 Power supply

3.5.1 The fire alarm system shall be supplied from at least two sources of electrical power. Should one supply fail, automatic changeover to the other power supply shall take place in, or close to, the central fire alarm panel. The changeover shall be signalled optically and audibly.

3.5.2 Continuity of power supply

3.5.2.1 Operation of the automatic changeover switch or a failure of one of the power supplies shall not result in permanent or temporary degradation of the fire detection and fire alarm system.

3.5.2.2 Where the fire detection and fire alarm system would be degraded by the momentary loss of power, a transitional source of stored energy having adequate capacity shall be provided to ensure the continuous operation during changeover between power supplies.

3.5.2.3 The arrangement of electrical power supplies to an automatic changeover switch shall be such that a fault will not result in the loss of all supplies to the automatic changeover switch.

3.5.2.4 There shall be sufficient power to permit the continued operation of the system with all detectors activated, but not more than 100 if the total exceeds this figure.

3.5.3 Transitional supply

3.5.3.1 The fire detection and fire alarm system emergency power is to be supplied by an accumulator battery (or from the emergency switchboard). For an accumulator battery, the arrangements are to comply with the following requirements:

- the accumulator battery shall have the capacity to operate the fire detection system under normal and alarm conditions during the period required by Section 3, D.
- the rating of the charge unit, on restoration of the input power, shall be sufficient to recharge the batteries while maintaining the output supply to the fire detection system.
- the accumulator batteries shall be within the fire detection and fire alarm panel or situated in another location suitable to provide a supply in the event of an emergency

Note

Requirements for Storage Batteries, Chargers and Uninterruptible Power Supplies (UPS) see Section 14, E.

3.6 Fire detection systems with remotely and individually identified detectors

3.6.1 The fire detection system shall meet the requirements set out in 3.1 correspondingly.

3.6.2 Where addressable detectors are used, each such detector shall be indicated at the central fire alarm panel, and the audible alarm according to regulations shall be initiated.

3.6.3 Where the detectors in the alarm mode are not all simultaneously indicated at the central fire alarm panel, the central panel shall 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.

3.6.4 A detection loop shall comprise not more than one fire zone or one watertight division.

3.6.5 If the fire detection system comprises remotely and individually identified detectors the loops may monitor several decks and any number of closed rooms.

3.6.6 The detector loop shall be so arranged within a fire section/part of a fire zone that in the event of damage, e.g. wire break, a short circuit or a fire, only the affected deck becomes faulty.

The spatial arrangement of the loops shall be submitted for approval.

3.7 Fire detection and alarm systems on ships with water spray systems (Sprinkler)

Sprinkler systems with automatic release are normally not used for naval ships. If such a system is required by the Naval Authority, **TL** Rules for Ship Operation Installations and Auxiliary Systems, Section 9, J. shall be observed.

3.7.1 Ships which shall be equipped with an automatic water spray system (Sprinkler) shall be additionally provided with a fire detection and alarm system with automatic smoke detectors and manually operated call points with displays on the navigating bridge in accordance with 3.1.

3.7.2 Where the accommodation and public rooms are fitted with sprinkler systems, the alarm devices shall meet the following requirements:

Each section of sprinklers shall include means of releasing automatically a visual and audible alarm signal at one or more indicating units whenever sprinkler comes into operation. Such units shall indicate in which section a sprinkler has come to operation and shall be centralized on the navigation bridge and in addition, visible and audible alarms from the unit shall be located in a position other than on the navigation bridge, e.g. in the MCC, so as to ensure that the indication of the fire is immediately received by the crew.

With regard to self-monitoring and to the electrical power supply, the alarm system shall be designed corresponding to a fire detection system according to 3.1.

3.8 Fire detection and alarm systems for unattended machinery spaces

3.8.1 For unmanned machinery spaces of category A in accordance with the **TL** Rules for Automation, Chapter 106, an automatic fire detection system shall be provided which detects a fire already in its initial stage, e.g. systems with smoke detectors.

General requirements see 3.1 and 3.2.

3.8.2 The fire alarm shall be optical and audible recognized on the bridge, in the accommodation and mess areas of the engineer officers or the crew member responsible for the machinery plant and also in the machinery space and it shall be distinguishable from other alarms. The fire alarm shall be executed in the machinery space without any time delay.

4. Fixed Water-Based Local Application Firefighting Systems (FWBLAFFS)

4.1 The **TL** Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 9, J.2 shall be observed.
Flame detectors, remotely controlled valves, control electronics and fire detection systems used for FWBLAFFS are subject to mandatory type approval.

4.2 The fire detection system shall be self-monitored. Faults, such as a supply failure, short-circuit or wire break in detection loops, the removal of a detector from its base and earth fault in detection loops with all-pole insulation shall be optically and audibly signaled at the central fire alarm panel. Fault alarms shall be acknowledgeable and, wherever possible, distinguishable from a fire alarm.

The emission of audible and optical alarms shall continue until they are acknowledged at the central fire alarms panel. Acknowledgement of the audible fire alarm shall be made before acknowledgement of the optical fire alarm. The acknowledgements of audible and optical fire alarm signals shall be independent of each other. Acknowledgement shall not disconnect the detection loop, nor shall it suppress further alarm signals in other detection loops.

In case the evaluation unit is part of the ship's main fire alarm panel, detectors and control units shall be separated from the main fire alarm system by using separate loops only for the purpose of FWBLAFFS.

4.3 In case of periodically unattended machinery space the FWBLAFFS shall have both automatic and manual release capabilities.

The automatic release shall have a manual stop function in case of a spurious release. The manual release shall be independent from the fire alarm panel.

For continuously manned machinery space only a manual release capability is required.

4.4 The manual release shall be located at easily accessible positions, adjacent to the protected area. Additional to this local release it shall be possible to release the FWBLAFFS from a safe position outside the engine room.

The installation inside the space should not be liable to be cut off by a fire in the protected areas.

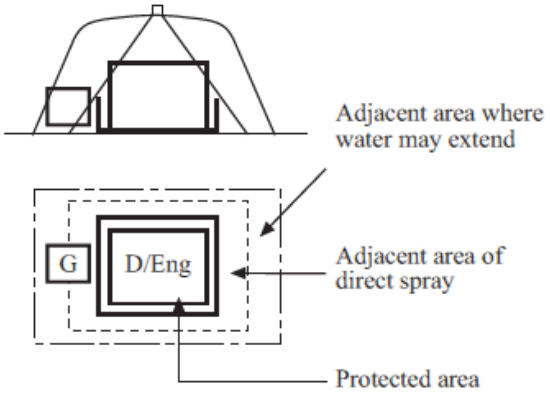


Figure 9.1 Space protected by a FWBLAFFS

Definitions:

Protected space: Is a machinery space where a FWBLAFFS is installed.

Protected areas: Areas within a protected space which is required to be protected by FWBLAFFS.

Adjacent areas: Areas, other than protected areas exposed to direct spray or areas, other than those defined above, where water may extend.

Where it is necessary to install equipment within FWBLAFFS protected areas, the following precautions are to be taken:

4.5 Detector initiating philosophy

4.5.1 Fire detectors shall be flame detectors. The viewing angle shall be adjusted to the monitored area only.

4.5.2 For each monitored area two detectors are needed to detect a fire before initiating the release. Activation of a single detector shall cause an alarm. The detectors shall operate with a maximum delay time of 10 seconds.

4.5.3 Other configuration of detectors concerning type and release philosophy shall be agreed with **TL.**

4.6 The outputs, which activate the valves, shall be designed so that potential faults such as loss of voltage or a broken wire for example shall not create a spurious release.

4.7 Activation of any local application system shall give a visual and distinct audible alarm in the machinery space and at a continuously manned station (e.g. MCC). This alarm shall indicate the specific system activated.

4.8 Ingress protection

4.8.1 Operation controls and other electrical and electronic equipment enclosures located in reach of the FWBLAFFS in the protected area and those within adjacent areas exposed to direct spray shall have as a minimum the degree of protection IP44, expect where evidence of suitability is submitted to and approved by **TL.**

4.8.2 IP-degree lower than IP44 for the mentioned electrical and electronic equipment within adjacent areas not exposed to direct spray may be approved with suitable evidence taking into account the design and equipment layout, e.g. position of inlet ventilation openings. The cooling airflow for the equipment is to be assured.

4.8.3 The electrical components of the pressure source for the system shall have a minimum IP-grade of IP54.

4.9 Components of the system such as pumps and valves requiring an external power source shall be supplied by the main power source.

4.10 The FWBLAFFS shall provide means for testing the automatic release without delivering water

into the protected areas. Each protected area shall be periodically tested.

4.11 Operating and maintenance instructions for the system and the cleaning interval for the optical parts of the detectors shall be displayed at each operating position and verified in practical operation.

5. 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:

5.1 For bulkhead doors Chapter 102 - Hull Structures and Ship Equipment, Section 9, A. shall be observed. For bow doors, side shell and stern doors, see Chapter 102 - Hull Structures and Ship Equipment, Section 22, B. and C.

5.2 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.

5.3 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.

5.4 Indicators shall be provided at the remote control position to signal a failure of the control system optically and acoustically.

5.5 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.

6. Bilge Level Monitoring

For the extent and design of the bilge level monitoring see the **TL** Rules for Propulsion Plants, Section 2, I.5.

7. Voyage Data Recorder (VDR)

7.1 If a voyage data recorder is specified in the building specification, the VDR should be supplied from the main and transitional power supply, see Section 4, H.11.1 1 and H.12.

7.2 Data or alarms for the Voyage Data Recorder have to be free of reactive effects to ship's operations.

8. Ballast Water Treatment Plants

8.1 The Naval Authority has to decide, if a ballast water treatment plant shall be provided, especially if Class Notation EP - Environmental Passport respectively BWM - Ballast Water Management is intended.

Ballast water treatment plants (BWTS) are to be approved by a flag administration acc. to BWMS Code (IMO Resolution MEPC.300(72)).

8.2 For BWTS these Rules are to be observed and the **TL** Rules for Automation, Chapter 106, if applicable.

8.3 BWTS shall in addition comply with **TL** Rules for Ship Operation Installations and Auxiliary Systems, Section 8 and 16.

8.4 For the electrical appliances the following documentation to be submitted for approval for each project:

- System description with technical data's,
- Wiring diagrams,
- Power balance, and
- Further documents necessary for the review of the construction.

8.5 On manufacturer's application**, TL** may issue an approval certificate confirming compliance with **TL** Rules as referred above.

SECTION 10

COMPUTER SYSTEMS

A. Introduction

1. Scope

These requirements apply to design, construction, commissioning and maintenance of computer based systems where they depend on software for the proper achievement of their functions.. These requirements apply to systems which provide control, alarm, monitoring, safety, or internal vessel communication functions that are subject to classification requirements.

2. Exclusion

Computer-based systems that are covered by statutory regulations are excluded from the requirements of this Section.

Guidance:

Examples of such systems are navigation systems and radio communication system required by SOLAS chapter V and IV, and vessel loading instrument/stability computer.

For loading instrument/stability computer, IACS recommendation no.48 may be considered.

3. References

3.1 Normative standards

For the purposes of this Section, the following standards are normative :

- IACS UR E10 Test specification for type approval
- IACS UR E 26 Cyber resilience of ships
- IACS UR E 27 Cyber resilience of on-board systems and equipment

3.2 Informative standards

For the purposes of this Section, the following standards are listed for information and may be used for the development of hardware/software of computer-based systems:

- IEC 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems
- ISO/IEC 12207: Systems and software engineering - Software life cycle processes
- ISO 9001: Quality Management Systems - Requirements
- ISO/IEC 90003: Software engineering - Guidelines for the application of ISO 9001:2015 to computer software
- IEC 60092-504: Electrical installations in ships - Part 504: Special features - Control and instrumentation
- ISO/IEC 25000: Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE
- ISO/IEC 25041: Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Evaluation guide for developers, acquirers and independent evaluators
- IEC 61511: Functional safety - Safety instrumented systems for the process industry sector
- ISO/IEC 15288:2015 Systems and software engineering - system life cycle process
- ISO 90007: Quality management – Guidelines for configuration management
- ISO 24060: Ships and marine technology - Ship software logging system for operational technology

Other industry standards may also be considered.

4. Structure

The general certification requirements for computer-based systems and the relation to type approval is described in B. The requirements and extent of verification of a computer-based system depends on its

categorization into one of three categories. The categories are described in C.

The requirements of this section cover the lifecycle of computer-based system from design through operations. The requirements are split into groups representing the different phases of the life cycle and the roles responsible for fulfilling the requirements.

The activities related to the development and delivery of a computer-based system is described in D, while the activities related to the maintenance in the operational phase are described in E

Management of changes to software and systems is given special attention in this section and the main aspects of a management of change process are described in F.

Most requirements in this section related to the way of working, and thus focus on activities to be performed, but it also contains some technical requirements. The technical requirements on computer-based systems have been gathered in G.

Each activity contains a requirement part which describes the minimum requirements on the role in question, and a part which describes the TL's verification of the activity in question.

5. Definition of abbreviations and terminology

5.1 Abbreviations

Table 10.1 Abbreviations

Abbreviation:	Expansion:
Cat I	Category one systems as defined in paragraph C.1
Cat II	Category two systems as defined in paragraph C.1
Cat III	Category three systems as defined in paragraph C.1
COTS	Commercial off-the-shelf
FAT	Factory acceptance test
FMEA	Failure mode and effect analysis
IT	Information technology
OT	Operational technology
PMS	Planned maintenance system
SAT	System acceptance test
SOST	System of systems test
SSLS	Ship software logging system
UR	Unified requirement

5.2 Terminology

Table 10.2 Terminology

Term:	Definition:
Black-box description	A description of a system's functionality and behaviour and performance as observed from outside the system in question
Black-box test methods	Verification of the functionality, performance, and robustness of a system, sub-system or component by only manipulating the inputs and observing the outputs. This does not require any knowledge of the system's inner workings and focuses only on the observable behaviour of the system/component under test in order to achieve the desired level of verification.
Computer-based system (CBS)	A programmable electronic device, or interoperable set of programmable electronic devices, organized to achieve one or more specified purposes such as collection, processing, maintenance, use, sharing, dissemination, or disposition of information. CBSs onboard include IT and OT systems. A CBS may be a combination of subsystems connected via network. Onboard CBSs may be connected directly or via public means of communications (e.g. Internet) to ashore CBSs, other vessels' CBSs and/or other facilities
Failure mode description	A document describing the effects due to failures in the system, not failures in the equipment supported by the system. The following aspects shall be covered: - list of failures which are subject to assessment, with - description of the system response to each of the above failures - comments to the consequence of each of these failures
Owner	The organization or person which orders the vessel in the construction phase or the organization which owns or manages the vessel in service. In the context of this UR this is a defined role with specific responsibilities.
Parameterization	To configure and tune system and software functionality by changing parameters. It does not usually require-computer programming and is normally done by the system supplier or a service provider, not the operator or end-user.
Programmable device	Physical component where software is installed
Robustness	The ability to respond to abnormal inputs and conditions
Service supplier	A person or company, not employed by an IACS Member, who at the request of an equipment manufacturer, shipyard, vessel's owner or other client acts in connection with inspection work and provides services for a ship or a mobile offshore unit such as measurements, tests or maintenance of safety systems and equipment, the results of which are used by surveyors in making decisions affecting classification or statutory certification and services
Simulation test	Monitoring, control, or safety system testing where the equipment under control is partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.
Society Certificate	Compliance document issued by a Class Society stating: - conformity with applicable rules and requirements. - that the tests and inspections have been carried out on: - the finished certified component itself; or - on samples taken from earlier stages in the production of the component, when applicable. - that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. Alternative Certification Scheme (ACS)
Software component	A standalone piece of code that provides specific and closely coupled functionality.
Software master files	The computer-files that constitutes the original source of the software. For custom made software this may be readable source- code files, and for COTS software it may be different forms of binary files
Software-structure	Overview of how the different software components interact and is commonly referred to as the Software Architecture, or Software Hierarchy
Sub-system	Identifiable part of a system, which may perform a specific function or set of functions.
Supplier	A generic term used for any organisation or person that is a contracted or a subcontracted provider of services, system components, or software.
System	A combination of components, equipment and logic which has a defined purpose, functionality, and performance. In the context of this section, a specific system is delivered by one system supplier.

Term:	Definition:
System of systems	A system which is made up of several systems, In the context of this section, the system of systems encompasses all monitoring, control and safety systems delivered from the Shipyard as a part of a vessel
System supplier	An organisation or person that is contracted or a subcontracted provider of system components or software under the coordination of the Systems integrator. In the context of this section this is a defined role with specific responsibilities.
Systemss integrator	Single organization or a person coordinating interaction between suppliers of systems and sub-systems on all stages of life cycle of computer-based systems in order to integrate them into a verified vessel-wide system of systems and to provide proper operation and maintenance of the computer-based systems. In the context of this section this is a defined role with specific responsibilities. During the design and delivery phase the Shipyard is the default Systems integrator, during operations phase the Owner is the default.
Type approval Certificate	Compliance document issued by a Class Society by which the Society declares that a product design meets a minimum set of technical requirements
Vessel	Ship or offshore unit where the computer-based system is to be installed.

B. Approval of System and Components

1. System certification

Computer-based systems that are necessary to accomplish vessel-functions of category II or category III (as defined in paragraph C.1 below) shall be delivered with a vessel-specific Society certificate. The objective of the vessel-specific system certification is to confirm that design and manufacturing of the system has been completed and that the system complies with applicable rules of TL

Vessel-specific system certification consist of two main verification activities:

1) Assessment of vessel-specific documentation (see paragraph D.2 and paragraph F)

2) Survey and testing of the system to be delivered to the vessel (see paragraph D.2.7)

TL may accept Alternative Certification Scheme (ACS) provided that the requirements are met, and that the system is provided with a vessel-specific certificate..

2. Type approval of computer-based systems

Computer-based systems that are routinely manufactured and include standardized software functions may be type approved in accordance with specified rules of TL. Hardware shall be documented according to the requirement in paragraph D.2.4.

The type approval consist of two main verification activities:

1) Assessment of type-specific documentation

2) Survey and testing of the standardized functions

Type approval will normally not yield exemption from vessel-specific system certification since vessel-specific functions, parameter configurations and installation elements demand vessel-specific verification.

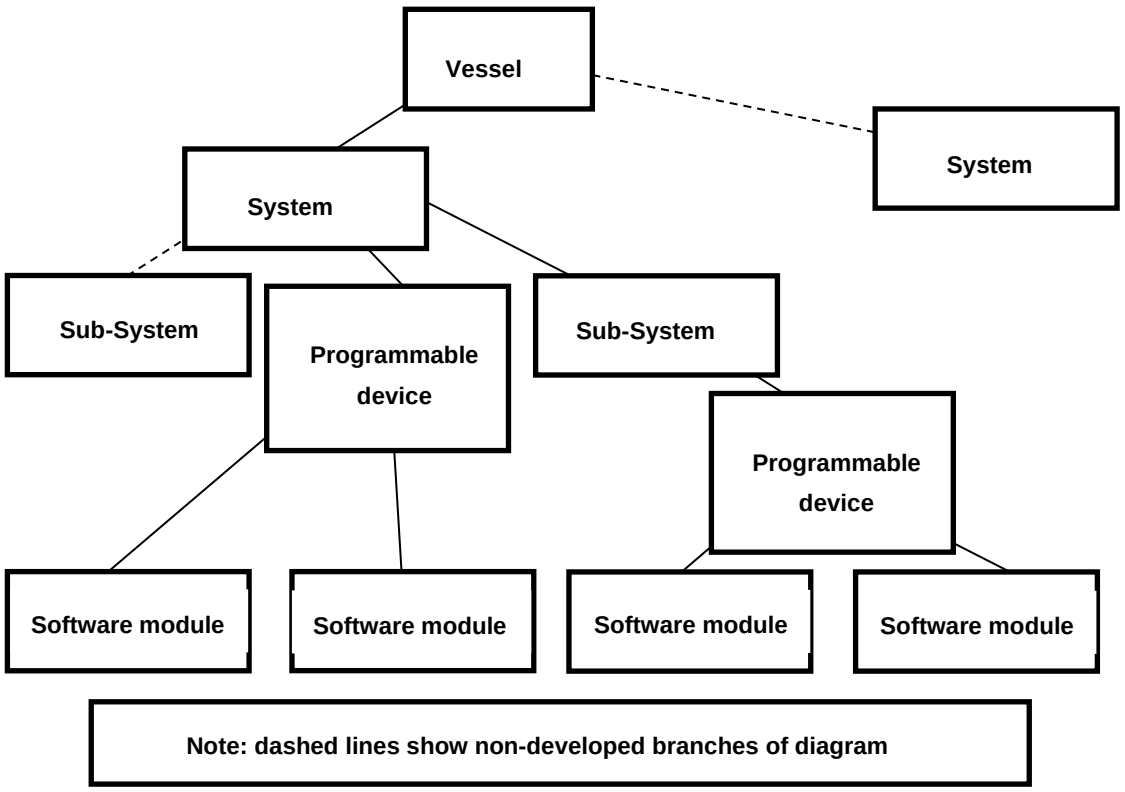


Figure 10.1 - Illustrative System Hierarchy

Table 10.3 System categories

Category	Failure Effects	Typical system functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment.	Monitoring, informational and administrative functions
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	Vessel alarm, monitoring and control functions which are necessary to maintain the vessel in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous or catastrophic for human safety, safety of the vessel and/or threat to the environment.	- Control functions for maintaining the vessel's propulsion and steering - Vessel safety functions

C. System Categories

1. System category definitions

The categorization of a system in the context of this section is based on the potential severity of the consequences if the system serving the function fails. Table 10.3 provides the definitions of the categories

2. TL's scope

Category I systems are normally not subject to verification by TL, as failure of these systems shall not lead to dangerous situations. However, information pertinent to category I systems shall be required upon request to determine the correct category or ensure that they do not influence the operation of systems in category II and category III.

3. System category examples

The category of a system shall always be evaluated in the context of the specific vessel in question; thus, the categorization of a system may vary from one vessel to the next. This means that the examples of categories below are given as guidance only. For determining the categorization of systems for a specific vessel, see paragraph D.3.3.

Examples of category I systems:
Fuel monitoring system, maintenance support system, diagnostics and troubleshooting system, closed circuit television, cabin security, entertainment system, fish detection system.

Examples of category II systems: Fuel oil treatment system, alarm monitoring and safety systems for propulsion and auxiliary machinery, Inert gas system, control, monitoring and safety system for cargo containment system.

Examples of category III systems: Propulsion control system, steering gear control system, electric power system (including power management system), dynamic positioning system (IMO classes 2 and 3).
The list of example systems is not exhaustive.

D. Requirements on development and certification of computer-based system

1. General requirements

1. 1 Life Cycle Approach with appropriate standards

Requirement:
A global top-down approach shall be undertaken in the design and development of both hardware and software and the integration in sub-systems, systems, and system of systems, spanning the complete system lifecycle. This approach shall be based on the standards as listed herein or other standards recognized by TL.

Class Society's verification:

This is verified by TL as a part of the quality management system verification described in paragraph D.1.2.

1. 2 Quality management system

Systems integrators and system suppliers in the development of computer-based systems for category II and category III, comply to a recognised quality standard such as ISO 9001; also incorporating principles of IEC/ISO 90003.

The quality management system shall as a minimum include the following topics, applicable for both category II and category III systems

Class Society's verification:
The quality management system may be verified by two alternative means:

1) TL confirming that the quality management system is certified as compliant to a recognized standard by an organisation with accreditation under a national accreditation scheme.

2) TL confirming compliance to a standard through a specific assessment of the quality management system. The documentation requirements will be defined per case.

Table 10.4 Quality management system

Area		Role	
No	**Topic**	**System supplier**	**Systems integrator**
1	Responsibilities and competency of the staff.	**x**	**x**
2	The complete lifecycle of delivered software and of associated hardware	**x**	**x**
3	Specific procedure for unique identification of a computer-based system, it's components and versions.	**x**	
4	Creation and update of the vessel's system architecture		**x**
5	Organization set in place for acquisition of software and related hardware from suppliers	**x**	**x**
6	Organization set in place for software code writing and verification	**x**	
7	Organization set in place for system validation before integration in the vessel	**x**	
8	Specific procedure for conducting and approving of systems at FAT and SAT	**x**	**x**
9	Creation and update of system documentation	**x**	
10	Specific procedure for software modification and installation on board the vessel, including interactions with shipyard and owner	**x**	**x**
11	Specific procedures for verification of software code	**x**	
12	Procedures for integrating systems with other systems and testing of the system of systems for the vessel	**x**	**x**
13	Procedures for managing changes to software and configurations before FAT	**x**	
14	Procedures for managing and documenting changes to software and configurations after FAT	**x**	**x**
15	Checkpoints for the organization's own follow-up of adherence to the quality management system	**x**	**x**

2. Requirements on the system supplier

2.1 Define and follow a quality plan

Requirement:

The system supplier shall document that the quality management system is applied for the design, construction, delivery, and maintenance of the specific system to be delivered.

All applicable items described in paragraph 1.2 (for the system supplier role) shall be demonstrated to exist and being followed, as relevant.

Class Society's verification:

Category I: No documentation required

Category II and III: The quality plan shall be available during survey (FAT) or submitted for information upon request (FI).

2.2 Unique identification of systems and software

Requirement:

A method for unique identification of a system, its different software components and different revisions of the same software component shall be applied. The method shall be applied throughout the lifecycle of the system and the software.

See also paragraph G.1 for related technical requirements on the system in question.

The documentation of the method is typically a part of the quality management system, see paragraph 1.2.

Class Society's verification:

Category I: Not required

Category II and III: Application of the identification system is verified as a part of the FAT (paragraph 2.7) and SAT (paragraph 3.6)

2.3 System description

Requirement:

The system's specification and design shall be determined and documented in a system description. In addition to serve as a specification for the detailed design and implementation, the purpose of the system description is to document that the entire system-delivery is according to the specifications and in compliance with applicable rules and regulations.
The system description shall contain information of the following:

- Purpose and main functions, including any safety aspects
- System category as defined
- Key performance characteristics
- Compliance with the technical requirements and TL rules
- User interfaces/mimics
- Communication and Interface aspects
    - Identification and description of interfaces to other vessel systems
- Hardware-arrangement related aspects:
    - Network-architecture/topology, including all network components like switches, routers, gateways, firewalls etc.
    - Internal structure with regards to all interfaces and hardware nodes in the system (e.g. operator stations, displays, computers, programmable devices, sensors, actuators, I/O modules etc)
    - I/O allocation (mapping of field devices to channel, communication link, hardware unit, logic function)
    - Power supply arrangement
    - Failure mode description

Guidance:
The information listed above is in this section collectively referred to as the system description. It may however be divided into a number of different documents and models.

Class Society's verification:
Category I: The system description documentation shall upon request be submitted for information (FI). Category II and III: The system description documentation shall be submitted for approval (AP)

2.4 Environmental compliance of hardware components

Requirement:
Evidence of environmental type testing according to IACS UR E10 regarding hardware elements included in the system and sub-systems shall be submitted to TL

Class Society's verification:
Category I: This requirement is not mandatory for category I systems. Reference to Type approval certificate or other evidence of type testing shall upon request be submitted for information (FI) see paragraph C.2.

Category II and III: Reference to Type approval certificate or other evidence of type testing shall be submitted for information (FI).

2.5 Software code creation, parameterization, and testing

Requirement:
The software created, changed, or configured for the delivery project shall be developed and have the quality assurance activities assessed according to the selected standard(s) as described in the quality plan.

The quality assurance activities may be performed on several levels of the software-structure and shall include both custom-made software and configured components (e.g. software libraries) as appropriate.

The verification of the software shall as a minimum verify the following aspects based on black-box methods:

- Correctness, completeness and consistency of any parameterization and configuration of software components

- Intended functionality

- Intended robustness

For components in systems of Category II and III, the scope, purpose, and results of all performed reviews, analyses, tests, and other verification activities shall be documented in test reports.

Guidance:
Some of the methods utilized in this activity are sometimes referred to as “software unit test” or “developer test” and may also include verification methods like code-reviews and static- or dynamic code analysis.

Class Society’s verification:
Category I: No documentation required
Category II and III: Software test reports shall upon request be submitted for information (FI).

2.6 Internal system testing before FAT

Requirement:
The system shall as far as practicable be tested before the FAT. The main purpose of the system test is for the system supplier to verify that the entire system delivery is according to the specifications, approved documentation and in compliance with applicable rules and regulations; and further, that the system is completed and ready for the FAT.

- The testing shall at least verify the following aspects of the system:

- Functionality

- Effect of faults and failures (including diagnostic functions, detection, alerts response)

- Performance

- Integration between software and hardware components

- Human-machine interfaces

- Interfaces to other systems

Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response.
Some of the testing may be performed by utilizing simulators and replica hardware.
The test-environment shall be documented, including a description of any simulators, emulators, test-stubs, test-management tools, or other tools affecting the test environment and its limitations

Test cases and test results shall be documented in test programs and test reports respectively.

Class Society’s verification:
Category I: No documentation required
Category II and III: Internal system test report shall be made available during FAT or submitted upon request (FI).

2.7 Factory acceptance testing (FAT) before installation on board

Requirement:
A factory acceptance test (FAT) shall be arranged for the system in question. The main purpose of the FAT is to demonstrate to TL that the system is completed and compliant with applicable classification rules, thus enabling issuance of TL Certificate for the system.

The FAT test program shall cover a representative selection of the test items from the internal system test (described in paragraph 2.6), including normal system functionality and response to failures.
For category II and III systems, network testing to verify the network resilience requirements in paragraph G.2.1 shall be performed. If agreed by all parties, the network testing may be performed as a part of the system test onboard the vessel.

The FAT shall as a rule be performed with the project specific software operating on the actual hardware components to be installed on board, with necessary means for simulation of functions and failure responses, however other solutions such as replica hardware or simulated hardware (emulators) may be agreed with TL

For each test-case it shall be noted if the test passed or failed, and the test-results shall be documented in a test

report. The test report shall also contain a list of the software (including software versions) that were installed in the system when the test was executed.

Guidance:
For complex systems there may be a large difference in scope between the "Internal system testing before FAT" activity and the FAT, while for some systems the scope may be identical.

Class Society's verification:
Category I: FAT not required.
Category II and III: The FAT program shall be approved (AP) before the test is executed. The FAT execution shall be witnessed by TL. The FAT report shall be submitted for information (FI).

Additional FAT documentation including e.g., user manuals and internal system test report shall be made available during FAT or submitted upon request for information (FI).

2.8 Secure and controlled software installation on the vessel

Requirement:
The initial installation and subsequent updates of the software components of the system shall be done according to a management of change procedure which has been agreed between the system supplier and the systems integrator.

The management of change procedure shall comply with the requirements in paragraph 6.
Cyber security measures shall be observed as described in relevant IACS URs.

Class Society's verification:
Category I: Not required
Category II and III: The management of change procedure shall upon request be submitted for information (FI).

3. Requirements on the systems integrator

3.1 Responsibilities

For the purposes of this section the Shipyard is considered as the systems integrator in the development and delivery phase unless another organization or person is explicitly appointed by the Shipyard.

3.2 Define and follow a quality plan

Requirement:
The systems integrator shall document that the quality management system is applied for the installation, integration, completion, and maintenance of the systems to be installed on board. All applicable items described in paragraph 1.2 (for the systems integrator role) shall be demonstrated to exist and being followed, as relevant.

Class Society's verification:
Category I: No documentation required
Category II and III: The quality plan shall be made available during survey (at SAT/SOST) or upon request submitted for information (FI).

3.3 Determining the category of the system in question

Requirement:
For each system delivery to a particular vessel, it shall be decided which category the system falls under based on the failure effects of the system (as defined in paragraph C). The category for a specific system must be conveyed to the relevant system supplier. TL may decide that a risk-assessment is needed to verify the proper system category.

Class Society's verification:

Category I, II and III: The category for the different systems shall upon request be documented and submitted for approval (AP).

3.4 Risk assessment of the system

Requirement:
If requested by TL, a risk assessment of a specific system in context of the specific vessel in question shall be performed and documented in order to determine the applicable category for the system.

Guidance:
IEC/ISO31010 “Risk management - Risk assessment techniques” may be used as guidance in order to determine method of risk assessment.

Class Society’s verification: Category I, II and III: The risk assessment report shall upon request be submitted for approval (AP).

3.5 Define the vessel’s system-architecture

Requirement:
The system of systems (SoS) shall be specified and documented. This architecture specification provides the basis for category determination and development of the different integrated systems by allocating functionality to individual systems and by identifying the main interfaces between the systems. It shall also serve as a basis for the testing of the integrated systems on the vessel level (see paragraph 4.3.7).

The vessel’s system architecture shall at least contain description of:

- Overview of the total systems architecture (the system of systems)
- Each system’s purpose and main functionality
- Communication and interface aspects between different systems

Guidance:
See also TL-R E26 for diagram of security zones and conduits

Class Society’s verification:
Category I, II, and III: The vessel’s system architecture shall upon request be submitted for information (FI).

3.6 System acceptance test (SAT) onboard the vessel

Requirement:
A system acceptance test shall be arranged onboard the vessel. The main purpose of the system acceptance test (SAT) is to verify the system functionality, after installation and integration with the applicable machinery/electrical/process systems on board including possible interfaces with other control and monitoring systems.

For each test-case it shall be noted if the test passed or failed, and the test-results shall be documented in a test report. The test report shall also contain a list of the software (including software versions) that were installed in the system when the test was executed.

Class Society’s verification:
Category I: Not required.
Category II and III: The SAT program shall be submitted for approval (AP) before the test is executed.

The SAT execution shall be witnessed by TL.

The SAT report shall be submitted for information (FI).

3.7 Testing of integrated systems on vessel-level (SOST)

Requirement:
Integration tests shall be conducted after installation and integration of the different systems in its final environment on board. The purpose of the tests is to verify the functionality of the complete installation (system of systems) including all interfaces and inter-dependencies in compliance with requirements and specifications.

The testing shall at least verify the following aspects of the system of systems:

- The overall functionality of the interacting systems as a whole
- Failure response between systems
- Performance
- Human-machine interfaces
- Interfaces between the different systems

Guidance:
For complex systems there may be a large difference in scope between the “System acceptance test (SAT) onboard the vessel” activity and the SOST, while for some systems the scope may be overlapping or identical. It is possible to combine the two activities into one when the test scope is similar.

Class Society's verification:
Category I: Not required. Category II and III: The SOST program shall submitted for approval (AP) before the test is executed.
The SOST execution shall be witnessed by TL.
The SOST report shall be submitted for information (FI).

3.8 Change management

The systems integrator shall follow procedures for management of change to the system as described in paragraph F .

Class Society's verification:
Category I: No documentation requirements
Category II and III: The management of change procedure shall upon request be submitted for information (FI).

E. Requirements on maintenance of computer-based systems

1. Requirements on the Vessel Owner

1.1 Responsibilities

For the purposes of this section, the vessel owner is considered to be the systems integrator in the operations phase unless another organization or person is explicitly appointed by the owner.

Accordingly, TL shall in a timely manner be informed by the owner about the appointed systems integrator which is responsible for implementing any changes to the systems in conjunction with system supplier(s).

2. Requirements on the Systems integrator

2.1 Change management

Requirement:
The systems integrator shall ensure that necessary procedures for software and hardware change management exist on board, and that any software modification/upgrade are performed according to the procedure(s). For details about change management please see paragraph F .

Changes to computer-based systems in the operational phase shall be recorded.
The records shall contain information about the relevant software versions and other relevant information as described in paragraph F.11 .

Class Society's verification:
Category I: No documentation requirements
Category II and III: See paragraph F.12 .

3. Requirements on the System Supplier

3.1 Change management

Requirement:
The system supplier shall follow procedures for maintenance of the system including procedures for management of change as described in paragraph F.

Class Society's verification:
Category I: No documentation requirements
Category II and III: See paragraph F.12.

3.2 Testing of changes before installation onboard

Requirement:
The system supplier shall make sure that the planned changes to a system have passed relevant in-house tests before the change is made to systems on board.

Class Society's verification:
Category I: No documentation requirements
Category II and III: See paragraph F.12 .

F. Management of Change

1. General

Paragraph F provides requirements for the management of change throughout the lifecycle of a computer-based system. Different procedures for the management of change may be defined for specific phases in a system's lifecycle as the different phases typically involve different stakeholders. TL's verification is described in paragraph F.12.

2. Documented change management procedures

Requirement:
The organization in question shall have defined and documented change management procedures applicable for the computer-based system in question covering both hardware and software. After FAT, the system supplier shall manage all changes to the system in accordance with the procedure. Examples could be qualification of new versions of acquired software, new hardware, modified control logic, changes to configurable parameters.

The procedure(s) shall at least describe the activities listed in paragraphs 3 through 11. The outcome of the impact analysis in 8 will determine to what extent the activities in 3 to 12 shall be performed. Change records (described in paragraph 11) shall always be produced.

3. Agreement between relevant stakeholders

Requirement:
The management of change process shall be coordinated and agreed between the relevant stakeholders along the different stages of the lifecycle of the computer-based system.

Guidance:
Typically, the management of change address at least three different stages:

- Development and internal verification before FAT; involving the system supplier and sub-suppliers.
- From FAT to handover of the vessel to the owner; involving the system supplier, the systems integrator, TL, and the owner.
- In operation; involving the system supplier, service suppliers, the owner, and TL

4. Approved software shall be under change management

Requirement:
If changes are required to a system after it has been approved by applicable stakeholders (typically the systems integrator and TL at FAT) the modifications shall follow defined change management procedures.

5. Unique identification of system and software versions

Requirement:
The system supplier shall make sure that each system and software version is uniquely identifiable, see paragraph D.2.2.

6. Handling of software master files

Requirement:
There shall be defined mechanisms for handling of the files that constitutes the master-files for a software component. Personnel authorities shall be clearly defined along with the tools and mechanisms used to ensure the integrity of the master files.

7 Backup and restoration of onboard software

Requirement:

It shall be clearly defined how to perform backup and restoration of the software components of a computer-based system onboard the vessel.

8. Impact analysis before change is made

Requirement:
Before a change to the system is made, an impact analysis shall be performed in order to:

- Determine the criticality of the change.
- Determine the impact on existing documentation.
- Determine the needed verification and test activities.
- Determine the need to inform other stakeholders about the change.
- Determine the need to obtain approval from other stakeholders (e.g. TL and or Owner) before the change is made.

9. Roll-back in case of failed software changes

Requirement:
When maintenance includes installation of new versions of the software in the system, it shall be possible to perform a rollback of the software to the previous installed version with the purpose of returning the system to a known, stable state.
Roll-backs shall be documented and analysed to find and eliminate the root cause.

10. Verification and validation of system changes

Requirement:
To the largest degree practically possible, modifications shall be verified before being installed onboard.

After installation, the modification(s) shall be verified onboard according to a documented verification program containing:

• Verification that the new functionalities and/or improvements have had the intended effect.
• Regression test to verify that the modification has not had any negative effects on functionality or capabilities that was not expected to be affected.

11. Change records

Changes to systems and software shall be documented in change records to allow for visibility and traceability of the changes. The change records shall contain at least the following items:

- The purpose for a change
- A description of the changes and modifications
- The main conclusions from the impact analysis (see paragraph 8)
- The identity and version of any new system or software version(s) (see paragraph .5)
- Test reports or tests summaries (see paragraph10)

Documentation of the changes to software may be recorded in the planned maintenance system (PMS), in a software registry or equivalent.

12. Verification of change management by TL

12.1 In operation (vessel in service) phase

The verification by TL regarding the management of change in operation is generally performed during the annual survey of the vessel. Procedures for management of change and relevant change records (see paragraph 11) shall be made available at the time of survey.

In the cases where the change requires approval from TL up front, the relevant procedures and documentation for the change in question may be verified at that time.

12.2 During newbuilding

The verification of management of change in the newbuilding phase is divided into two; Procedures are verified as a part of the verification of the quality management system (paragraph D.1.2), while project

specific implementation of the procedures are verified during FAT (D.2.7) and after FAT (F.12.1)

G. Technical requirements on computer-based systems

The paragraphs below contain technical requirements on computer-based systems. The compliance to these requirements shall be documented in the design documentation (see paragraph D.2.3) and verified through the verification activities described in this section.

1 Reporting of system and software identification and version

1.1 System identification

The system shall provide means to identify its name, version, identifier, and manufacturer. It is recommended that the system can automatically report the status of its software to a ship software logging system (SSLS) as specified in the international standard ISO 24060.

2. Data links

2.1 General requirements for category II and III systems

Loss of a data link shall be specifically addressed in risk assessment analysis/FMEA. See paragraph D.2.3.

1) A single failure in data link shall not cause loss of vessel- functions of category III. Any effect of such failures shall meet the principle of fail-to-safe for the vessel-function(s) being served.

2) For vessel-functions of category II and III, any loss of functionality in the remote control system shall be compensated for by local/manual means.

3) The data link shall have means to prevent or cope with excessive communication rates.

4) Data link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link.

5) Detected failures shall initiate an alarm.

2. 2 Specific Requirements for Wireless Data Links

1) Category III systems shall not use wireless data links unless specifically considered by **TL** on the basis of an engineering analysis carried out in accordance with an International or National Standard acceptable to **TL.**

Other categories of systems may use wireless data links with following requirements:

2) Recognised international wireless communication system protocols shall be employed, incorporating:

-a Message integrity. Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message.

- b Configuration and device authentication. Shall only permit connection of devices that are included in the system design.

- c Message encryption. Protection of the confidentiality and or criticality of the data content.

- d Security management. Protection of network assets, prevention of unauthorized access to network assets.

3) The internal wireless system within the vessel shall comply with the radio frequency and power level requirements of International Telecommunication Union and flag state requirements.

4) Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

5) For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self-fail as a result of electromagnetic interference during expected operating conditions.

3. Verification of technical requirements by TL

The implementation of the technical requirements provided in paragraph G is verified by TLas part of the system description (paragraph D.2.3), FAT (paragraph D.2.7) and SAT (paragraph D.3.6) described above.

Annex A: Summary of documentation submittal

Table 10.5 and Table10. 6 below summarise the documentation to be submitted to TL.

Table 10.5 Summary of documentation submittal by the system supplier

Item		Responsible role	System category		
Paragraph reference	**Document**		**Cat I**	**Cat II**	**Cat III**
D.2.1	Quality plan	System supplier	-	FI on req.	FI on req.
D.2.3	System description	System supplier	FI on req.	AP	AP
D.2.4	Environmental compliance	System supplier	FI on req.	FI	FI
D.2.5	Software test reports	System supplier	-	FI on req.	FI on req.
D.2.6	System test report	System supplier	-	FI on req.	FI on req.
D.2.7	FAT program	System supplier	-	AP	AP
D.2.7	FAT report	System supplier	-	FI	FI
D.2.7	Additional FAT docs. (e.g. user manual, etc)	System supplier	-	FI on req.	FI on req.
D.2.8	Management of change procedure	System supplier	-	FI on req.	FI on req.

Legend: AP = Approval, FI = For Information, "-" = No requirement, on req. = Upon request from TL

Table 10.6 Summary of documentation submittal by the systems integrator

Item		Responsible role	System category		
Paragraph reference	**Document**		**Cat I**	**Cat II**	**Cat III**
D.3.2	Quality plan	System integrator	-	FI on req.	FI on req.
D.3.3	List of system categorizations	System integrator	AP on.req.	AP on.req.	AP on.req.
D.3.4	Risk assessment report	System integrator	AP on.req.	AP on.req.	AP on.req.
D.3.5	Vessel's system architecture	System integrator	FI on req.	FI on req.	FI on req.
D.3.6	SAT program	System integrator	-	AP	AP
D.3.6	SAT program	System integrator	-	FI	FI
D.3.7	SOST program	System integrator	-	AP	AP
D.3.7	SOST program	System integrator	-	FI	FI
D.3.8	Change management procedure for software	System integrator	-	FI on req.	FI on req.

Legend: AP = Approval, FI = For Information, "-" = No requirement, on req. = Upon request from TL

Annex B: Summary of test witnessing and survey

Table 10.7 below summarises the activities that shall be witnessed or surveyed by the Class Society. The responsible role shall facilitate the activity.

Table 10.7 Summary of test witnessing and survey

Item		Responsible role	System category		
Paragraph reference	**Activity**		**Cat I**	**Cat II**	**Cat III**
D.2.7	FAT witnessing	System supplier	-	x	x
D.3.6	SAT witnessing	System integrator	-	x	x
D.3.7	SOST witnessing	System integrator	-	x	x
F.12	Verification of changes	System integrator	-	x	x

Legend: “x” = Witnessing required “-“ = Witnessing not required

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 Authority, 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.

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

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	250
- Workshops - Hangars - Service rooms (excluding galleys) - Messrooms, lecture rooms - Accommodation, cabins - Chart rooms - Main passageways - Stairs in main passageways	200
- Steering positions (maintenance lighting) - Working spaces - Machinery spaces - Well decks	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

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.3.11.

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 11.2 shall be applied for lighting fixtures in accordance with IEC publication 60598-1 "Lumi-naires, Part 1: General Requirements and Tests".

Table 11.2 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

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, G.

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

Page

A. Choice of Cables and Wires

1. General Instructions

Cables and conductors must conform to the requirements stated in Section 14, G.

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.6.

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.

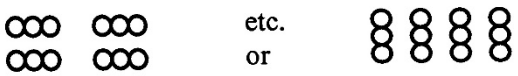
The calculated current must be equal to, or smaller than, the permissible current for the chosen conductor cross section.

1.2 The permissible current-carrying capacities of cables listed in Tables 12.5 - 12.9 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 - 12.9 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.

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.

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.

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	12.6	1,29	1,15	1,0	0,82	-	-	-	-	-	-	-
75	12.6	1,15	1,08	1,0	0,91	0,82	0,71	0,58	-	-	-	-
80	12.7	1,13	1,07	1,0	0,93	0,85	0,76	0,65	0,53	-	-	-
85	12.7, 12.8	1,12	1,06	1,0	0,94	0,87	0,79	0,71	0,61	0,50	-	-
90	12.9	1,10	1,05	1,0	0,94	0,88	0,82	0,74	0,67	0,58	0,47	-
95	12.9	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 of power, control and communication cables

Range of application	Remarks
Within the ship in all areas and on open deck	Cables with shielding and outer sheath
Within the ship in all areas, except where EMC requirements exist and not in hazardous areas	Cables without shielding
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
At diesel engines, turbines, boilers and other devices with higher temperatures	Heat-resistant cables (wires)
Other application areas	See type test certificate

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, H,8.

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) (90 °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 - 12.9. 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,2.4.

4.5 In special cases neutral conductors in three-phase distribution systems shall be in cross-section equal to at least half the cross-section of the outer conductors. If the outer conductor cross-section is 16 mm^2 (AWG 5) or less, the cross-section of the neutral conductor shall be the same as that of the outer conductors.

4.6 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. The values shown on the name plate of a consumer are valid.

1.2 The following loads are to be assumed for 250 V AC lighting circuits and socket-outlet circuits:

- For each lighting point, at least 100 W,

- For each socket-outlet, at least 200 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 The diversity factors shown in Table 12.5 may be applied to the rating of cables used to supply groups of winches.

The values given in the Table 12.5 shall be related to the rated motor current, or, in the case of motors with several different outputs, to the current corresponding to the highest output.

2.4 Group supply feeders for hydraulic winches shall be rated for the installed power without the application of a diversity factor.

2.5 The cross-section of group supply feeders for cargo cranes shall be determined in the same way as for cargo winches.

2.6 For shipboard cranes with one drive motor, the supply cable shall be rated according to the current rating of the maximum load capacity.

2.7 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.

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.					

Table 12.5 Diversity factors during operations with winches

Number of winches	The following values shall be used for determining the cable cross-section	
	Winches with DC motors	Winches with induction motors
2	100 % of the largest motor + 30 % of the second motor, or, with identical motors, 65 % of their combined full current	100 % of the largest motor + 50 % of the second motor, or, with identical motors, 75 % of their combined full current
3	100 % of the largest motor + 25 % of the remaining motors, or, with identical motors, 50 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors, 67 % of their combined full current
4	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors, 40 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors, 62 % of their combined full current
5	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors, 36 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors, 60 % of their combined full current
6 and more	33 % of the combined full load current	58 % of the combined full load current

2.8 If current diagrams for the various operating conditions of cranes or groups of winches have been ascertained, the average current based on the diagram may be used instead of application of a diversity factor.

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.

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.

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, four-core cables are required for circuits with loaded neutral point.

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 switchboards of the electrical power generation plants, main group switchboards or group 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.

6. Electro-Magnetic Compatibility

6.1 For basic requirements concerning electromagnetic compatibility see also Section 1, J.5.

6.2 The EMC aspect has to 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.

6.3 If Class Notation EMC is assigned:

- All cables are to be shielded

- The laying of the cables has to be specially checked by the **TL** Surveyor.

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.

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 The tensile stress of the cables at long cable runs caused by thermal expansion and/or movement of ship structure shall not damage the cables, cable runs or cable penetration systems.

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, so that there is no damaging of the cables, cable runs or cable penetration systems.

The diameter of the cable loop shall be at least 12 times the diameter of the thickest cable. In each division should be provided at least one cable loop.

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 essential equipment and emergency consumers shall not be run through fire zones containing the main source of electrical power and associated facilities, as well as galleys, laundries, category A machinery spaces and their casings. 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 In general this applies to:

- 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 sufficiently separated from each other.

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 (at least in areas attended by the crew in action stations), 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 1 m apart, shall be used additionally in the following areas:

- Generally in escape routes and emergency exits, and on the open deck
- Holds for military cargo, 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/protective casings 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.

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 Where pipes or ducts passing through areas where panting is expected, suitable means of compensation shall be provided.

5.5 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.

5.6 Pipes and ducts must be earthed.

5.7 Single-core cables of single and three-phase AC systems shall be provided with plastic outer sheaths if they are installed in metallic pipes or ducts.

5.8 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

6.1 Cable trays/protective casings made of plastic materials are to be type tested in accordance with TL- R E 16, see Section 17, E.5.1.1.d).

Note:

"Plastics" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as polyvinyl chloride (PVC) and fibre reinforced plastics (FRP).

"Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

Applicable for pipes with a diameter of more than 80 mm.

6.2 Non-metallic pipes or cable ducts shall be made of flame-retardant material.

6.3 Cable trays/protective casings made of plastic materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, spaced not more than 1 m apart are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note

When plastic cable trays/protective casings are used on open deck, they are additionally to be protected against UV light.

6.4 The load on the cable trays/protective casings is to be within the Safe Working Load (SWL). The support spacing is not to be greater than the manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing is not to exceed 1 meter.

Note

The selection and spacing of cable tray/protective casing supports are to take into account:

- *Cable trays/protective casings' dimensions*
- *Mechanical and physical properties of their material*
- *Mass of cable trays/protective casings*
- *Loads due to weight of cables, external forces, thrust forces and vibrations*
- *Maximum accelerations to which the system may be subjected*
- *Combination of loads*

6.5 The sum of the cables' total cross-sectional area, based on the cables' external diameter, is not to exceed 40 % of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

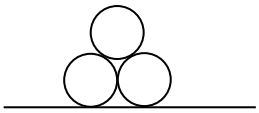
7. Laying of Single-Core Cables and Wires in Single-Phase and Three-Phase AC Systems

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.

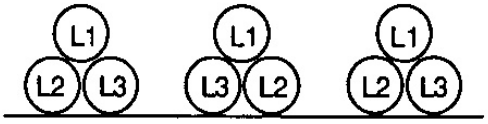
7.3 All conductors belonging to one circuit must be run together in the same pipe or duct, or clamped by common clamps, unless the clamps are made of non-magnetic materials.

7.4 The cables forming a circuit must be laid immediately beside of each other and preferably in triangular configuration. If spacings between the cables 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, unless the cables belonging to the same AC circuit are installed trefoil formation, see 7.4.

For the installation of single core parallel cables between the cable groups these measures are not necessary, if the cable groups are arranged in trefoil formation.



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.

8. Bulkhead and Deck Penetrations

8.1 Cable penetrations shall not impair the mechanical strength or watertightness of the bulkhead and are to be type approved by **TL.**.

8.2 Bulkhead and deck penetrations must have been type-approved. 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.

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 0,5° 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 1.5 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 shall maintain the flame-retardant and where required the fire-resistant properties of the cables.

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. Measures for Limitation of the Propagation of Fire Along Cable- and Wire Bundles

14.1 All cables shall be so installed that the original flame-retardant properties of the individual cables are not impaired. This requirement can be considered to be fulfilled if:

- the bundled cables are individually flameretardant and have been successfully passed the bundle fire test in accordance with IEC publication 60332-3 category A/F
- suitable measures have been taken during the installation, e.g. by providing of fire stops or application of flameproof coatings

14.2 For cable bundles consisting of cables which have not been subjected to a bundle fire test, the following precautions shall be taken to limit the fire propagation:

14.2.1 Fire stops shall be provided:

a) At main- and emergency switchboards

b) At cable entries to engine control rooms

c) At central control panels and -consoles for the main propulsion plant and for important auxiliaries

14.2.2 In closed- and semi-enclosed rooms, fire stops shall be provided at the following locations:

- at each entry- and exit point of cable runs in enclosed metallic installation shafts
- for open vertical cable runs, at least for every second deck, limited to a maximum interval of 6 m
- every 14 m for open horizontal cable runs

14.3 Exceptions

Fire stops in accordance with 14.2.1 a) and c) can be omitted if the switchboards or consoles are installed in separate rooms and measures have already been taken at the cable entrances to these rooms, in holds for military cargo and in under-deck service passageways in the zone of the holds. Fire stops shall be provided only for the boundaries of these rooms.

14.4 Versions of fire stops

The flame propagation of cables passing through fire

stops shall fulfil the SOLAS requirements for B-0 partitions.

Fire stops may, for example, be formed by existing partitions or by a steel plate (min. 3 mm in thickness) together with a B-0 penetration in each case.

The steel plate shall be so formed that it extends around the cables as specified below:

- Twice the maximum dimension of the cable run with vertically laid cables

- The maximum dimension of the cable run with horizontally laid cables

The steel plates, however, need not to be extended through upper covers, decks, bulkheads or trunk walls.

14.5 Application of flameproof coatings

Instead of the fire stops prescribed in 14.4, installed cable bundles may be provided with (**TL** type approved) flameproof coatings as follows:

- On horizontal cable runs for every 14 m, a length of 1 m

- On vertical cable runs over the entire length

Other distances for the coatings may be approved after special testing.

14.6 Alternative methods

Other methods which have been proved to be equivalent to the measures stated in 14.4 and 14.5 may be accepted.

14.7 Explanatory sketches

Explanatory notes to the installation provisions described above are given in Figs 12.1 to 12.4.

15. Application of Fire-Resistant Cables

15.1 Scope of installations

15.1.1 Where cables specified in Section 14, G.1.3 for services (see 15.1.4) including their power supplies pass through high fire risk areas, and main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables being of a fire resistant type complying with IEC 60331-1:2018 for cables of greater than 20 mm overall diameter, otherwise IEC 60331-21:1999+AMD1:2009 or IEC 60331-2:2018 for cables with an overall diameter not exceeding 20 mm, are installed and run continuous to keep the fire integrity within the high fire risk area, see Fig.12.5.

b) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

15.1.2 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.

15.1.3 The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s).

They are to be of a fire resistant type, in accordance with 15.1.1.a), where they pass through other high fire risk areas.

Notes) *The definition for "high fire risk areas" is the following:*

- Machinery spaces as defined in Regulation 3.30 of SOLAS Chapter II-2 as amended by IMO resolutions up to MSC.421(98) (hereinafter the same) except spaces having little or no fire risk as defined by paragraphs (10) of Chapter II-2 / Reg. 9.2.2.3.2.2 of SOLAS. (Including the interpretations for tables 9.3, 9.4, 9.5, 9.6, 9.7 and 9.8 given in MSC/Circ.1120, as amended by MSC.1/Circ.1436 and MSC.1/Circ.1510)

- *Spaces containing fuel treatment equipment and other highly flammable substances*

- *Galley and Pantries containing cooking appliances*

- *Laundry containing drying equipment*

b) *Fire-resistant type cables shall be easily distinguishable.*

c) *For special cables, requirements in the following standards may be used:*

IEC60331-23:1999: Procedures and requirements - Electric data cables

IEC60331-25:1999: Procedures and requirements - Optical fibre cables

15.1.4 Services required to be operable under fire conditions on the cables include:

- Fire and general alarm system
- Fire-extinguishing systems and fire-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
- Secondary lighting
- Public address system
- Escape, evacuation and rescue lighting
- At least one fire pump
- Remote emergency stop/shut-down arrangements for systems which may support the propagation of fire and/or explosion

15.2 Installation

For installation of fire-resistant cables the following shall be observed:

15.2.1 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.

15.2.2 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 61439-1 and IEC publication 61439-6.

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. Degaussing

1. Class Notation

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. System Configuration

2.1 Basic procedure

The signature requirements of a naval ship will determine the special technical requirements for the degaussing system and its elements. This applies in particular to the determination of the geometry and the electrical dimensioning of the degaussing windings system.

The magnetic field induced by the degaussing system shall be capable of a real-time compensation of the permanent, the induced and the eddy-current generated magnetizations of the ship's hull.

2.2 System elements

In general degaussing systems have to include the following system elements:

- Central control unit
- Winding amplifier
- Degaussing probe
- Winding system

The detailed requirements for these elements are specified in the following.

3. Control Unit

3.1 The control and monitoring unit has to be protected against data losses, even in the case of failing of the main power supply.

3.2 The task of the control unit is the time and motion-related control of the currents in the windings of the degaussing system.

3.3 As the induced interference magnetic field and the interference field caused by eddy currents depend on the earth magnetic field and the eddycurrent field depends additionally on the rolling and pitching of the ship, the complete field has to be determined. This should be possible in three operation modes:

- Measuring with a ship-mounted triaxial geomagnetic sensor, see degaussing probe in 5.
- Determination by a computer based geomagnetic data model in the control unit which calculates the earth magnetic field values corresponding to the actual position and the own motion of the ship

- Emergency operating mode for manual input of the position and heading of the ship

3.4 To compensate the magnetic interference effects the degaussing system has on the magnetic compass of the ship, the control unit should be equipped with a facility to generate suitable correcting currents, which can be fed into the electrical compass compensation windings of the magnetic compass.

3.5 System malfunctions shall be signalled by an optical and an acoustic alarm, error messages shall be recorded at the control unit.

4. Winding Amplifiers

4.1 The task of the winding amplifiers is to supply the degaussing windings with a total current consisting of three portions, to be able to compensate each of the three interference field portions (permanent, induced and eddy-current fields) in a timely and amplitude-related manner.

4.2 The coil amplifiers triggered by the central control unit shall be designed as static transformers. They have to provide the necessary supply voltage individually for each winding and shall be equipped with an internal control of the winding current determined by the central control unit.

4.3 Winding amplifiers may be integrated in the ship in the following ways:

- Decentral location, near to the related degaussing windings

- Central location of all amplifiers in a common space

- Partially decentral location, i.e. several amplifiers distributed over the ship

4.4 High-frequency interference signals from the shipboard electrical power generation plants are to be prevented from being coupled into the winding amplifiers to avoid wide-ranging radiation of these interference signals via the degaussing windings system and, vice versa, their influence on other ship components. One point of the shielding of the cable should be connected to the ship's hull.

5. Degaussing probe

5.1 The system for measuring the earth magnetic field has to include the degaussing probe usually to be installed on a mast as well as the related electronic triggering and evaluation equipment (magnetometer).

5.2 The mast shall be manufactured of a low-magnetic material. In general, the immediate vicinity of the degaussing probe shall be free of ferromagnetic materials within a radius of abt. 2 m.

5.3 It shall be possible to adjust the degaussing probe with the main axes of the ship by a mechanical adjusting device.

6. Winding System

6.1 General requirements

6.1.1 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 by the Naval Authority.

A degaussing winding diagram containing the winding geometry as well as the required electric data of each winding has to be established and submitted.

6.1.2 Unless stipulated otherwise in the building specification, the orientation of windings in the ship is differentiated as follows:

6.1.2.1 V windings: windings laid horizontally, i.e. the effective magnetic direction is VERTICAL

6.1.2.2 A windings: windings laid parallel to the longitudinal direction of the ship, i.e. the effective magnetic direction is ATHWART

6.1.2.3 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 and E (eddy-current)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.

6.2 Installation

6.2.1 Degaussing windings shall be run along separate cable trays or cable racks, the construction of which must be in compliance with D.

6.2.2 All cable routes should be selected so that the windings run precisely in the stipulated layer.

6.2.3 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.

6.2.4 If not otherwise specified, it is recommended to keep the distance between the degaussing windings and the ship's shell between 100 and 200 mm.

6.2.5 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.

6.2.6 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.

7. Testing

The degaussing system shall be tested in accordance with the requirements agreed for the respective naval ship. A test program for basic functions is to be submitted to **TL.**

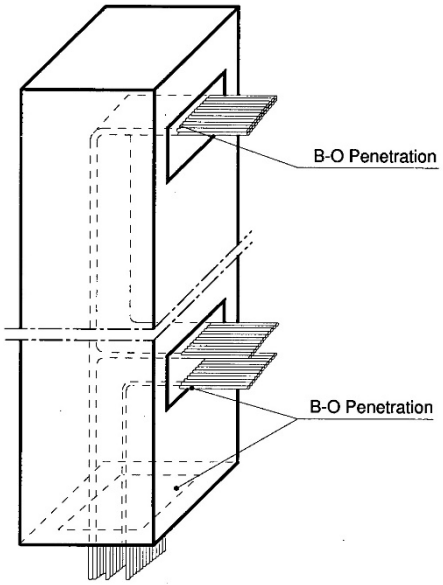


Fig. 12.1 Fire stops All steel plates at least 3 mm thick

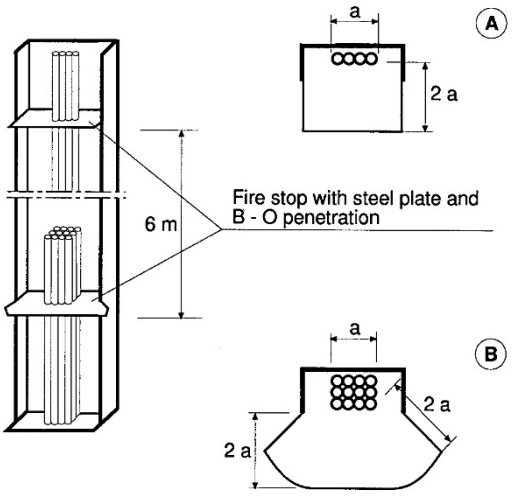


Fig. 12.2 Partly enclosed ducts, vertical

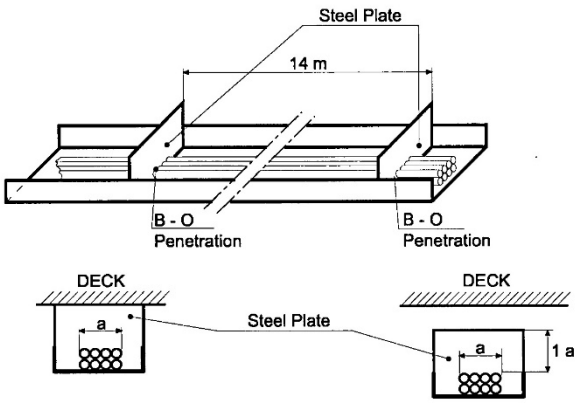


Fig. 12.3 Partly enclosed ducts, horizontal

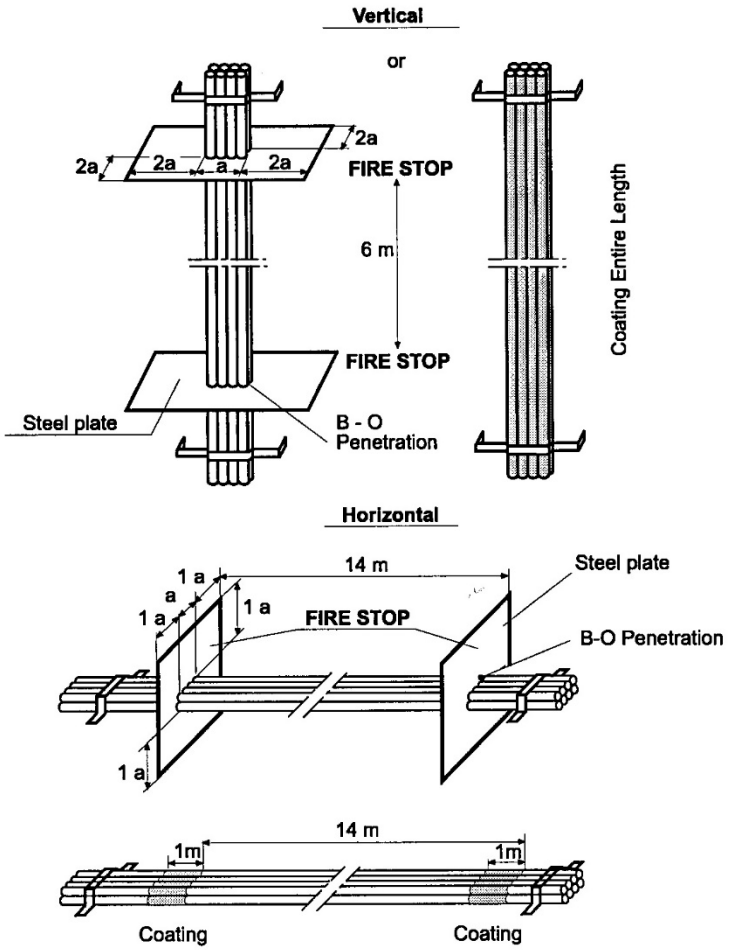


Fig. 12.4 Open cable runs

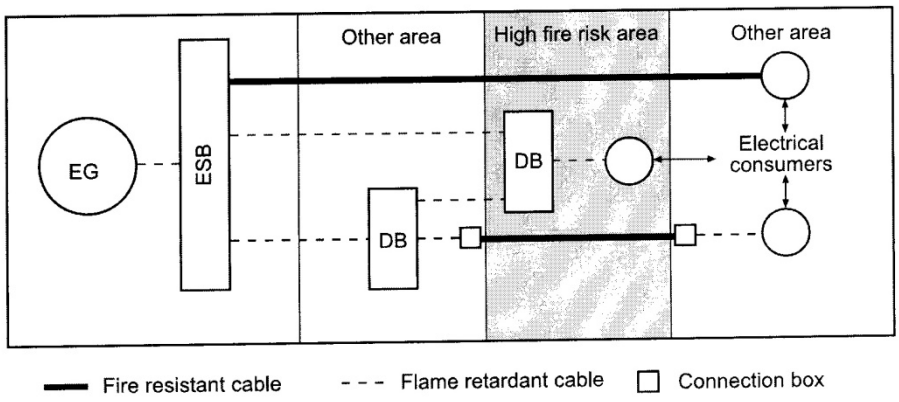


Fig. 12.5 Installation of fire resistant cables through high fire risk areas

Table 12.6 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 12.7 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		
mm²	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 12.8 Current-carrying capacity of cables, max. permissible conductor operating temperature of 85 °C (JIS)*

Nominal cross-section To JIS* mm²	Current-carrying capacity based on a maximum conductor operating temperature of 85 °C		
	S1-cont. operation [A] maksimum	S2-30 min [A] maksimum	S2-60 min [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 12.9 Current-carrying capacity of cables, max. permissible conductor operating temperature of 90 °C and 95 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature					
		90 ° C			95 ° C		
		S1-cont. operation	S2-30 min	S2-60 min	S1-cont. operation	S2-30 min	S2-60 min
mm^2	AWG/MCM	**A max.**	**A max.**	**A max.**	**A max.**	**A max.**	**A max.**
Single core cables							
1	17	18	19	19	20	21	21
1,5	15	23	24	24	24	25	25
2,5	13	40	43	43	32	34	34
4	11	51	54	54	42	45	45
6	9	52	55	55	55	58	58
10	7	72	77	77	75	80	80
16	5	96	102	102	100	106	106
25	3	127	135	134	135	144	143
35	2	157	170	167	165	178	175
50	0	196	214	208	200	218	212
70	2/0	242	269	257	255	283	270
95	4/0	293	331	314	310	350	332
120	250	339	390	362	360	410	385
150	300	389	459	420	410	484	443
185	400	444	541	484	470	573	512
2-core cables							
1	17				17	18	18
1,5	15	20	21	21	20	21	21
2,5	13	26	28	28	27	29	29
4	11	34	37	36	36	39	38
6	9	44	48	46	47	51	50
10	7	61	68	65	64	71	68
16	5	82	93	88	85	96	91
25	3	108	128	116	115	137	124
3-core cables							
1	17				14	15	15
1,5	15	16	17	17	17	18	18
2,5	13	21	23	22	22	24	23
4	11	28	30	30	29	32	31
6	9	36	39	38	38	42	40
10	7	50	56	53	52	58	55
16	5	67	77	72	70	80	75
25	3	89	107	97	94	113	102
35	2	110	136	121	115	143	127
50	0	137	178	153	140	182	157
70	2/0	169	232	195	178	244	205
95	4/0	205	295	244	217	312	258
120	250	237	356	289	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

ADDITIONAL RULES for ELECTRICAL MAIN PROPULSION PLANTS

A. General

1. Basic requirements

1.1 A ship has an electrical main propulsion plant if the main propulsion is produced by at least one electrical propulsion motor, or if this motor provides temporarily the entire propulsive power.

1.2 Auxiliary propulsion plants are additional propulsion systems.

1.3 As the minimum requirement for an electrical main propulsion plant, the following requirements apply:

- At least two mutually independent static converters shall be provided, with mutually independent cooling systems, regulating systems, reference value inputs, actual-value acquisition, etc.

- The supply of the power circuits are to be provided by separate cables from different sections of the propulsion switchboard.

1.4 The engines driving the generators for the electrical propulsion plant are main engines, the motors driving the propeller shaft or the thrusters are propulsion motors.

1.5 Where lithium batteries are used for propulsion or as part of a hybrid propulsion system, refer to **TL** rules "Additional Rules for Certification, Installation and Testing of Lithium Batteries" for installation and safety requirements.

1.6 If electrical main propulsion plants are supplied from the ship's low or medium voltage network the Rules in this Section apply also to the generators and the associated switchgear.

1.7 The static converters shall be easily accessible for inspection, repair and maintenance.

1.8 Equipment shall be provided to support the fault diagnosis process.

1.9 IEC publication 60092-501: "Special features

- Electric propulsion plant" shall be considered.

1.10 Number of propulsion plants

The main propulsion plant shall consist of at least two independent propulsion systems.
The design of the electrical propulsion system has to ensure that the ship at least remains manoeuvrable after a single failure in the mechanical or electrical part of the main propulsion plant.

1.11 Redundant propulsion

For more stringent requirements concerning the propulsion plant see **TL** Rules for Propulsion Plants, Section 2, K. and the **TL** Rules for Redundant Propulsion and Steering Systems.

1.12 Azimuthing Propulsors

For electrical requirements of azimuthing propulsors see also the **TL** Rules for Propulsion Plants, Section 7B, G.

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.

1.3 Each shaft shall be fitted with an adequately dimensioned locking device that permits towing of the ship, or the operation of other propulsion systems, without rotation of the locked, non-driven shaft.

The remaining drives may be operated at reduced power, provided that sufficient manoeuvring capability is ensured.

2. Main Engines

The main engines must also conform to the requirements

of Chapter 104 - Propulsion Plants, Section 3 and 4A.

2.1 The diesel governors must allow safe operation under all running and manoeuvring conditions, for both single operation and parallel operation.

2.2 The response on different reduction alarms shall be agreed with **TL.**

3. Propulsion Motors

The propulsion motors must also conform to the requirements of Section 14, B.

3.1 The effects of the harmonics of currents and voltages shall be taken into consideration for the design of the propulsion motors.

3.2 The winding insulation shall be designed to withstand the overvoltages which may arise from manoeuvres, switching operations, converter operation and earth faults.

3.3 Separately cooled machines shall be so dimensioned that in case of failure of the separate cooling, limited operation is still possible. Versions deviating from this principle require approval.

3.3.1 It shall be possible to check the function of the cooling system by means of local temperature indicators (e.g. water: inlet and outlet; air: intake and discharge).

If it is not possible to install local, directly measuring thermometers, external indicators which are independent from other systems shall be provided.

It shall be ensured that water due to leakage or condensation is kept away from the windings.

3.4 Electrical propulsion motors shall be able to withstand without damage a short-circuit at their terminals and in the system under rated operating conditions until the protection devices respond.

3.5 All stator winding ends shall be routed to terminals in the terminal box and to be connected only there.

C. Static Converter Installations

1. General

1.1 Power electronic equipment must also conform to the requirements of Section 6.

1.2 Static converters must be designed for all operating and manoeuvring conditions, including overload.

1.3 For the design of the static converter cabinets, the requirements for main switchboards shall be applied as and where appropriate.

2. Converter Assemblies

2.1 For separately cooled static converters, independent cooling systems shall be provided for each converter.

If static converters are separately cooled, it shall be possible to continue operation of the plant at reduced power in the event of failure of its cooling system. Failure of the cooling system shall be signalled by an alarm.

The temperature of the converter cabinet as well as the temperature of the power semiconductors or of the heat sinks shall be monitored.

2.2 If limited operation of liquid cooled static converters is not possible after failure of the separate cooling system, then two coolant pumps with the corresponding stand-by circuits shall be provided.

2.3 For liquid-cooled static converters, the following monitoring arrangements shall be provided in addition:

- Coolant flow or differential pressure
- Coolant leakage
- Coolant pressure
- Coolant conductivity

- Coolant temperature
- Failure of the coolant pumps/fans
- Stand-by alarm of the coolant pumps

2.4 For the components of the DC link, the following monitoring arrangements shall be provided:

- Temperature monitoring of the DC link reactor
- Undervoltage and overvoltage monitoring
- Current monitoring
- Short-circuit monitoring
- Current monitoring of the braking resistor

2.5 The input supply shall be provided with the following monitoring arrangements:

- Failure of the supply
- Overvoltage
- Undervoltage
- Underfrequency

These values shall be coordinated with the mains supply protection and the generator protection.

2.6 The following internal monitoring equipment shall be provided for the static converter:

- Semiconductor failure
- Semiconductor fuse failure
- Firing pulse error
- Control deviation
- System error of the control system
- Actual speed / rotor position encoder failure
- Current actual value failure
- Faulty setpoint input
- Power supply failure
- Failure in the bus system

3. Main and Exciter Power Circuits

3.1 The circuits for main power supply and exciters shall be supplied directly from the switchboard and shall be separate for each motor respectively each winding system.

The exciter shall be supplied from the dedicated section of the main- or propulsion switchboard supplying the main circuit. This applies also to other auxiliary systems.

DC motors and separately excited machines designed as a single drive shall be fitted with two exciter devices.

3.2 The main circuits shall be supplied through remotely actuated circuit-breakers.

3.3 In the supply of exciter circuits, only short-circuit protection shall be provided.

3.4 In the event of failure of the excitation, the corresponding power component shall also be switched-off. Failure of the excitation system shall be signalled by an alarm.

4. Installation According to IEC 60533

4.1 Plants that do not meet the requirements set out in the **TL** Guidelines Test Requirements for Electrical / Electronic Equipment and Systems relating to the stray radiation from the housing and/or the conducted interference shall be installed in separate spaces.

4.1.1 The supply lines, and the cables to the propulsion motor, shall be run separately from each other and from other cables.

4.1.2 Such plants shall be supplied via transformers.

5. Filter Circuits

5.1 If filter circuits are used to reduce the

harmonics, these circuits are to be protected against overload and short-circuit.

5.2 Filters shall be monitored for failure.

5.3 The operating instructions shall document which propulsion settings and generator combinations are admissible after failure of one or all of the filters. This shall be verified by means of a THD measurement.

5.4 Filters shall function properly in all propulsion settings and grid configurations and shall not lead to increases in voltage or current. This shall be verified through measurements during the sea trial.

D. Control Stations

Control equipment must conform to Chapter 106 - Automation, as **a**nd 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 (e.g., when control taken over by a local control station, due to a malfunction, and reboot one of the propulsion sides (PS or SB)) at the concerned control station is to be signalled optically and audibly.

2.2 Ships with Class Notations **K50, K 20** 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.

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.

3. All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

4. A malfunction in a system for synchronizing or in a position equalization 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 Network

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 stop of main engines during manoeuvring shall be prevented.

2.1 During estuary operation, each main busbar section shall be supplied by at least one generating set.

3. Propulsion Switchboards

The propulsion switchboard mainly distributes the energy to the propulsion system.

3.1 If the total installed power of the main generator exceeds 3 MW, the propulsion switchboard shall be provided with a circuit-breaker for sectionalising the plant.

3.2 Propulsion switchboards shall meet the requirements for switchboards of electrical power generation plants as and where appropriate.

F. Control and Regulating

1. Generally the control and regulating functions of the propulsion plant shall be completely independent of other systems. In normal operation computers and bus systems shall be permanently assigned to the corresponding drive train. The failure of other control and monitoring equipment shall not lead to malfunctions in the propulsion plant.

2. If alarms are passed on to the machinery alarm system by means of collective alarms, it shall be considered that each additional new single alarm will retrigger this collective alarm; see also Section 9, B.6. and the **TL** Rules for Automation.

3. An automatic power limitation and reduction of the propulsion plant shall ensure that the ship mains and propulsion network are not loaded inadmissibly.

4. In the event of overcurrent, undervoltage, underfrequency, reverse power and overload, the propulsion shall be limited or reduced accordingly.

5. Upon failure of a generator or a bus tie breaker, the resulting load surge shall be limited to the admissible values by the drives.

6. The reverse power applied during reversing or speed-reducing manoeuvres shall be limited to the acceptable maximum values.

G. Protection of the Plant

1. General

1.1 Automatic tripping of the propulsion plant, such that it impairs the ship's manoeuvring capability, shall be limited to such malfunctions which would result in serious damage within the plant.

1.2 The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition shall remain recognisable even after switching-off. A limitation of the running-up of the propulsion plant that is caused by generators reaching their maximum output should not be signaled as an alarm.

1.3 The protection concept for the propulsion motor shall be described and agreed with **TL.**

1.4 The settings of the protection devices for the generators, transformers and propulsion motors shall be coordinated with the settings of the power management system and those of the propulsion plant's converters. Any protection devices in the exciter circuits shall be deactivated or adjusted so that they respond subsequently.

2. Protection devices shall be set to such values that they do not respond to overload occurring under normal service condition, e.g. while manoeuvring or in heavy seas.

3. Defects in reducing and stopping devices shall not impair the remaining manoeuvrability in accordance with A.1.10.

4. In the event of failure of an actual or reference value, it shall be ensured that the propeller speed does not increase unacceptably, that the propulsion will not be reversed or that 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:

- Where drives can be mechanically blocked in an uncontrolled manner, they must be provided

with monitoring devices which prevent damage to the plant.

- Overspeed protection
- Protection against overcurrent and short circuit.
- Earth fault monitoring of stator and exciter windings
- Protection device which detects internal faults of the motor (e.g. differential protection) for propulsion motors with an output of more than 1500 kW
- Following an internal fault in the motor or a short-circuit in the output circuit, various measures may be necessary, depending on the location of the damage and the motor type. Error indication shall make it possible to identify the damaged parts of the plant. The feeder breakers and the disconnector shall open automatically, insofar as they serve to limit the damage.

6. Permanently Excited Motors

6.1 For Permanently excited motors and motors with several stator windings, a disconnector shall be arranged between the motor terminals and the static converter.

6.2 In the case of a fault below the disconnector of permanently excited motors, the ship shall be stopped as soon as possible and the corresponding shaft shall be locked. The corresponding alarm shall be provided at the control station. The installation shall be so designed that it is able to carry the shortcircuit current of the motor for the stopping time. The disconnector shall have a corresponding switching capacity. In the event of faults in the output circuit of the static converter, this disconnector shall open automatically.

7. Separately Excited Motors

7.1 For separately excited motors the disconnectors in the main circuit shall open and the exciter devices shall be switch off in the event of faults in the output circuit.

8. Asynchronous Motors

8.1 For asynchronous motors, it is sufficient to switch off the static converter and, if applicable, to open disconnecting devices for single windings.

9. The transformers of propulsion plants shall be protected against over current and short-circuit. Medium-voltage transformers of propulsion plants shall be equipped with an earthed shield winding. Propulsion transformers shall be monitored for over temperature. Propulsion transformers with an output of more than 1500 kVA shall be equipped with differential protection.

H. Measuring, Indicating, Monitoring and Operating Equipment

1. Faults

Faults in measuring, monitoring, indicating and operating equipment must not cause any failure of control and regulating functions.

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
- Pitch indicator for plants with variable-pitch propellers
- Indication of the available power for propulsion or alternatively load indication of the generators used for propulsion

- On/off pushbuttons for each static converter
- On/off signals for each static converter
- Selected static converter
- Plant ready for switching on
- Plant ready for operation
- Plant disturbance
- Control from machinery control centre (MCC)
- Control from the bridge
- Control from the local control station
- Reduced power and pushbutton “Override reduction” or “request for reduction”
- System-dependent alarms

2.2 At the propulsion main control stations in the machinery control centre (MCC)

- Power meter
- Revolution indicator for each shaft
- Pitch indicator for plants with variable-pitch propellers
- Indication of the available reserve power for propulsion or alternatively load indication of the generators used for propulsion
- On/off pushbuttons for each static converter
- On/off signals for each static converter
- Plant ready for switching on
- Plant ready for operation
- Plant disturbance
- Reduced power and pushbutton “Override reduction” or “request for reduction”
- Control from engine control room
- Control from the bridge
- Control from the local control station
- Indication of the generators used for propulsion
- Change-over switch for different operating conditions (e.g. in-port readiness, manoeuvring, transit, etc.)
- System-dependent alarms

2.3 Propulsion main control station on the bridge

- Revolution indicator for each shaft
- Pitch indicator for plants with variable-pitch propellers
- Indication of the available power reserve for propulsion or alternatively load indication of the generators used for propulsion
- On/off pushbuttons for each static converter
- On/off signals for each static converter
- Plant ready for switching on
- Plant ready for operation
- Plant disturbance
- Reduced power and pushbutton “Override reduction” or “request for reduction”
- Control from engine control room
- Control from the bridge
- Control from the local control station
- System-dependent alarms

3. Monitoring Equipment

The actuation of the following monitoring equipment shall be signalled optically and acoustically:

3.1 Monitoring of the ventilators and temperatures of the cooling air for forced ventilation of machines and transformers.

3.2 Monitoring of the flow rate and leakage of the coolant for machines and transformers with closed cooling systems.

In the secondary cycle, at least the inlet temperature shall be registered. The separate cooling system shall be monitored for failure.

3.3 For generators above 500 kVA and for motors and transformers, winding-temperature monitoring shall be provided.

3.4 Bearing-temperature monitoring shall be provided for generators above 1500 kVA and for propulsion motors. A thermometer shall be installed locally for monitoring purposes. If the bearings are inaccessible, the temperature measurement system shall be designed to provide redundancy.

3.5 Bearings with external lubrication shall be monitored for adequate lubrication under all operating conditions (e.g. pressure, flowrate, filling level).

The oil temperature shall be monitored.

A sight glass shall be provided for manual inspection. If the bearings are inaccessible, the lubrication monitoring system shall be designed to provide redundancy.

See also Section 14, B.1.6.

3.6 Both end positions of the shaft locking device (locked and released) shall be monitored. An alarm shall be triggered if the locking device is in an inadmissible position.

3.7 In the case isolated networks or subnetworks, the insulation resistance shall be monitored.

4. Alarm Coordination

Generally a pre-alarm should be triggered, wherever possible, before shut-down or reduction of the propulsion plant.

5. Start Blocking

The start-up process of the propulsion plant shall be interlocked that starting is impossible if existing malfunctions would trigger a shut-down or if the start-up process itself would cause damage to the propulsion plant.

5.1 Start-blockings:

- Shaft locking device not released
- No cooling of static converter (overridable)
- No cooling of propulsion motor (overridable)
- No cooling of propulsion transformer (overridable)
- Malfunction in exciter device
- Malfunction in static converter
- Converter control: shut-down activated
- Propulsion switchboard switch-off active
- Emergency stop actuated
- Setpoint not equal to zero
- Bearings: lubrication oil pressure too low
- Conductivity of the cooling medium too high
- Protection triggered
- Circuit-breaker malfunction
- Missing enabling signal from variable-pitch propeller

5.2 The pilot light “plant ready for switching on” may only be activated when all the prerequisites for start-up have been met.

5.3 The pilot light “plant ready for operation” may only be activated if the propulsion plant would respond to set point setting.

I. Cables and Cable Installation

The cable network for electrical propulsion plants must comply with the requirements of Section 12.

1. If there is more than one propulsion unit, the cables of any one unit shall, as far as is practicable, be run over their entire length separately from the cables of the other units.

J. Construction Supervision, Testing and Trials

1. Supervision During Construction

Propulsion motors, generators, static converters and switchgear as part of the main propulsion plant are subject to supervision during construction by **TL.**

To allow supervision during construction, a quality assurance plan shall be submitted to **TL.**

The quality assurance plan shall contain the planned internal receiving, in-process and final inspections/ tests, together with the relevant test instructions and the planned test records. The hold points with participation of **TL** will be determined on the basis of the quality assurance plan.

2. Testing at the Manufacturer’s Works

The following additional tests shall be carried out :

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 and 17.

2.1.1 Testing of the static converters

2.1.1.1 These tests shall meet the requirements of Section 6 as and where appropriate. All alarms of the categories “Stop” and “Reduction” shall be documented with their limit values and tested. In the case of type-approved static converters, this is only necessary for the project-specific parameters.

2.1.1.2 For type-approved static converters, the function of the general alarms shall be verified by spot checks. For static converters that are not type approved, a complete test is required for the first converter of each series.

2.1.1.3 Faults such as the failure of reference and actual value signals, power supply failure, ventilator failure, inadequate pressure and leakage of coolant, failure of miniature circuit-breakers, communication error, etc. shall be listed together with their effects on the system and shall then be tested.

2.1.1.4 The scope of tests for the first static converter of a series and for the subsequent converters shall be agreed with **TL** in each case.

2.1.2 Testing of the propulsion switchboard

A complete test of the protection devices, interlocks, etc. shall be carried out in accordance with the test requirements for main switchboards.

2.1.3 Testing of the remote control

For the first vessel of a series the remote control shall be set up with all control stations and tested.

2.1.4 Testing of the transformers

A complete type and routine test shall be carried out according to IEC publication 60076 or verification thereof submitted. For the temperature-rise test, the effect of the harmonics shall be considered; see Section 14, B.

2.1.5 Testing of the motors

A complete type and routine test shall be carried out

according to IEC publication 60034. For the temperature-rise test, the effect of the harmonics shall be considered; see Section 14, B.

2.1.6 Testing the power management system

The power management systems shall be subject to a functional test (software FAT) in the manufacturer's works. Joint testing with the propulsion switchboard is recommended. A test specification shall be defined and agreed with **TL.**

2.2 Testing of the shaft material for generators and propulsion motors

Proof of compliance with Chapter 2 - Materials shall be provided by means of a shaft material test as for ship's shafting.

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

Newly-constructed or enlarged plants require testing and trials on board. The scope of tests shall be agreed with **TL.**

3.1 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:

- 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 as far as possible.
- Verification of the propeller speed variation and all associated equipment.
- Verification of the protection, monitoring and indicating/alarm equipment, including the interlocks, for faultless operation.
- Verification of the reannunciation of collective alarms
- Verification of the insulation condition of the main-propulsion circuits.
- For testing the ship mains, the main engines and the propulsion plant, a trial with a zero-thrust propeller or comparable equipment is recommended.

3.2 Sea trial

The trial programme shall at least include:

3.2.1 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 closed loop controls setting:

- At 100% power (rated electrical power of generator): at least 60 min.
- At 110% power (rated electrical power of generator): at least 10 min.
- 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

Note:

Each engine is to be tested 100% electrical power for at least 60 min and 110% of rated electrical power of the generator for at least 10 min. This may, if possible, be done during the electrical propulsion plant test, which is required to be tested with 100% propulsion power (i.e. total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach stable operating temperatures of all rotating machines or for at least 4 hours. When some of the gen. set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.

3.2.2 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.

3.2.3 Performance of the manoeuvres typical for estuary navigation.

3.2.4 Checking of the machinery and plant in all operating conditions.

3.2.5 Checking of the grid quality in the ship's propulsion network and mains:

- Measurement at various propulsion speeds in normal operation.
- Measurements with which the most unfavourable mains and propulsion plant configuration is determined.
- Measurement at various propulsion speeds in most unfavourable mains and propulsion plant configuration
- Repeat measurement without THD filter as far as possible; see also C.5.3.

The measurement results shall be recorded.

3.2.6 Upon completion of the sea trial, a visual inspection of the components of the propulsion plant shall be performed. The insulation resistances of the propulsion transformers, propulsion motors and generators shall be determined and recorded..

SECTION 14

ELECTRICAL EQUIPMENT

A. General

1. Depending on the application and deployment profile of the naval ship the Naval Authority may request additional requirements concerning the electrical equipment, which are beyond the normal scope of Classification.

- Such additional requirements may be asked for e.g. in the fields of shock resistance, vibration resistance, noise and others and may be subject to additional Class Notations.

In these cases special designs and tests have to be determined and verified for electrical equipment and assemblies under consideration of the ambient conditions, see Section 1, E.

2. The required tests shall be subjected to a quality assurance system, documented and the test reports submitted to **TL** on request, see also Section 17.

B. Electrical Machinery

1. Generators and Motors

1.1 General

Electrical machines shall conform to IEC 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.

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 Heat exchanger/cooler

Cooling units shall comply with the **TL** Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 16. Cooling units with the operating medium water, a design pressure $p_c \leq 16$ bar and a design temperature $t \leq 200$ °C correspond to pressure vessel class III.

1.4.3 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.

1.4.4 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.

1.4.5 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.

Shaft material for other machines is to be in accordance with recognized international or national standard.

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 in accordance with Section 1, Table 1.2. 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 ≥ 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 maintenance

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 supplying the motors of electric propulsion systems 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 especially for application on open deck. 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

All electric machines shall be tested at the manufacturer’s work.

Manufacturer’s test records are to be provided for machines for essential services, for other machines they are to be available upon request.

The tests shall be performed in accordance with IEC 60092-301:1980/AMD2:1995. **TL** reserves the right to stipulate additional tests in the case of new types of machines or where it is required for another particular reason.

4.1 Tests in the presence of a TL Surveyor

The machines listed below are subject to testing in the manufacturer's works in the presence of a **TL** Surveyor**:**

Note:
*An alternative survey scheme may be agreed by the **TL** with the manufacturer whereby attendance of the Surveyor will not be required as required below.*

4.1.1 Generators and motors for essential equipment with outputs of 100 kW (kVA) and over.

4.1.2 Material test for the shafts of:

4.1.2.1 motors of electric propulsion plants,

4.1.2.2 main generators supplying the motors of electric propulsion plants, and,

4.1.2.3 shaft generators or supplementary electrical drives if their shafts form part of the ship's main shafting.

4.1.2.4 Shaft material for other machines is to be in accordance with recognised international or national standard.

4.2 Manufacturer Test Reports

On request, Manufacturer Test Reports shall be presented for machines not tested in presence of a **TL** Surveyor.

4.3 Extent of tests

Type tests are to be carried out on a prototype machine or on the first of a batch of machines, and routine tests carried out on subsequent machines in accordance with Table 14.1

Note:
Test requirements may differ for shaft generators, special purpose machines and machines of novel construction.

4.3.1 Examination of the technical documentation

Technical documentation of machines rated at 100kW and over is to be available for examination by the Surveyor.

4.3.2 Visual inspection

A visual examination is to be made of the machine to ensure, as far as is practicable, that it complies with technical documentation.

4.3.3 Measurement of winding resistance

The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

4.3.4 Verification of the voltage regulation system

For verification of the voltage regulation see Sec.3,B.2.4

4.3.5 No Load test

Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor or if a generator it is to be driven by a suitable means and excited to give rated terminal voltage.

During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.3.6 Heat test

4.3.6.1 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.

4.3.6.2 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.

4.3.6.3 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.

4.3.7 Load characteristics

For generators the voltage, and for motors the speed, shall be checked as a function of the load.

4.3.8 Overload/overcurrent test

Overload test is to be carried out as a type test for generators as a proof of overload capability of generators and excitation system, for motors as a proof of momentary excess torque as required in IEC 60034-1:2017. The overload test can be replaced at routine test by the overcurrent test. The over current test shall be the proof of current capability of windings, wires, connections etc. of each machine. The overcurrent test can be done at reduced speed (motors) or at short circuit (generators).

The overload test shall be performed:

4.3.8.1 for generators at 1,5 times the rated current for two minutes;

4.3.8.2 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;

4.3.8.3 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; three phase motors shall not pull-out. During the routine test the overload test can be replaced by the overcurrent test.

4.3.8.4 for anchor windlass motors, at 1,6 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.

4.3.8.5 The overload/overcurrent test is not necessary, if a **TL** type test for motors and generators is available

4.3.9 Short-circuit test

It is to be verified that under steady-state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which will be fitted in the tripping device for discrimination purposes.

In order to provide sufficient information to the party responsible for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer shall provide documentation showing the transient behaviour of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator shall be taken into account, and the setting parameters for the voltage regulator shall be noted together with the decrement curve. Such a decrement curve shall be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based on physical testing. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through the previous type test on the same model.

4.3.9.1 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.

4.3.9.2 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.

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	Insulation resistance measurement	x	x	x	x
3	Winding resistance measurement	x	x	x	x
4	Verification of the voltage regulation system	x	x **(3)**		
5	Rated load test and temperature rise measurements	x		x	
6	Overload, overcurrent test	x	x **(4)**	x	x **(4)**
7	Verification of steady short circuit condition **(5)**	x			
8	Overspeed test	x	x	x	x
9	Dielectric strength test	x	x	x	x
10	No-load test	x	x	x	x
11	Verification of degree of protection	x		x	
12	Verification of bearings	x	x	x	x

(1) *Type tests on prototype machine or tests on at least the first batch of machines.*
(2) *The report of machines routine tested is to contain the manufacturer's serial number of the machine which has been type tested and the test result.*
(3) *Only functional test of voltage regulator system.*
(4) *Only applicable for machine of essential services rated above 100kW.*
(5) *Verification of steady short circuit condition applies to synchronous generators only.*

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

4.3.10 Overspeed test

Machines are to withstand the overspeed test as specified in to IEC 60034-1:2017. As proof of mechanical strength, a two-minute over-speed test shall be carried out as follows:

4.3.10.1 for generators with their own drive, at 1,2 times the rated speed;

4.3.10.2 for generators coupled to the main propulsion plant and not arranged in the main shafting, at 1,25 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.*

4.3.10.3 for shaft generators arranged in the main shafting and whose construction makes testing impracticable, proof by computation of mechanical strength is required,

4.3.10.4 for motors with one nominal speed, at 1,2 times the no-load speed;

4.3.10.5 for variable-speed motors, at 1,2 times the maximum no-load speed;

4.3.10.6 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.

4.3.11 Winding test (high-voltage test)

Machines are to withstand a dielectric test as specified in IEC 60034-1:2017. For high voltage machine an impulse test is to be carried out on the coils according to TL-R E11.

4.3.11.1 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.

4.3.11.2 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.

4.3.11.3 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.

4.3.12 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 **s**hall be taken from Table 14.5. The maximum anticipated no-load voltage or the maximum system voltage shall be taken for the rated voltage.

4.3.13 Test of degree of protection

As secified in IEC 60034-5:2000+AMD1:2006.

4.3.14 Bearing check

Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by TL Surveyor, to establish that the shaft is correctly seated in the bearing shells.

4.3.15 Test of voltage regulator

For the requirements for testing of voltage regulators see Section 3, B.3.

C. Power Transformers

1. General

The design of transformers shall in general comply with the requirements of IEC 60092-303 and relevant parts of IEC 60076 – “Power Transformers”. For high-voltage transformers, see also Section 8.

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	2 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.*		

1.1 Coolant

Preferably dry type transformers shall be used on board of ships.

For separately cooled transformers the cooling air shall be monitored and alarm on failure. Where forced cooling is used, it shall be possible to operate at reduced power on failure.

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. Medium voltage distribution transformers and propulsion transformers are to be provided with temperature monitoring. Medium voltage propulsion transformers shall have earthed screen windings.

2. Rating

2.1 Voltage variation during loading

The voltage drop in the secondary voltage between no load and rated load, under resistive load, shall comply with definition and calculation methodology in IEC 60076-8.

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 unintentionally contact.

2.3 Short-circuit resistance

Transformers shall be constructed to withstand a primary or secondary terminal short circuit with a duration of minimum 1 s, with rated primary voltage and frequency, without damage to internal parts or enclosure.

2.4 Parallel operation

Transformers for parallel operation shall have compatible coupling groups and voltage regulation. The actual current of each transformer will not differ from its proportionate share of the total load by more than 10% of its full load current.

3. Rating Plate

Transformers shall be provided with a durable corrosion-resistant rating plate, giving the following information:

- Make, type, serial no.
- Performance standard
- Rated values for: output apparent power, voltage(s), frequency, current(s)
- Duty type, if other than S1
- Thermal classification of insulation
- IP code of enclosure and termination box
- Vector group of windings
- Maximum permissible cooling medium temperature
- Short circuit impedance value
- Liquid type (if applicable)
- Total mass.

4. Tests

Transformers shall be tested in the manufacturer's works. Transformers rated with 100 kW and above shall be tested in the presence of a Surveyor. A works test report covering the tests carried out shall be prepared.

The works test reports shall be presented on request. Tests noted as type tests shall be carried out on a prototype or the first of a batch of identical transformers.

Tests noted as routine tests shall be carried out on each transformer.

Required inspection and tests for transformers are given in Table 14.7.

Scope of the tests:

4.1 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 test at full load may be difficult to realise on large transformers, due to insufficient test power being available. One of these simulated tests, or equivalent may be accepted:

- Back to back method, according to IEC 60076-11 23.2.2
- Simulated load method, according to IEC 60076-11 23.2.1.

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.

Table 14.5 Minimum values for measurement voltage and insulation resistance

Rated voltage [V]	Measurement voltage [V]	Insulation resistance [MΩ]
$U_n \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$U_n/1000+1$
$7200 < U_n \leq 15000$	5000	$U_n/1000+1$

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

The following tests shall be performed at approximately operating temperature.

4.2 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 applied frequency shall be tested up to twice of nominal frequency (including twice of nominal frequency) for 60 seconds. The duration of the test shall be

$$120\,\mathrm{s} \cdot \frac{\text{rated frequency}}{\text{test frequency}}$$

but not less than 15 s.

4.3 Short-circuit test

On request, the short-circuit proof property in accordance with C.2.3 shall be verified.

4.4 Winding test (High Voltage Test)

The test voltage shown in Table 14.8 shall be applied after temperature rise test (if done) 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.

After rewinding or other extensive repair the transformer shall be subjected to a high voltage test with a test voltage of at least 75% of that specified in Table 14.8.

Tablo 14.7 Scope of testing and inspection of transformers

No	*Task*	*Routine Tests*	*Type Tests*	*IEC reference*
1	Inspection of enclosure, terminations, instrumentation or protection	x		
2	Measuring of insulation resistance	x		
3	Measuring of voltage ratio at no load and check of phase displacement	x		IEC 60076-11.16
4	Measuring of winding resistance	x		IEC 60076-11.15
5	Short circuit impedance and load losses	x		IEC 60076-11.17
6	Measuring of no-load loss and current	x		IEC 60076-11.18
7	Separate-source AC withstand voltage test	x		IEC 60076-11.19
8	Inducted AC withstand voltage test	x		IEC 60076-11.20
9	Temperature rise test		x	IEC 60076-11.23
10	Partial discharge measurement on transformer windings with Um ≥ 3.6 kV. Maximum level of partial discharge shall be 10 pC. (Not applicable to liquid immersed transformers.)	x		IEC 60076-11.22

Table 14.8 Test voltage for transformers

Maximum operating voltage [V]	Alternating withstand voltage [V]
≤1000	3000
3600	10000
7200	20000
12000	28000
17500	38000

4.5 Determination of insulation resistance

The measurement of insulation resistance shall be carried out at the end of the test sequence. Test voltage and minimum insulation resistance is given in Table 14.5. The test shall be carried out between:

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

The insulation resistance shall at least conform to the values indicated in Table 14.5.

4.6 Onboard testing

All transformers shall be subject to function tests with intended loading, after installation onboard.

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 by the use of series inductors and/or the selection of a higher capacitor voltage rating.

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.

4.5 Reactive power controllers or electrical interlocks are required to avoid overcompensation of the ship's network.

E. Storage Batteries, Chargers and Uninterruptible Power Supplies (UPS)

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 Charger equipment shall be suitable for the type of storage batteries, the required charging characteristic and the selected connection.

3.2 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.

3.3 If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed the rated voltage described in Section 1, Table 1.7. The power demand of the consumers shall be considered for the selection of the chargers.

3.4 Chargers with a charging power above 2 kW shall be tested in the presence of a **TL** Surveyor.

3.5 Refer to Section 17, C.2.2 c) regarding tests in the manufacturer’s works of battery chargers.

4. Uninterruptible Power Supplies (UPS)

4.1 General

4.1.1 These requirements to UPS units apply when providing an alternative power supply or transitional power supply to services as defined in Section 3, C. and D.
A UPS unit complying with these requirements may provide an alternative power supply as an accumulator battery in terms of being an independent power supply for services defined in Section 3, D.2.

4.1.2 Definitions

4.1.2.1 Uninterruptible Power System (UPS)

Combination of converter, inverter, switches and energy storage means, for example batteries, constituting a

power supply system for maintaining continuity of load power in case of input power failure (IEC publication 62040)

4.1.2.2 Off-line UPS unit

A UPS unit where under normal operation the output load is powered from the input power supply (via bypass) and only transferred to the inverter if the input power supply fails or goes outside preset limits. This transition will invariably result in a brief break in the load supply.

4.1.2.3 On-line UPS unit

A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the power supply input failing or going outside preset limits.

4.2 Design and construction

4.2.1 UPS units are to be constructed in accordance with IEC 62040, or an acceptable and relevant national or international standard. Battery ventilation shall be designed in accordance with Section 2, B.

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

4.2.3 The type of UPS unit employed, whether offline or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

4.2.4 A bypass or a second UPS in parallel is to be provided.

4.2.5 The UPS unit is to be monitored. An audible and visual alarm is to be given on the ship's alarm system for

- Power supply failure (voltage and frequency) to the connected load,
- Earth fault, if applicable,
- Operation of battery protective device,
- When the battery is being discharged, and
- When the UPS is not operating under normal condition.

4.3 Performance

4.3.1 The output power is to be maintained for the duration required for the connected equipment as stated in Section 3, D.

4.3.2 No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in Section 3, D.

4.3.3 On restoration of the input power supply, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

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 and 17.

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 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. Thermal bimetallic relays shall be temperature compensated.

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 Electronic protection devices

Electronic protection devices shall remain operative at their maximum permissible load at an ambient temperature of 55 °C.

4.6 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.

4.7 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.

4.8 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.

4.9 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 In areas attended by the crew at action stations only halogen-free cables shall be used for permanent installations. Cable trays/protective casings made of plastic materials as well as mounting materials shall be halogen-free as well.

Exceptions for individual cables for special purposes have to be agreed with **TL.**

For all other areas of the ship, the use of halogen-free cables is recommended.

1.2 Cables and wires shall be flame-retardant and self-extinguishing. If cable and wire types have passed a bundle fire test to IEC 60332-3, category A/F or IEEE 45. -18.13.5, the installation of fire stops is dispensed with when laying in bundles (see Section 12, D.14 and SOLAS II-1, Part D, Rule 45.5.2)

1.3 Where fireproof cables are to be installed, it is permissible to use cables with a retention of insulating capability in accordance with IEC publication 60331 (see Section 12, D.15).

1.4 Cables manufactured in accordance with the relevant recommendations of IEC 60092- 350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370, and 60092-376 will be accepted by **TL** provided that they are tested to its satisfaction.

Cables manufactured and tested to standards other than those specified like above mentioned will be accepted provided they are in accordance with an acceptable and relevant international or national standard and are of an equivalent or higher safety level than those listed in item 1.4 above. However, cables such as flexible cable, fibre-optic cable, etc. used for special purposes may be accepted provided they are manufactured and tested in accordance with the relevant standards accepted by **TL**.

2. Conductor material and structure

2.1 The conductor materials of cables and wires shall comply with IEC 60228.

2.2 If the insulation consists of natural or synthetic rubber vulcanized with sulphur, the individual conductor wires shall be tinned.

2.3 The conductors of movable wires must be finely stranded.

The conductors of permanently laid cables and wires shall be made of finely stranded copper conductors (class 2) or flexible stranded copper conductors (class 5), see IEC 60228.

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 and for special cables of TV and multimedia applications.

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.

2.4 Separating layer shall be used between conductor and insulation for single or multi-core cables. This layer may not be used when insulation easily removable from conductor guaranteed.

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 shall have a coating of protective paint, which shall be lead-free and flame-retardant. The paint shall be of sufficiently low viscosity when applied to enable it to penetrate readily into the wire braid. When dry, it shall not flake-off when the cable is bent around a mandrel with a diameter of 15 times that of the cable.

5. Identification

5.1 Each cable must be marked with the type and the name of the manufacturer.

5.2 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.

5.3 Protective earth conductors must have a green/ yellow colour coding.

6. Approvals

6.1 Cables and wires for shipboard installation are subject to mandatory type-approval by **TL**. Special cables and wires may be approved by individual tests.

6.2 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.

6.3 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.

7. Tests

7.1 Tests for type approvals 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.

7.2 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 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.

7.3 Major modifications to the electrical installations of ships in service or new ships under construction;

- Individual tests on type-approved cables and wires shall be performed at the manufacturer's works in the presence of a **TL** Surveyor.

- Individual tests on non-type-tested cables and wires shall be performed according to **TL** rules at the manufacturer's works in the presence of a **TL** Surveyor.

The scope of the tests shall be agreed according to the related standards 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. Cable Penetrations and Fire Stops

1. Bulkhead and deck penetrations

1.1 The sealing compounds and packing systems must be type-approved by **TL.**

1.2 The requirements for bulkhead and deck penetrations are stated in Section 12, D.8.

1.3 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.

2. Fire Stops

2.1 The requirements for fire stops using partitions or coatings are listed in Section 12, D.14.

2.2 The construction of fire stops using coatings is subject to a type test in the presence of a staff member of the **TL** Head Office in the manufacturer's works or in independent institutions.

The test requirements shall be agreed with **TL.**

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).

The method of connection shall be compatible with the terminals used.

For materials see Section 1, I.

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 (at least in areas attended by the crew in action stations) plastic, or shall 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, e.g. 60130 and 60603
- Containers, see Section 7, G.

J. Lighting Fixtures

1. General Requirements

Luminaires, floodlights and searchlights shall conform to IEC 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 Lighting fittings shall be so arranged as to prevent temperature rises which could damage the cables and wiring, and to prevent surrounding material from becoming excessively hot.

2.4 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.

2.5 All metal parts of a lighting fixture must be conductively connected together.

2.6 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.

2.7 Each lighting fixture must be durably marked with the following details:

- Maximum permitted lamp wattage
- Minimum mounting distance

K. Electrical Heating Equipment

1. General Requirements

1.1 Electrical heating equipment and boilers shall conform to IEC, e.g. 60335, with particular attention to IEC 60092-307. In addition the general assignments in I.1 shall be observed.

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 thermo-static controller.

Automatic reconnection of the safety temperature limiter is not permitted.

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 arrangements:

- An automatic or manual fire extinguishing system tested to an international standard **(1).**
- A primary or back up thermostat with an alarm to alert the operator in the event of failure of either thermostat
- Arrangements for automatically shutting of the electric power upon activation of the fire extinguishing system
- An alarm for indicating operation of the fire extinguishing system in the galley where the equipment is installed
- Controls for manual operation of the fire extinguishing system which are clearly labeled for ready use by the crew.

(1) *Reference ISO 15371:2000 "Fire-extinguishing systems for protection of galley deep-fat cooking equipment".*

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. Hazardous Areas

1. General

Hazardous areas can be divided according to IEC 60079 into the following zones depending on the probability that a dangerous explosive atmosphere may occur.

Zone 0:

This zone comprises areas in which a dangerous explosive atmosphere is present either permanently or for long periods.

Zone 1:

This zone comprises areas in which a dangerous explosive atmosphere is liable to occur occasionally.

Zone 2:

This zone comprises areas in which a dangerous explosive atmosphere is liable to occur only rarely, and then only for a brief period.

Non-classified areas:

Other areas, e.g. open decks, are considered to be nonclassified areas, i.e. safe areas. Reference is made to Section 1, J.3.

Typical hazardous area classifications are shown in Fig. 15.1.

2. Zone 1 Areas

2.1 Amphibious warfare ships

2.1.1 Closed vehicle decks extending to full height (with < 10 air changes/hour) or closed vehicle decks up to a height of 450 mm (with ≥ 10 air changes/ hour). The spaces above grating vehicle decks with adequate permeability are safe areas.

2.1.2 Vehicle decks below the bulkhead deck extending to the full height.

2.1.3 Well decks for landing craft, vehicles, etc. to the full height.

2.1.4 Exhaust ducts from holds and vehicle decks with a surrounding radius of 1 m of any ventilation opening for natural ventilation and of 3 m for forced ventilation.

2.1.5 Hazardous areas, e.g. for refuelling, maintenance, storage of fuel, weapon or explosives.

2.2 Ships for flight operation

2.2.1 Hangar decks above the bulkhead deck up to a height of 450 mm (at least 10 air changes/hour).

2.2.2 Hangar decks below the bulkhead deck extending to the full height.

2.2.3 Exhaust ducts from hangar decks with a surrounding radius of 1 m of any ventilation opening for natural ventilation and of 3 m for forced ventilation.

3. Zone 2 Areas

3.1 In general all spaces following a zone 1 in the horizontal or vertical direction have to be considered as zone 2 except they are divided by a gastight wall.

3.2 Areas above closed well decks (e.g. for military landing craft or military vehicles) are considered as zone 2.

3.3 Zone 2 applies also to areas of 1 m resp. 3 m after surroundings of open or semi-enclosed spaces of zone 1 as described in 2.1.4 or 2.2.3.

4. Other Area Classification

In exceptional cases hazardous area classification based on standard IEC 60079-10 may be accepted.

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.

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.

(1) *Monitoring of motor-fan switching devices is sufficient.*

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:

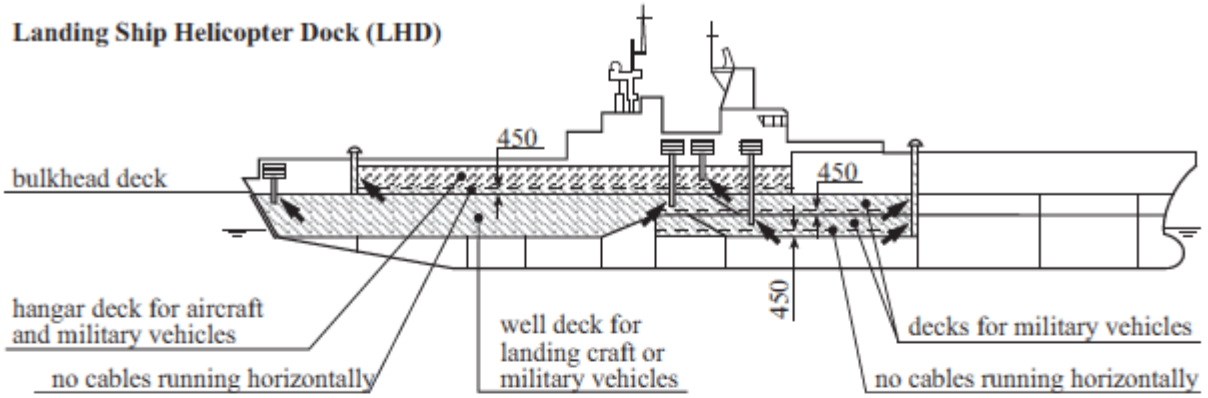
- Closing and opening of the door and
- Operation of the locking and securing devices

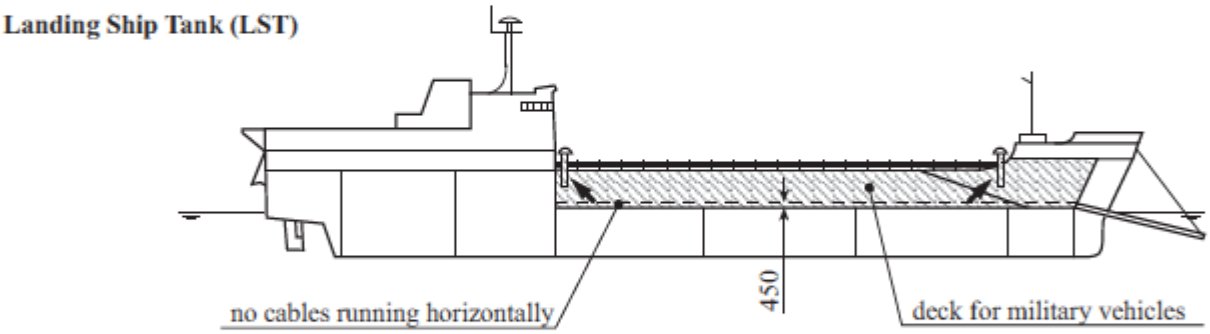
An indication of the open/closed position of each locking and securing device shall be provided at the remote-operating position. The operating consoles serving the doors shall be accessible only to authorised personnel. A notice drawing attention to the fact that all locking devices must be locked and 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 theindicating system must be independent of that for opening and closing the doors and is to be provided with a second power supply. The sensors of the indicating system must be protected against water,icing-up and mechanical damage (minimum degrees of protection IP 56).





Zones	Equipment design
above protection zone (zone 2)	IP 55 in conjunction ≥ 10 changes of air per hour (see Section 1, I.3.3.2)
protection zone (zone 1)	certified safe type equipment (see Section 1, I.3.4.2)

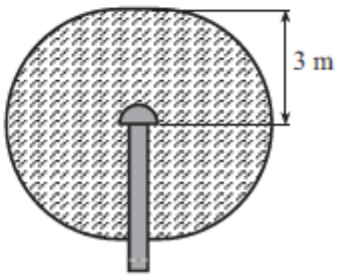


Figure 15.1 **Examples of protection areas at aircraft hangars, well decks and on vehicle decks for the carriage of military vehicles which are driven on and off the ship by their built-in drives and/or carry fuel in their tanks**

1.4 The indicating equipment on the bridge must have a "open/closed" selector switch which initiates an alarm if the ship leaves the harbor/landing location 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 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 luminaires

1.1 For illumination in all rooms and holds intended for vehicles of embarked troops primary lighting and additional secondary lighting have to be provided, which are to be supplied from two different switchboard.

The luminaires for secondary lighting are to be equipped with additional integral batteries which ensure that the escape routes are easily recognizable.

1.2 If all other sources of electrical power fail, these luminaires with additional batteries 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.

2. Escape Route Lighting

For marking of the escape routes and passageways

from the vehicle decks, hangars, etc. to safe locations an escape, evacuation and rescue lighting according to Section 11, B.5. is to be provided.

G. Installation of Electrical Equipment in Hazardous Areas

1. In 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. Zone 1

1.1 In areas, mentioned in B.2.1.1 to B.2.1.4 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.2.1.5 and B.2.2 shall be equipped under consideration of the characteristic hazards.

1.3 Certified safe type equipment in accordance with Section 1, J. 3.3.2 is permitted.

2. Zone 2

Equipment in accordance with Section 1, J.3.4.2 is permitted; the surface temperature must not exceed 200 °C.

SECTION 16

ADDITIONAL RULES FOR CARRIAGE OF DANGEROUS GOODS

A. General

1. Scope

These Rules apply to the electrical installations on naval ships which have to transport also dangerous goods in packaged form. Other forms of transport for dangerous goods are not covered by this Section.

The requirements are not applicable if such goods are transported only in limited or excepted quantities according to the IMDG Code, Volume 2, Chapter 3.4 and 3.5.

2. Certification

On request the "Document of Compliance for the Carriage of Dangerous goods" according to **SOLAS**, Chapter II-2, Regulation 19.4 may be issued after successful survey. These ships will be assigned the Notation **DG**, see also the **TL** Rules for Classification and Surveys, Chapter 101, Section 2.

B. References to other Rules

1. TL Rules

1.1 Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 9, N.

2. International Regulations and Codes

2.1 **SOLAS**, Chapter II-2, Regulation 19, "Carriage of dangerous goods"

2.2 **SOLAS**, Chapter VI, Part A, "General provisions"

2.3 **SOLAS**, Chapter VII, Part A, "Carriage of dangerous goods in packaged form"

2.4 IMO International Maritime Dangerous Goods (IMDG) Code

2.5 Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG)

2.6 IEC 60079, "Electrical apparatus for explosive atmospheres"

C. Classes of Dangerous Goods in Packaged Form

The dangerous goods in packaged form for which safety measures regarding the electrical equipment are required are committed in **SOLAS**, Chapters II-2 Reg. 19, IMDG Code and they are divided into Classes 1 to 9. A detailed definition of these classes for goods in packaged form is given in the **TL** Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 9, N.

D. Hazardous Areas and Permitted Electrical Equipment

Hazardous areas are areas, in which cargo according to C. is carried, and where this cargo can give rise to potentially explosive or explosive atmospheres. Explosion-protection measures are required in these areas.

1. General

Hazardous areas comprise the following:

1.1 Areas in which a dangerous gas/air mixture, dangerous vapours or a dangerous quantity and concentration of dust are liable to occur from time to time are defined to be areas subject to explosion hazard (zone 1).

1.2 Areas in which a dangerous gas/air mixture, dangerous vapours or a dangerous quantity and concentration of dust are liable to occur only rarely, and then only for a brief period, are defined to be extended dangerous areas (zone 2).

1.3 For the definition of hazardous areas, see Section 1, J.3.

2. Definition of Zones

Compare Figures 16.1 and 16.2.

2.1 Hazardous zone 1

2.1.1 For carriage of explosive substances in packaged form, according to class 1 (see C.), except goods in division 1.4, compatibility group S

a) Closed cargo spaces, and closed or open ro-ro cargo spaces

b) Stationary containers (e.g. magazines)

2.1.2 For carriage of flammable liquids with a flash point ≤ 23 °C in packaged form, flammable gases (see C.)

a) Closed cargo spaces and closed or open ro-ro cargo spaces

b) Ventilation ducts for hazardous areas

c) Enclosed or semi-enclosed rooms with nonclosable (e.g. by doors or flaps) direct openings to a) or b)

d) Areas on open deck or semi-enclosed spaces on open deck within 1,5 m of any ventilation opening as described in b)

2.2 Extended hazardous zone 2

a) Areas which can be separated by gas-tight doors from hazardous areas. Weathertight doors are considered to be adequately gastight.

These areas pass for safe if they

- have overpressure mechanical ventilation with at least 6 changes of air per hour.
  Should the ventilation fail, this shall be announced optically and audibly and the facilities not permitted for the extended hazardous area shall be switched off (see also 3.5)

or

- are naturally ventilated and protected by airlocks.

b) Bilge pump rooms and pipe ducts with components such as flanges, valves, pumps, etc., which come into contact with dangerous goods These areas pass for safe if they are mechanically ventilated with at least 6 changes of air per hour. Should the ventilation fail, this shall be announced optically and audibly and the equipment not permitted for the extended hazardous area shall be switched off (see also 3.5)

c) Areas of 1,5 m surrounding open or semienclosed spaces of zone 1 as described in 2.1.2 d.

3. Requirements for Electrical Equipment

3.1 Electrical equipment shall be installed in hazardous areas only when it is unavoidable for operational reasons. The explosion protection of the installed and operated electrical equipment shall meet the characteristics of the dangerous cargo.

3.2 Electrical equipment is defined as a certified safe type if it is manufactured to a recognized standard, such as IEC Publication 60079 and has been tested and approved by an approval authority recognized by **TL.**

3.3 For a naval ship intended to be used for the carriage of all the goods defined in C., the electrical equipment shall fulfil the following requirements:

- Degree of protection IP 65
- Maximum surface temperature 100 °C
- Explosion group II C
- Temperature class T5

3.4 On ships where containers with dangerous goods are stowed in special cargo holds (with the exception of class 1 goods, hydrogen and hydrogen mixtures), the electrical equipment shall fulfil the following requirements:

- Degree of protection IP 55

- Maximum surface temperature 135 °C

- Explosion group II B

- Temperature class T4

3.5 In ventilated rooms of zone 2, equipment important for the safety of the crew or the ship shall be so designed that it fulfils the requirements for unventilated spaces. It shall not be switched off.

3.6 Deviations from the provisions stated in 3.3 or 3.4 are possible. They are to be noted in the Certificate and restrict the carriage of dangerous goods in accordance with the characteristics of the materials and the equipment.

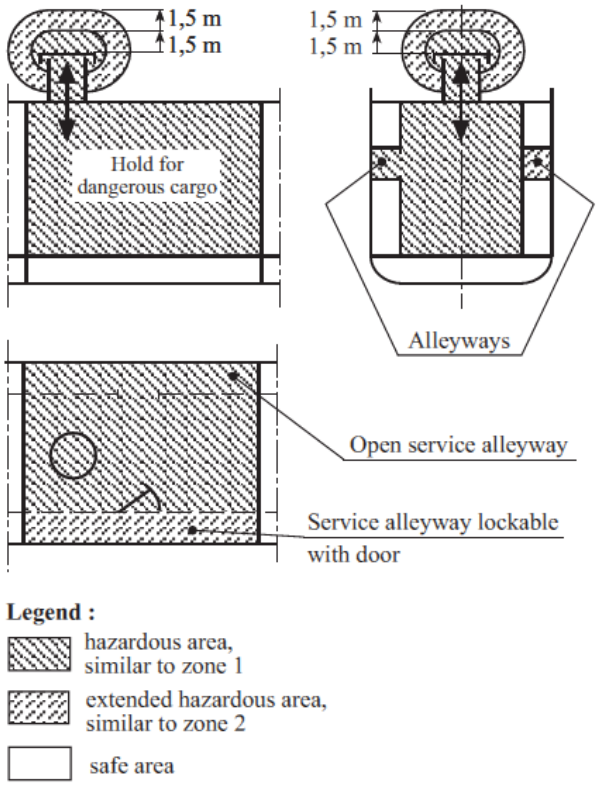


Fig. 16.1 Examples for service alleyways, open to the hold and lockable with door

E. Installation of Electrical Systems in Hazardous Areas

1. Installation of Electrical Equipment in Hazardous Area (Zone 1)

1.1 If electrical equipment is installed which is not suitable for use in areas with an explosion hazard, it shall be capable of being switched-off and safeguarded against unauthorized re-switching. The switching devices shall be located outside the hazardous area, and shall, wherever possible, consist of isolating links or lockable switches.

Where electrical equipment is important for the safety of the crew or the ship, it shall not be switched-off and shall be approved for use in hazardous areas.

1.2 Cables shall be armoured or shall have a braided screen, unless they are laid in metallic conduits.

1.3 Bulkhead- and deck penetrations shall be sealed to prevent the passage of gases or vapours.

1.4 Portable electrical equipment, important for aboard operation and used in hazardous areas or stipulated for such use by regulations shall be of a certified safe type.

2. Installation of Electrical Equipment in Extended Hazardous Areas (zone 2)

2.1 If electrical equipment is installed which is not suitable for the use in extended dangerous areas, it shall be capable of being switched-off and safeguarded against unauthorized re-switching. Switching-off shall be made outside of the hazardous area, unless the switching devices are approved for this area.

Where electrical equipment is important for the safety of the crew or the ship, it shall not be switched-off and shall be approved for the use in extended hazardous areas.

2.2 Cables shall be protected installed.

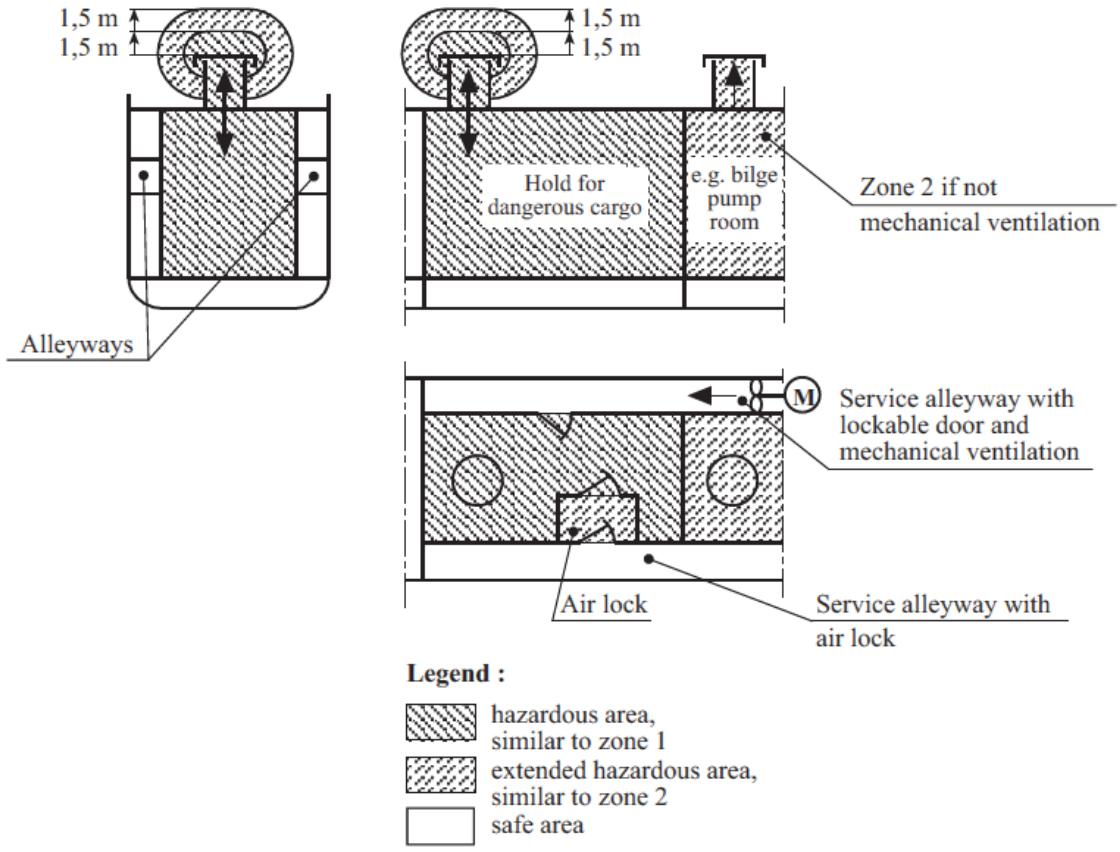


Fig. 16.2 Examples for service alleyways, lockable with door and air lock to the hold

F. Fire Pumps

If the fire extinguishing pressure drops, the fire pumps shall start automatically or shall be switched-on by a remote-starting device installed on the bridge, see also the **TL** Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 9.

SECTION 17

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, 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.

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

1. 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 unless the preconditions for one's own responsibility test by the manufacturer are fulfilled, see 3.

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 ≥ 100 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.

The following switchboards are subject for testing:

a) Electrical power generation plants

b) Electric propulsion plants

c) Motors starters for essential equipment

d) Distribution switchboards (e.g. main groups, groups, sub-groups) with connected power ≥ 50 kW

e) Equipment with Class Notation

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.

3. One's own responsibility tests made by the manufacturers

3.1 The products under 2.1 b), c); 2.2 b), c) and 2.3 c), d), e) may be tested on the manufacturer's own responsibility if the following preconditions are fulfilled:

- A QM system recognized by **TL** is available.
- **TL** has carried out type tests of the products.
- The one's own responsibility tests have been agreed with **TL.**

D. Tests on Board

1. General

The tests are divided into:

- Tests during construction/installation
- Tests during dock trials
- Tests during sea trials

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:

a) Protection against foreign bodies and water, see Section 1, J.

b) Protection against electric shock, such as protective earthing, protective separation or other measures as listed in Section 1, J.

c) Measures of explosion protection

The design must conform to the details on "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:

a) Acceptability of cable routing according to:

- separation of cable routes
- fire safety
- the reliable supply of essential equipment
- EMC measures, if class notation EMC is assigned

b) Selection and fixation of cables

c) Construction of watertight and fireproof bulkhead and deck penetrations

d) Insulation resistance measurement

For testing of cable network for medium-voltage installations, see Section 8.

3. Tests During Dock Trials

3.1 General

Proofs are required of the satisfactory condition and proper operation of all kinds of power supply (e.g. main, auxiliary, transitional, means for overcoming black-out and dead-ship condition), 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

3.2.1 A test run of the generator sets and as far as possible of the shaft generators shall be conducted under normal operating conditions.

3.2.2 For ships, where electrical power is necessary to restore propulsion, it shall be proved that after black-out and dead-ship condition (see **TL** Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 6, A.4.) the propulsion of the ship in conjunction with required machinery can be restored within 30 minutes after black-out.

3.3 Storage batteries

The following shall be tested:

a) Installation of storage batteries

b) Ventilation of battery rooms and boxes, and cross-sections of ventilation ducts

c) Storage-battery charging equipment

d) The required caution labels and information plates

3.4 Switchgear

The following items shall be tested:

a) Accessibility for operation and maintenance

b) Protection against the ingress of water and oil from ducts and pipes in the vicinity of the switchboards, and sufficient ventilation

c) Equipment of power station-, main group- group- and emergency (if applicable) switchboards with insulated handrails, gratings and insulating floor coverings

d) Correct settings and operation of protection devices and interlocks

e) 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:

a) Ventilation of the place of installation

b) Function of the equipment and protection devices

3.6 Electrical power generation plants

The following items shall be tested:

a) 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.

b) The emergency remote stops of equipment such as:

- engine room fans
- fuel pumps
- lubrication oil pumps
- separators
- boiler blowers, etc.

c) 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, E.

4. Tests During the Sea Trial

4.1 Rating of electrical power supplies

During the sea trial it shall be proved that all kinds of power supply (e.g. main, auxiliary, transitional, means for overcoming black-out and dead-ship condition) 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 operate satisfactorily at all operating conditions particularly during engine and steering gear manoeuvres.

4.2.2 Tests shall be carried out on the restoration of electrical power supplies following a black-out during navigation. The test procedure shall be submitted and agreed with **TL.**

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 Electrical propulsion plants

Regarding scope of tests, see Section 13.

E. Type Approvals

1. The installations, equipment and assemblies listed in 5. are subject to mandatory type-approval.

2. Type approvals shall be coordinated by staff members of **TL** Head Office and executed either in the manufacturer's works or, by agreement, in suitable institutions.

3. Type approvals are carried out according to IACS UR E10 and to defined standards.

4. Type approved installations, apparatuses and assemblies shall be used within the scope of valid Construction Rules only. The suitability for the subject application shall be ensured.

Special consideration is given additional to shock stress.

5. Equipment, Apparatuses and Assemblies Subject to Type Approval

5.1 Electrical equipment

5.1.1 Cables and accessories, see Section 14, G. and H.

a) Cables and insulated wires

b) Sealing compounds and packing systems for bulkhead- and deck penetrations

c) Busbar trunking systems for the installation

d) Cable trays/protective casings made of plastic materials are to be type tested in accordance with IACS UR E16, see Section 12, D.6. For guidance on testing, refer to IACS REC 73.

5.1.2 Switchgear, see Section 5, H.

a) Circuit-breakers, load switches, disconnect switches and fuses for direct connection to the main busbars or non-protected distribution busbars of electrical power generation plants-main groups-, and propulsion switchboards

b) Standardized switchgear units manufactured in series with reduced clearance- and creepage distances, see Section 5, F.3.2

5.1.3 Generator/network protection devices, see Section 4, A.

a) Short-circuit protection

b) Overcurrent protection

c) Reverse-power protection

d) Automatically synchronizing device

e) Underfrequency protection

f) Over- and undervoltage protection

g) Differential protection

h) Earth fault/insulation monitoring.

5.2 Steering gear and azimuting propulsors

For steering gear, see Section 7, A.

5.2.1 Input devices such as:

a) Phase failure relays

b) Level sensors

5.2.2 Steering gear control systems with all components important for the function, e.g.

a) Steering mode selector switch

b) 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.

a) Open and closed loop control for speed and power of internal combustion engines (main and auxiliary engine- and electrical actuators

b) Safety devices

c) Safety systems

5.5 Ship's control and safety systems

For ship's control and safety systems, see Section 9, B., C., D and Chapter 107, Section 2.

a) Fire detection- and alarm systems

b) Suction-type smoke-detection systems

c) Loading computer (e.g. for amphibious warfare ships), if applicable;

d) Automatic stop devices and control units for ship stabilization systems, see **TL** Rules for Ship Operatiom Installation and Auxiliary Systems, Chapter 107, Section 2.

e) Flame detectors, remotely controlled valves, control electronics and fire detection systems for fixed water-based local application fire-fighting systems (FWBLAFFS, see Section 9, D.)

f) Combustion engine crankcase oil mist detection monitoring device/syste. See TL Rules for Ship Operation Installations and Auxiliary Systems, Chapter 107, Section 2

5.6 Computer systems

For computer systems, see Section 10, E.

5.7 Installations, applied by **TL** Rules for Construction for automated and/or remotely controlled systems, see the **TL** Rules for Automation, Chapter 106.

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6. Exceptions

6.1 Instead of the stipulated type approvals 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 18

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 the manufacturer's recommendations are to be considered.

3. The amount of spare parts shall be documented and a corresponding list shall be carried on board.