RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 2. INLAND WATERWAYS SHIP

VOLUME IV
RULES FOR ELECTRICAL INSTALLATIONS
2015 EDITION

BIRO KLASIFIKASI INDONESIA

RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 2. INLAND WATERWAYS SHIP

VOLUME IV
RULES FOR ELECTRICAL INSTALLATIONS
2015 EDITION

Biro Klasifikasi Indonesia
Jl. Yos Sudarso No. 38-40, Tanjung Priok
Jakarta 14320
www.bki.co.id
rules@bki.co.id

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Foreword

Rules for Electrical Installations – Inland Waterways Volume IV 2015 Edition. Reference source of the rules are derived from Safety of Life at Sea (SOLAS), IACS Unified Requirement, IACS Recommendation, others code and input from BKI Branch Office and Technical Division of BKI Head Office.

The content of this rules consist of eight section below :

A. General
B. Design and Construction of Power Generating Plant
C. Electrical Machines
D. Transformers and Reactors
E. Storage Batteries
F. Power Distribution
G. Switchgear Installations and Switchgear
H. Steering Gears, Lateral Thrust Propeller Systems and Active Rudder Systems
I. Electric Heating Appliances
J. Lighting Installations
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N. Power Electronics
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Section 1
Electrical Installations

A. General

1. General

1.1 Scope

These Construction Rules apply to electrical installations aboard inland ships as well as on other water craft and floating gear on inland waters. BKI reserves the right to authorize departures from these Rules in individual cases or to stipulate special requirements for new types of installation or operating equipment.

1.2 Rules and standards

Beside these Rules electrical equipment shall meet a standard approved by BKI such as IEC.

Existing national rules are to be observed.

1.3 Basic requirements

1.3.1 All electrical machinery, appliances, cables and accessories are to be selected, designed and constructed for satisfactory performance under the conditions stated in Table 2.1.

Table 2.1. Working conditions

Conditions	
Permanent list to port or starboard [1]	1512 °
Permanent trim [1]	5 °
Ambient temperature	45 °C
[1] May occur simultaneously	

Ambient temperature inside 0 to + 45°C

Ambient temperature on open decks -20 to + 45°C

1.3.2 All the electrical appliances used on board shall be so designed and constructed that they remain serviceable despite the voltage and frequency variations occurring in normal shipboard service. Unless otherwise specified, considerations may be based on the variations shown in Table 2.2.

Networks or sub-networks with greater voltage variations may be approved for consumers intended for operation with greater variations.

1.3.3 In equipment with electronic frequency converters, the voltage waveform may deviate from that specified in B.5.2.1 provided that measures are taken to ensure that this does not interfere with the operation of consumers or other equipment such as radio and navigation facilities.

If necessary, converters or similar means should be used for separation from the mains.

The total harmonic distortion shall be less than or equal to 5 %.

Table 2.2. Voltage and frequency variations

	Variable	Variation	
		Permanent	Transient
General	Frequency	± 5 %	± 10 % 5 s
	Voltage	+ 6 %	± 20 % 1.5 s
		– 10 %	
Battery operation	Voltage	± 20 %	

1.3.4 Electrical machines and appliances shall be so constructed and installed that they will not be damaged by the vibrations and shaking occurring in normal shipboard service.

The natural frequencies of foundations, fastenings and suspensions for machines, appliances and electrical components (including those inside appliances) shall not lie within the frequency range 5 − 100 Hz.

If, for reasons of design, the natural frequency has unavoidably to lie within the aforementioned frequency range, the accelerations are to be sufficiently damped to exclude the likelihood of malfunctions or damage.

1.3.5 The materials used for the construction of electrical machines, cables and appliances shall be resistant to moist air and oil vapours. They shall not be hygroscopic and shall be flame-retardant. The dimensions of minimum creep distances and air clearances are to conform to IEC 60664-1. Relaxations may be allowed for installations up to 50 V.

1.4 Protective measures

1.4.1 Protection against shock and water

The type of protection or enclosure of every machine and every other item of equipment shall be compatible with the site where it is installed. The particulars in Table 2.3 are minimum requirements.

1.4.2 Protection against electric shock: direct

Protection against direct contact includes all the measures designed to protect persons against the dangers arising from contact with live parts of electrical appliances. Live parts are deemed to be conductors and conductive parts of appliances which are live under normal operating conditions.

Electrical appliances shall be so designed that the person cannot touch or come dangerously close to live parts, in way of the determined operation.

Protection against direct contact may be dispensed with in the case of equipment using safety voltage.

In service spaces, live parts of the electrical appliances shall remain protected against accidental contact when doors and covers which can be opened without a key or tool are opened for operation purposes.

Table 2.3. Minimum degrees of protection

Type of space	Minimum type of protection in accordance with IEC Publication 60529							
	Generators	**Motors**	**Transformers**	**Switchboards, consoles, distribution boards**	**Measuring instruments**	**Switchgear**	**Installation material**	**Lamp fittings**
Service spaces, machinery and steering gear spaces	IP 22	IP 22	IP 22	IP 22 [1, 4]	IP 22	IP 22 [1, 4]	IP 44	IP 22
Refrigerate d holds		IP 44		IP 44		IP 44	IP 55	IP 55
Cargo holds		IP 55		IP 55		IP 55	IP 55	IP 55
Storage battery, paint storage and lamp room								IP 44 [5] and (EX)
Ventilating trunks(deck)		IP 44					IP 55	
Exposed deck, steering stations on open deck		IP 55 [3]		IP 55 [3]	IP 55 [3]	IP 55 [3]	IP 55 [3]	IP 55
Closed wheelhouse		IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
Accommoda tion and Public rooms				IP 22			IP 20 IP 55 [2]	IP 20
Sanitary Facilities and commissary spaces		IP 44	IP 44	IP 44			IP 55	IP 44

[1] IP 12 for appliances generating a large amount of heat.

[2] Where laid behind ceiling.

[3] IP 56 for appliances subject to flooding.

[4] Where the class of protection is not provided by the appliance itself, the site at which it is installed must have the level of protection stated in the Table.

[5] Electrical appliance of certified safety, e.g. in accordance with IEC Publication 60079 or EN 50014-50020.

1.4.3 Protection against electric shock: indirect contact

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

– protective earthing (see 1.4.4)

– protective insulation (double insulation)

– operation at very low voltages presenting no danger even in the event of a fault

The additional usage of Residual Current Protective Devices is allowed except for steering and propulsion plant.

1.4.4 Protective earthing

Metal casings and all metal parts accessible to touch which are not live in normal operation but may become so in the event of a fault are to be earthed except where their mounting already provides a conductive connection to the ships's hull. Special earthing may be dispensed with in the case of:

a) metal parts insulated by a non-conductor from the dead or earthed parts

b) bearings of electrical machines which are insulated to prevent currents flowing between them and the shaft

c) electrical equipment whose service voltage does not exceed 50 V

Where machines and equipment are earthed to the hull via their mountings, care is to be taken to ensure good conductivity by clean metal contact faces at the mounting. Where the stipulated earth is not provided via the mountings of machinery and equipment, a special earthing conductor is to be fitted for this purpose.

For the earthing of metal sheaths, armouring and cable braiding, see L.15.1.4.

Protection shall be provided by an additional cable, an additional lead or an additional core in the power cable.

Metal cable armouring may not be used as an earthing conductor.

A conductor normally carrying current may not be used simultaneously as an earthing conductor and may not be connected with the latter by a common connection to the ship's hull.

The cross-section of the earthing conductor shall be at least in accordance with Table 2.4.

Table 2.4. Cross-section of earthing conductors

Cross-section of main conductors [mm^2]	**Minimum cross-section of earthing conductor**	
	Earthing conductor incorporated in the cable [mm^2]	**Earthing conductor separated from the cable [mm^2]**
0,5 up to 4	Equal to the main conductor	4
> 4 up to 16	Equal to the main conductor	Equal to the main conductor
> 16 up to 35	16	16
> 35 up tp 120	Equal to the half main conductor	Equal to the half main conductor
> 120	70	70

The connections of earthing conductors to the metal parts to be earthed and to the ship's hull are to be made with care and are to be protected against corrosion.

The casings of mobile power consumers and portable devices shall, during normal operation, be earthed by means of an additional earthing conductor, that is incorporated into the power cable. That provision shall not apply where a protective circuit separation transformer is used, nor to appliances fitted with protective insulation (double insulation).

Electrical equipment in the area subject to explosion hazard is in every case to be fitted with an earthing conductor irrespective of the type of mounting used.

1.4.5 Explosion protection: hazardous areas, zone 0

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

For electrical installations in these areas the permitted equipment that may be fitted is:

– intrinsically safe circuits Ex ia

– equipment specially approved for use in this zone by a test organization recognized by BKI

1.4.6 Explosion protection: hazardous areas, zone1

These areas include e.g.:

– paint rooms

– storage battery rooms

– areas with machinery, tanks or piping for fuels with a flash point below 60 °C, or flammable gases, see 1.4.10

– ventilation trunks

Areas subject to explosion hazard zone 1 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.

Electrical equipment shall not be installed or operated in areas subject to explosion hazard, with the exception of explosion-protected equipment of a type suitable for shipboard use. Electrical equipment is deemed to be explosion-protected, if they are manufactured to a recognized standard such as IEC 60079 publications, and if they have been tested and approved by a testing authority recognized by BKI. Notes and restrictions at the certificate have to be observed.

Certified safe type equipment listed in Table 2.5 is permitted.

Cables in hazardous areas zone 0 and 1 shall be armoured or screened, or run inside a metal tube.

Table 2.5. Certified safe type equipment

Permitted equipment	
Intrinsic safety	Ex i
Flameproof enclosure	Ex d
Pressurized apparatus	Ex p
Increased safety	Ex e
Special type of protection	Ex s
Oil immersion	Ex o
Encapsulation	Ex m
Sand filled	Ex q

1.4.7 Explosion protection: extended hazardous areas, zone 2

Areas directly adjoining zone 1 lacking gastight separation from one another are allocated to zone 2. For equipment in these areas protective measures are to be taken which, depending on the type and purpose of the facility, could comprise e.g.:

– use of explosion-protected facilities, or

– use of facilities with type Ex n protection, or

– use of facilities which in operation do not cause any sparks and whose surfaces, which are accessible to the open air, do not attain any unacceptable temperatures, or

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

1.4.8 Explosion protection: electrical equipment in paint rooms

In the above-mentioned rooms (Zone 1) and in ventilation ducts supplying and exhausting these areas, electrical equipment shall be of certified type as defined in 1.4.6 and comply at least with II B, T3.

Switches, protective devices and motor switchgear for electrical equipment in these areas shall be of all poles switchable type and shall preferably be fitted in the safe area.

Doors to paint rooms have to be gastight with self closing devices without holding back means.

1.4.9 Protective measures in the case of ignitable dust

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

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

1.4.10 Explosion protection: Pipe tunnels

All equipment and devices in pipe tunnels containing fuel lines or adjoining fuel tanks shall 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, e.g. in ore or oil carriers, or where pipes inside these tunnels convey combustible liquids with a flash point below 60 °C, all the equipment and devices in pipe tunnels shall be certified explosion-protected in accordance with 1.4.6 (zone 1).

1.4.11 Amount of electrical facilities

Amount and ignition protection of approved electrical equipment in zones 0,1 and 2 may be restricted in the different areas where they are used. The relevant current construction Rules have to be observed for this reason.

1.4.12 Explosion protection on tankers

Regarding hazardous areas and approved electrical equipment on tankers see the Rules for Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) Section 3.

1.4.13 Explosion protection for ships for the carriage of dangerous goods

Regarding hazardous areas and approved electrical equipment on ships for the carriage of dangerous goods, see the Rules for Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) Section 3.

1.4.14 Batteries room

See E.

1.4.15 Electromagnetic compatibility (EMC)

Where necessary, appropriate measures shall be taken to avoid interference due to electromagnetic energy. This applies especially to radio equipment and electronic appliances (e.g. self-steering gear for river navigation).

Details are contained in IEC 60533.

2. Documents for review/approval

2.1 New buildings

2.1.1 The drawings and documents listed below are to be submitted to BKI, at least, in triplicate[1] for examination in sufficiently good time to enable them to be reviewed/approved and made available to the Building Yard and the Surveyor by the time the manufacture or installation of the electrical equipment begins. To facilitate a smooth and efficient approval process. the drawings could be submitted in electronic format.

Where non-standard symbols are used in circuit and wiring diagrams, a legend explaining the symbols is to be provided.

All documents for review/approval shall bear the yard number and the name of the shipbuilder.

BKI reserves the right to call for additional documents and drawings should those stipulated in 2.1.2 to 2.1.9 prove insufficient for an assessment of the plant.

2.1.2 Details of the nature and extent of the electrical installations including the power balance (electrical balance).

2.1.3 A general circuit diagram of the electrical plant showing the basic configuration of the power distribution system with details of the power ratings of generators, converters, transformers, storage batteries and all major consumers.

2.1.4 Cable layout or tabulated list of cables showing cable sections and types as well as generator and consumer loads (currents).

2.1.5 Circuit diagrams for:

– main switchgear installations
– emergency switchgear installations, where applicable
– spaces with an explosion hazard with details of installed equipment, where applicable
– lighting system
– navigation light system
– electrical propulsion plants, where applicable

2.1.6 Circuit diagrams of control, alarm and monitoring installations, where applicable, such as:

– alarm systems

[1] For ships flying Indonesian flag in quadruplicate, one of which intended for the Indonesian Government

– fire alarm systems
– tank level indicators, alarms, shut-off facilities
– gas detector systems
– emergency shut-off facilities
– watertight door control systems
– computer systems
– communication systems
– propulsion system

2.1.7 Steering gear circuit diagrams with details of the drive, control and monitoring systems. The steering gear includes lateral thrust propellers, active rudder equipment etc.

2.1.8 Installation plan

The plan is to provide details of the exact location of the switchboard, the size of service passageways, distances from bulkheads and frames etc.

2.1.9 For tankers carrying cargo with a flash point of ≤ 60 °C additional plans are to be submitted which shall show the following:

– the installation sites of all electrical equipment
– the limits of the cargo area with differentiation of those parts of the installation situated above and below deck
– machines and equipment whose use is forbidden during loading, unloading and gas-freeing are to be marked in red
– details in line with Rules Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) Section 3 are to be observed.

3. Systems, Voltages and Frequencies

3.1 Systems

3.1.1 As a general principle, systems listed in 3.1.2 to 3.1.4 are permitted.

3.1.2 For direct current and single-phase alternating current:

– 2 conductors, one of which is earthed
– single conductors with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)
– 2 conductors insulated from the ship's hull

3.1.3 For 3-phase alternating current:

– 4 conductors with earthed neutral and no hull return
– 3 conductors insulated from the hull
– 3 conductors with hull as neutral conductor, however, not in final subcircuits.

3.1.4 Other systems have to be approved by BKI in each case.

3.1.5 Special rules

Systems using the hull as neutral conductor are not permitted:

– on tankers (see the Rules Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) Section 3, B.4 and C.5.

– on floating craft or ships whose hull can be dismantled.

This provision does not apply to:

– local installations outside the cargo area (e.g. connections of starters of diesel engines)

– the device for checking the insulation level

– the installations for cathodic protection.

The power supply lines from one barge to another in pusher tug trains shall be insulated on all poles.

3.2 Voltage and frequencies

3.2.1 Standard voltages

The use of standard voltages and frequencies is recommended. Generators may have rated voltages up to 5 % higher than the rated voltage of the consumers.

3.2.2 Operating voltages

The operating voltages indicated in Table 2.6 may not be exceeded.

In special installations (e.g. radio equipment, specific power systems, ignition equipment) higher voltages are permitted subject to compliance with the necessary safety measures.

4. Type approvals

4.1 General

4.1.1 The installations, equipment and assemblies mentioned in 4.1.5 are subject to mandatory type approval.

4.1.2 Type tests shall be carried out in the presence of a BKI Surveyor either in the manufacturer's works or, by agreement, in suitable institutions.

4.1.3 Type tests are carried out according to the BKI Rules for approval of equipment.

4.1.4 Type tested installations, apparatuses and assemblies shall be used within the scope of valid construction Rules only. The suitability for the subject application shall be ensured.

4.1.5 Installations, apparatuses and assemblies subject to type testing

Following installations, apparatuses and assemblies are subject to type testing:

– steering gear electronic control systems

– variable pitch propeller electronic control systems

– main engine electronic control systems for speed and power

– fire detection and alarm systems on passenger ships

Table 2.6. Maximum permissible operating voltages

Type of installation	Maximum permissible operating voltage		
	DC	1-phase AC	3-phase AC
Power and heating installations including the relevant sockets	250 V	250 V	500 V
Lighting, communications, command and information installations including the relevant sockets	250 V	250 V	–
Sockets intended to supply portable devices used on open decks or within narrow or damp metal lockers, apart from boilers and tanks:			
– In general	50 V [1]	50 V [1]	–
– Where a protective circuit-separation transformer only supplies one appliance	–	250 V[2]	–
– Where protective-insulation (double insulation) appliances are used	250 V	250 V	–
– Where ≤ 30 mA default current circuit breakers are used.	–	250 V	500 V
Mobile power consumers such as electrical equipment for containers, motors, blowers and mobile pumps which are not normally moved during service and whose conducting parts which are open to physical contact are grounded by means of a grounding conductor that is incorporated into the connecting cable and which, in addition to that grounding conductor, are connected to the hull by their specific positioning or by an additional conductor	250 V	250 V	500 V
Sockets intended to supply portable appliances used inside boilers and tanks	50 V [1]	50 V [1]	–

[1] Where that voltage comes from higher voltage networks galvanic separation shall be used (safety transformer).

[2] All of the poles of the secondary circuit shall be insulated from the ground.

– tank level gauging equipment on tankers

– computer systems with Requirement Class 3 and higher

4.2 Exceptions

Instead of the stipulated type approvals in well founded cases routine tests in the presence of a Surveyor may be carried out. An agreement with BKI prior to testing is required.

B. Design and Construction of Power Generating Plant

1. General requirements

Every power supply system on inland ships shall comprise at least one main and one auxiliary power source.

2. Power source

2.1 Design

The power source may take the form of:

a) Two diesel sets. Special restrictions for the supply of steering gear systems see H.1.4.8.

b) One diesel set and one power supply battery (in accordance with c).

c) One generator driven by the main propulsion unit (shaft generator) is accepted as a main source provided a power supply battery is installed as the auxiliary source.

This design may be accepted if, in all sailing and maneuvering conditions, including propeller being stopped, this generator is not less effective and reliable than an independent generating set.

The power supply battery shall be capable of supplying essential consumers for at least 30 minutes automatically and without intermediate recharging.

It shall be possible to recharge the battery with the means available on board even when the main engine is stationary, e.g. by using charging generators (lighting dynamos) driven by auxiliary machinery or by shore power via a battery charger.

d) Other energy generating systems can be permitted by BKI.

3. Power balance

3.1 Power requirements

A power balance for the electrical plant shall be furnished as proof that the generator rating is sufficient.

The power requirements are to be determined for day/night running service and emergency supply, if any.

A table is to be compiled listing all the installed electrical consumers together with their individual power ratings:

a) Account is to be taken of the full power rating of those consumers permanently required for the operation of the ship.

b) The installed capacity of consumers kept in reserve is to be listed. The consumption of those consumers which operate only following the failure of a unit of the same kind need not be included in the calculation.

c) The aggregate power consumption of all consumers intermittently connected to the supply is to be multiplied by a common simultaneity factor and the result added to the sum of the permanently connected consumers.

The simultaneity factor may be applied only once in the course of the calculation.

Consumers with a relatively high power consumption, such as the drive units of bow thrusters, are to be included in the calculation at their full rating even though they may be used only intermittently.

The sum of the loads represented by a) and c), with due allowance for the battery charging capacity, is to be used when deciding the generator rating.

Unless some other standby capacity such as a floating battery is available, some spare capacity is to be designed into the system to cover short-lived peak loads like those caused by the automatic start-up of large motors.

4. Emergency power source on passenger ships

4.1 General

For emergency power sources on passenger ships, see Rules for Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) section 2.D.5.

5. Generator ratings control

5.1 DC generators

5.1.1 The following may be used to supply DC shipboard networks:

– regulated single or 3-phase AC generators connected to a rectifier

– compound-wound generators

– shunt generators with automatic voltage regulator

5.1.2 Generators shall be designed so that, even with the battery disconnected, their voltage characteristic and harmonic content remain within the prescribed limits over the whole load range and they themselves suffer no damage. They should be so designed that a short-circuit at the terminals produces a current not less than three times the rated current. They shall be able to withstand the sustained short-circuit current for 1 second without suffering damage. Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short-circuits in the ship's network is assured at even lower sustained short-circuit currents, possibly in conjunction with a parallel connected power supply battery.

The regulator characteristic of the generators shall ensure that connected power supply batteries are without fail fully charged over the whole load range and overcharging is avoided.

5.2 Single and 3-phase AC generators

5.2.1 Generator design

The apparent output of 3-phase generators shall be rated such that no unacceptable voltage dips occur in the shipboard supply as a result of the starting currents affecting normal operation. On no account may the start up of the motor with the greatest starting current give rise to an undervoltage causing consumers already in service to cut-out.

The waveform of the no-load phase-to-phase voltage should be sinusoidal as far as possible. The deviation from the sinusoidal fundamental wave should at no time be greater than 5 % in relation to the peak value of the fundamental wave.

The root-mean-square (r.m.s.) values of the phase voltage with symmetrical loading shall not vary from each other by more than 0,5 %.

If the neutral points of generators running in parallel are connected, the waveforms of the phase voltages should coincide as nearly as possible. The use of generators of the same type is recommended. As a general principle, it is necessary to ensure that the equalizing current determined by the harmonic content does not exceed 20 % of the rated current of the machine with the lowest capacity.

The generators and their exciters are to be so designed that for two minutes the generator can be loaded with 150 % of its rated current with an inductive power factor of 0,5 while approximately maintaining the rated voltage. Generators may suffer no damage as a result of a short-circuit and the short circuits which may occur in the supply network in later service. The design shall take account of the short time delay of the generator switches which is necessary to the selectivity of the system and during which the short-circuit current is sustained.

With voltage-regulated generators it is necessary to ensure that an input data failure cannot lead to unacceptable high terminal voltages.

5.2.2 Conditions

Under balanced load conditions, 3-phase alternators and their exciters are required to meet the following conditions:

a) Steady conditions

When the alternator is operated with the associated prime mover, 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. For this purpose the prime mover shall be set to its rated speed at rated output.

b) Transient control conditions

With the generator running at rated speed and rated voltage, the voltage shall not deviate below 85 % or above 120 % of its rated value as the result of the sudden connection or disconnection of balanced loads with a specified current and power factor. It shall regulate within the limits stated in a) in not more than 1,5 seconds. Under test conditions, the generator may in this connection be driven at practically constant speed, e.g. by a suitable electric motor.

Unless the client specifies particular load changes, the above requirements are to be satisfied under the following conditions:

The idling generator, excited to its rated voltage, is to be suddenly connected to a load equal to 60 % of its rated current with a (lagging) power factor not greater than 0,4. Once steady state control conditions have been attained, the load is to be suddenly disconnected.

c) Sustained short-circuit current

The sustained short-circuit current at a single, two or 3-phase terminal short shall not be less than three times the rated current. The generator and its exciter shall be able to carry the sustained short-circuit current for a period of one second without suffering damage.

Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the ship’s network is assured at even lower sustained short-circuit currents.

5.2.3 Three-phase AC generators for parallel operation

Where generators of the same output are run in parallel with the active load shared equally, the reactive power of each machine shall not deviate from its percentage share by more than 10 % relative to its rated reactive power.

Where the generators differ in output, the deviation from the proportional share within the aforementioned load range shall not exceed the smaller of the following values, assuming proportionally equal sharing of the active load:

a) 10 % of the rated reactive power of the largest machine

b) 25 % of the rated reactive power of the smallest machine.

6. Generator prime movers

6.1 Design and control

The design and control of generator prime movers are to conform to Section 1, B.

6.2 Parallel operation

The governing characteristics of prime movers in the case of single or 3-phase alternator sets of the same output operating in parallel shall 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.

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

a) 15 % of the rated active power of the largest machine

b) 25 % of the rated active power of the smallest machine.

6.3 Cyclic irregularity

The permissible cyclic irregularity is to be agreed upon between the prime mover and generator manufacturers. The following has to be ensured:

a) faultless parallel operation of 3-phase generators

b) Regular or irregular load variations shall not give rise to fluctuations in active power output exceeding 10 % of the rated output of the machine concerned.

c) practically non-flicker lighting at all working speeds

7. Special rules

7.1 General

Notwithstanding the conditions set out above, other speed and control characteristics may be approved for generators with outputs of up to 10 kW (kVA) provided that trouble free operation remains assured.

Where generators are backed up by floating batteries it is necessary to ensure that the absence of the battery voltage cannot damage the generators and controllers.

C. Electrical Machines

1. Construction

1.1 General

1.1.1 This unless otherwise stated in the following Rules, all motors and generators shall conform to a standard accepted by BKI.

1.1.2 In conjunction with the protective equipment to be provided, generators shall be capable of withstanding the dynamic and thermal stresses produced by a short circuit. All machines are to be so designed and constructed that the permissible temperature rises stated in Table 2.7 are not exceeded.

The insulation classes have to correspond to the ratings IEC 60085.

In the case of laminated insulations, the highest temperature permitted for each individual insulating material shall not be exceeded.

All windings shall be effectively protected against the effects of moist or salty air and oil vapours.

On DC machines, the commutating pole windings are to be connected symmetrically to the armature, wherever possible. Anti-interference capacitors are to be connected directly to the armature terminals. Anti interference capacitors on generators shall have built in cut-outs.

1.1.3 The carbon brushes shall be compatible with the slip ring and commutator materials and, in the case of the latter, with the commutating conditions.

The working position of the brush holder is to be clearly marked.

1.1.4 The terminals shall be located in an easily accessible position and shall be dimensioned to suit the cross-section of the cables to be connected. The terminals are to be clearly marked.

The class of protection shall match that of the machine and shall be at least IP 44.

Exceptions to this Rule may be permitted for machines with a working voltage of ≤ 50 V.

1.1.5 The manufacturer shall provide every generator and motor with a name and data plate containing the machine's serial number and all essential operating data.

1.1.6 Commutators, slip rings and, wherever possible, windings shall be easily accessible for the purposes of inspection, maintenance and repair. On larger machines with plain bearings it shall be possible to check the air gap.

1.1.7 Generators driven by the main engine, the propeller shaft or by an auxiliary set intended for other purposes shall be designed with respect to the range of rotational speeds which can occur during normal operation.

2. Testing of electrical machines

2.1 Works test certificates

2.1.1 For generators and electrical motors with rated power less than 50 kVA or 50 kW, which have not been tested in the presence of a Surveyor, works test certificates are to be submitted to BKI Head Office.

2.2 Scope of tests

2.2.1 Temperature rise test (heat test)

a) A heat test shall be performed until the steady state temperature corresponding to the required mode of operation is reached. The steady-state temperature pass for 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 2.7 shall not be exceeded.

b) An extrapolation of the measured values to the disconnection time (t = 0) is not necessary if the reading takes place within following periods:

   – up to 50 kVA/kW 30 s

   – over 50 up to 200 kVA/kW 90 s

   – over 200 up to 5000 kVA/kW 120 s

c) Heat tests on machines of identical construction made not more than 3 years previously can be recognized. The referenced temperature rise shall be at least10 % lower than that listed in Table 2.7.

The following tests shall be carried out at approximately normal operating temperatures.

2.2.2 Load characteristics

On generators the voltage and on motors the speed is measured as a function of the applied load.

2.2.3 Overload test

a) For generators:

1,5 times the rated current for two minutes

1,6 times the rated torque for 15 seconds. During the test, the motor speed may not drop below its pull out speed

c) For windlass motors:

1.6 times the rated torque for 2 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.

b) For standard motors:

2.2.4 Short-circuit test on 3-phase AC generators

a) On all synchronous generators, the steady short circuit current shall be determined with the exciter unit in operation (see B.5.2.2 c).

b) 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.

2.2.5 High-voltage test (winding test)

a) The test voltage shall be as shown in Table 2.8.

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 is to be used as reference in determining the test voltage.

b) Any repetition of the voltage test which may be necessary shall be performed at only 80 % of the nominal test voltage specified in Table 2.8.

2.2.6 Over speed test

As proof of mechanical strength, a two-minute over speed test is to be carried out as follows:

a) for generators with their own drive, at 1,2 times the rated speed

b) for generators coupled to the main propulsion system, at 1,25 times the rated speed

c) for constant-speed motors, at 1.2 times the no load speed

Table 2.7 Permitted temperature-rises of air cooled machines at an ambient temperature of 40°C (difference values in K)

No.	Machinery component		Method of Measurement[3]	Installation class				
				A	E	B	F[1]	H[1]
1	AC windings of machines		R	60	75	80	105	125
2	Commutator windings		R	60	75	80	105	125
3	Field windings of AC and DC machines with DC excitation, other than those specified under 4		R	60	75	80	105	125
4	a) Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors		R	-	-	90	110	130
	b) Stationary field windings of DC machines having more than one layer		R	60	75	80	105	125
	c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer		R Th	60	75	80	100	120
	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	80	90	110	130
5	Permanently short-circuited, insulated windings		Th	60	75	80	100	120
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	60	75	80	100	120
9	Commutators and slip rings, open or closed		Th	60	70	80	90	110
10	Plain bearings	measured in the lower bearing shell or in the oil sump after shut-down		50				
11	Roller bearings Roller bearings with special grease	measured in the lubrication nipple bore or near the outer bearing seat		50 80				
12	Surface temperature			Reference 40 [2]				

[1] The 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 accidently touched and there is a risk of burns (> 80 °C), the Society reserves the right to request means of protection such as a handrail to prevent accidental contacts

[3] R = resistance method
Th = thermometer method

d) for variable-speed motors, at 1.2 times the maximum no-load speed

e) for motors with series characteristics, at 1.2times the maximum speed shown on the nameplate, but at least at 1.5 times the rated speed

The over speed test may be dispensed with in the case of squirrel cage induction motors.

2.2.7 Measurement of insulation resistance

Measurement of insulation resistance is to be performed, wherever possible, on the machine at service temperature at the end of the test schedule. The test is to be carried out using a DC voltage of at least 500 V.

Table 2.8 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 [V]
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 3 to 6	2U + 500
2	Insulated windings of rotating machines with the exception of those in item 1 and items 3 to 6	2U + 1000, with a minimum of 1500
3	Separately excited field windings of DC machines	1000 + twice the maximum excitation voltage but not less than 1500
4	Field windings of synchronous generators, synchronous motors and rotary phase converters: a) Rated field voltage up to 500 V over 500 V	 10 times the rated voltage, with a minimum of 1500 4000 + twice rated field voltage
	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	10 times the rated field voltage, minimum 1500, maximum 3500
	c) When a 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	1000 + 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
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheiostatic starting) a) for non-reversing motors or motors reversible from standsill only	 1000 + twice the open-circuit standsill voltage as measured between slip rings or secondary terminals with rated voltage applied to the primary windings
	b) for motors to be reversed or braked by reversing the primary supply while the motor is running	1000 + four times the open circuit secondary voltage as defined in item 5a)
6	Exciters (exception below) a) Exception 1 Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting	As for the windings to which they are connected twice rated exciter voltage + 1000, with a minimum of 1500
	b) Exception 2 Separately excited field windings of exciters	as under item 3

The minimum insulation resistance shall be not less than 1 MΩ.

2.3 Testing in the presence of a Surveyor

2.3.1 All electrical machines are to be tested at the manufacturer's works. When test procedure is not specified, requirements of IEC 60034 apply.

2.3.2 All generators and electrical motors with an output of 50 kVA or 50 kW and over are to be tested at the manufacturer's works in the presence of a Surveyor.

BKI reserves the right to stipulate that a works test be performed on new types of machines which are to be installed for the first time on a ship with class or where there are special grounds for specifying such a test.

Individual tests may be replaced by type tests.

D. Transformers and Reactors

1. General

1.1 General requirements

1.1.1 Transformers are to be installed in well ventilated locations or spaces. Transformers with exposed live parts are to be installed in special spaces accessible only to the responsible personnel. The installation of liquid-cooled transformers requires BKI's special approval.

1.1.2 As a general principle, the primary and secondary windings of transformers are to be separated electrically. For the adjustment of the secondary voltage, taps are to be provided corresponding to ± 2,5 % of the rated voltage.

Starting transformers are excepted from this rule.

1.1.3 Power transformers have to be tested according to IEC 60076.

Transformers with a power rating of 50 kVA or more are to undergo a test at the manufacturer's works in the presence of a Surveyor.

Individual tests may be replaced by One's Own Responsibility Test made by the manufacturer.

1.1.4 The manufacturer is to fit to transformers/reactors a name and date plate containing the serial number of the unit and all essential operating data.

E. Storage Batteries

1. General

1.1 Application

1.1.1 These regulations apply to permanently installed storage batteries.

1.1.2 Only storage batteries suitable for marine use can be used.

2. Design and construction of cells

2.1 General

Cells shall be so designed that they retain their normal operation at inclination of up to 15° and no electrolyte leaks out at inclination of up to 40°. Cells should be combined in cabinets, containers or racks if the weight of single cells allows this.

The weight of a battery or battery element shall not exceed 100 kg.

3. Data plate and operation instructions

3.1 General requirements

3.1.1 Each battery or battery element shall be marked with maker's name and type of battery, containing all relevant data for operation.

3.1.2 For each type of battery an operation manual shall be delivered. It shall contain all information for proper maintenance and operation.

4. Installation and location

4.1 General requirements

4.1.1 Storage batteries are to be installed in such away that they are accessible for cell replacement, inspection, testing, topping-up and cleaning.

The installation of batteries in the accommodation area, in cargo holds and wheelhouses is not permissible.

Gastight batteries can be seen as an exception, e.g.in case of internal power source of emergency lighting fittings, where charging does not result in the development of harmful gases.

4.1.2 Storage batteries are not to be installed in locations where they are exposed to unacceptably high or low temperatures, spray or other effects liable to impair their serviceability or reduce their life essentially. They are to be installed in such a way, that adjacent equipment is not damaged by the effects of escaping electrolyte vapours.

4.1.3 Lead-acid batteries and alkaline storage batteries are not to be installed in the same room or in the immediate vicinity of each other.

4.1.4 Measures are to be taken to prevent storage batteries from shifting. The braces used shall not impede ventilation.

4.1.5 For the installation of storage batteries the total power of associated charger has to be considered.

The charging power is to be calculated from the maximum current of the battery charger and the rated voltage of the battery.

For automatic IU-charging, the charging power maybe calculated as stated under 6.3.

5. Battery room equipment

5.1 General requirements

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

– Explosion group II C

– Temperature class T 1

Other electrical equipment is permitted only with the special approval of BKI.

5.1.2 Where leakage is possible, the inner walls of battery rooms, boxes and cup boards, and all supports, troughs, cabinets and containers shall be protected against the injurious effects of the electrolyte.

6. Ventilation

6.1 General requirements

All battery installations, in rooms, cabinets and containers shall be constructed and ventilated in such away as to prevent the accumulation of ignitable gas mixtures.

Gastight NiCd-, NiMH- or Li- batteries may not be ventilated.

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

Lead batteries with charging power up to 0,2 kW maybe installed without separation to the switchgear, if:

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

b) the switchboards are not closed completely (IP2X will be suitable) and

c) the charger is an automatic IU-charger with a maximum continuous charging voltage of 2,3V/cell and rated power is limited on 0,2 kW.

6.3 Ventilated spaces, battery charging power up to 2 kW

Batteries with charging power up to 2 kW may be installed in ventilated cabinets or containers arranged itself in ventilated rooms (except in rooms according to 4.1.1 and 4.1.2).

The unenclosed installation (IP 12) in well-ventilated positions in machinery spaces is permitted, provided that they are protected against falling objects and dripping water. The charging power for automatic IU-charging should be calculated as follows:

$$P = U \cdot I$$

$I = 8.C/100$ for Pb - batteries

$I = 16.C/100$ for NiCd - batteries

P = charging power [W]

U = rated battery voltage [V]

I = charging current [A]

C = rated battery capacity [Ah]

Battery's gassing voltage shall not be exceeded. If several battery sets are be used, the sum of charging power has to be calculated.

The room free air volume should be calculated depending on battery size as follows:

$$V = 2{,}5.\ Q$$

V = free air volume [m^3]

Q = air quantity [m^3/h]

= 0,25.f .I .x .n

N = number of battery- cells in series connection

f = 0,03 for lead batteries (VRLA) with solid electrolyte

= 0,11 for batteries with fluid electrolyte

If several battery sets will be installed in one room, the sum of air quantity shall be calculated. The air ducts for natural ventilation shall have a cross section as follows, assuming an air speed of 0,5m/s:

$$A = 5{,}6 . Q$$

A = cross section [cm^2]

The required minimum cross-sections of ventilation ducts are shown in Table 2.9.

Small air ducts and dimensions of air inlet and outlet openings should be calculated based on lower airspeed (≤ 0,5m/s).

6.4 Ventilated rooms, battery charging power more than 2 kW

If the charging power of batteries exceeds 2 kW, it has to be installed either in closed cabinets, containers or a Battery room to be ventilated to the open deck. Lead batteries up to 3 kW still may be ventilated by natural ventilation.

Battery rooms are to exhaust to open deck area. It should be used forced ventilation.

Doors to battery rooms have to be gastight with self closing devices without holding back means.

6.5 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. If necessary, weather tight closures shall be carried out otherwise.

Air ducts for natural ventilation shall lead to the open deck directly. Openings shall be at least 0,9 m above the cabinet/container. The inclination of air ducts shall not exceed 45° from vertical.

6.6 Forced ventilation

If natural ventilation is not sufficient or required cross sections of ducts according to Table 2.9 are too big, forced ventilation shall be provided. The air quantity Q shall be calculated according to 6.3. 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 explosion proof and resistant to electrolyte or, preferably, located outside of the endangered area.

The fan impellers shall be made of a material which does not create sparks on contact with the housing, and dissipates static charges.

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.

7. Caution Label

7.1 General

At doors or openings of battery rooms, cabinets or containers caution label have to be mounted drawing attention to the explosion hazard in those areas and that smoking and handling of open flames are prohibited.

Table 2.9 Cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU- charging)			
Battery Charging power	**Cross-section [cm2]**		
[W]	Lead battery solid electrolyte VRL	Lead battery fluid electrolyte	Nickel-Cadmium battery
< 500 500 < 1000 1000 < 1500 1500 < 2000 2000 < 3000	40 60 80 80 80	60 80 120 160 240	80 120 180 240 forced ventilation
> 3000	forced ventilation		

8. Starter batteries

8.1 General requirements

8.1.1 Storage batteries for starting internal combustion engines shall be designed to have sufficient capacity for at least six starting operations in 30 minutes without intermediate recharging.

8.1.2 Starter batteries shall be capable of being recharged with the means available on board and may only be used to start engines and supply energy to the monitoring systems allocated to them.

8.1.3 Starting internal combustion engines with the ship's supply battery is permitted only in emergencies.

8.1.4 Wherever possible storage batteries used for starting and preheating internal combustion engines are to be located close to the machines.

9. Rating of storage battery chargers

9.1 General requirements

Charging equipment shall be so rated that discharged storage batteries can be charged to 80 % of their rated capacity within a period not greater than 15 hours without exceeding the maximum permissible charging currents.

Only automatic chargers shall be used with charging characteristic adapted to the type of batteries.

If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120 % of the rated voltage. The power demand of the consumers shall be considered for the selection of the chargers.

Battery chargers with a rated power of 2 kW upwards have to be tested in manufacturer's works in the presence of the BKI Surveyor.

F. Power Distribution

1. Subdivision of the distribution network

1.1 General

Consumers are to be arranged in sections or consumer groups. The following main groups are to be supplied separately:

– lighting circuits
– power plants
– heating plants
– navigation, communication, command and alarm system

2. Hull return

2.1 General

In systems using hull return, the final subcircuits for space heating and lighting are to be insulated on all poles. The earth for the hull return connection is to be formed by connecting the earth busbar in the main or subsidiary distribution board to the ship's hull. The earth connection shall be located in an easily accessible position so that it can easily be tested and disconnected for the purpose of testing the insulation of the circuit. Earth connections shall be at least equal in cross-section of the supply leads. Bare leads may not be used. Casings and their retaining bolts may not be used for the earth return or for connecting the return lead to the ship's hull. The connecting surface of the cable lug shall be metallically clean. The cable lug is to be tinned. The terminal screws are to be made of brass and are to be compatible with the cable crosssections. The smallest permissible size is M 6.

3. Final subcircuits

3.1 General

3.1.1 Final lighting subcircuits and plug socket circuits within the accommodation and day rooms are to be fitted with fuses rated for not more than 16 A. The load on each lighting subcircuit shall not exceed 10 A. The number of lighting points supplied by a final subcircuit shall not exceed the following maxima:

Table 2.10 Lighting points

Voltage	Maximum number of lighting points
Up to 55 V	10
from 56 V to 120 V	14
from 121 V to 250 V	24

3.1.2 Plug sockets (outlets) are to be connected to separate circuits wherever possible.

Final subcircuits for lighting in accommodation spaces may, as far as practicable, include socket outlets.

In that case, each socket outlet counts for 2 lighting points.

3.1.3 In main machinery spaces and other important service spaces and control stations, the lighting shall be supplied by at least two different circuits.

The lamps are to be so arranged that adequate lighting is maintained even if one of the circuits fails.

4. Navigation lights and signal lamps

4.1 General

4.1.1 The switchboard for navigation lights and signal lamps shall be mounted in the wheelhouse and shall be supplied by a separate cable from the main switchboard, if no change-over to a separate feeder is provided.

4.1.2 Navigation light, each shall be individually supplied, protected and controlled from the navigation lights switchboard.

4.1.3 The navigation lights switchboard may be enlarged to provide connections for other signal lamps. No other consumers may be connected to this switchboard.

4.1.4 A number of locally grouped signal lamps may be jointly supplied, controlled and monitored provided that the monitoring system indicates or signals the failure of even one such lamp. However it shall not be possible to use both light sources in a double light (two lights mounted one above the other or in the same housing) simultaneously.

4.1.5 The switchboard is to be fitted with a device which indicates or signals the extinction of a navigation light. Where pilot lamps are used as indicators, special precautions shall be taken to ensure that the navigation light is not extinguished if the pilot lamp burns out.

4.1.6 Navigation lights shall be designed for the standard voltages: 24 V, 110 V or 220 V.

4.1.7 The voltage at the lamp socket shall not permanently deviate by more than 5 % above or below the standard voltages mentioned in 4.1.6.

5. Shore connection

5.1 General

5.1.1 Shore line terminal containers are to be connected to the main switchboard by a permanently laid cable. The shore connection is to be protected against short-circuit and overload at the main switchboard by a switch or contactor with control switch and fuses or a power circuit breaker with overload protection. Switch, contactor or power circuit breaker are to be interlocked with the generator circuit in such a way as to prevent the ship's generator operating in parallel with the shore mains or another external network. A brief period of concurrent operation shall be permitted when changing from one system to another without break in voltage.

5.1.2 When using plug-type shore connectors with a current rating of more than 16 A, an interlocking device with switch is to be fitted so that the connection on board can only be made in the dead condition. Short-circuit protection at the connection can then be dispensed with.

In order to prevent contact with live parts, plug-type shore connectors are to be designed as appliance connectors comprising a coupler plug mounted on board and a coupler socket supplied from the shore.

With a connecting voltage of more than 50 V a provision is to be made for connecting the ship's hull to earth. The connection point shall be marked.

On ships with DC-power system with hull return the negative pole of the shore side power source shall be connected to the ship's hull.

5.1.3 The main switchboard is to be equipped with an indicator showing whether the shore connection cable is live.

5.1.4 Instruments shall be available for comparing the polarity of a DC power supply or the phase sequence of a 3-phase power supply from the shore with that of the ship's network. The installation of a phase change-over switch is recommended.

5.1.5 The following details are to be given on a data plate in the shore line terminal box:

– kind of current, rated voltage and frequency for alternating current
– concerning measures to be taken for the shore connection

5.1.6 To reduce the load on the terminals, the shore line is to be provided with a tension relief device.

5.1.7 Only flexible, oil-resistant and flame retardant cables are to be used as feeder cables.

6. Power supply to other ships

6.1 General

A separate junction box is to be provided in the case of supplying power to other ships. The branch is to be fitted with fuses and an on-load switch or with a power circuit breaker with overcurrent and short-circuit protection. Where voltages of more than 50V and/or currents of more than 16 A are transmitted, it is necessary to ensure that the connection can only be made in the dead condition. Where a connecting line carrying a voltage of more than 50 V is wrenched out of its connector, it shall immediately be de-energized by a forcing circuit. The same applies to a rupture of the connecting cable.

Ship hulls have to be conductively connected.

Facilities have to be provided to allow this.

Connecting cable suspensions shall be tension relieved.

G. Switchgear Installations and Switchgear

1. Switchboards

1.1 General rules

1.1.1 Switchboards shall contain all the gear, switches, fuses and instruments necessary for operating and protecting the generators and main power distribution systems. They shall be clearly, easily and safely accessible for the purposes of maintenance, repair or renewal. Terminals for voltages up to 50 V,and those for voltages higher than 50 V, shall be kept separately and marked appropriately.

1.1.2 Built-in gear, instruments and operating equipment are to be indelibly marked. The current ratings of fuses and the response values of protective devices are to be indicated.

1.1.3 The replacement of fuse elements shall be possible without removing panels or covers. Different voltages and types of current are to be clearly indicated.

1.1.4 Where switchgear or fuses carrying a voltage of more than 50 V are located behind doors, the live parts of appliances mounted on the door (switches, pilot lights, instruments) shall be protected against being touched by accident (see A.1.4).

1.1.5 Busbars and bare connections shall be made of copper. Even under adverse operating conditions, their temperature rise may not exceed 40 K Busbars are to be fastened and secured in such a way that they are able to withstand the mechanical stresses produced by the greatest possible short-circuit currents.

1.1.6 All screwed joints and connections are to be secured against self acting loosening. Screws up to M 4 size may be secured with lacquer or enamel.

1.1.7 With the exception of the connections between switchgear and outgoing terminals, switchboards may only contain lines with cross sections of up to 50 mm^2. If larger cross-sections are required, a main busbar system is to be provided for connecting generators and consumers.

1.1.8 The power feed for the control of consumers is to be picked up on the consumer side downstream of the main fuses. Exceptions will be permitted only in special cases.

1.1.9 Where fuses and switches are used, the sequence shall be busbar - fuse - switch.

1.1.10 Neutral conductors in 3-phase systems shall have at least half the cross-section of the outer conductors. For line cross-sections of up to 16 mm^2, neutral conductors shall have the full cross-section of the outer conductors. Equalizer lines for 3-phase alternator exciters shall be designed to carry half the exciting current of the largest alternator and shall be laid separately from other lines.

1.1.11 The smallest permissible cross-section for wiring inside the switchboard, including measuring wires and control lines, is generally 0,5 mm^2. Smaller cross-sections are allowed only in automation and telecommunication equipment and for data bus/data cables. Lines without fuse protection from the main busbar to fuses and protective switches shall be as short as possible not longer than 1 m. They may not be laid and fastened together with other lines.

Shunt circuits within the switchboard shall be laid separately from other lines and shall generally not be protected by fuses.

Important control lines shall be laid and protected in such a way they cannot be damaged by arcing due to switching operations or, as far as possible, short circuits.

1.1.12 It shall be possible to observe meters and indicators and to operate the switchgear from the front of the switchboard with the doors closed.

1.1.13 Operating handles shall generally not be located less than 300 mm above floor level. The operating handles of generator switches are to be located at a distance of at least 800 mm from the floor.

1.2 Installation of switchboards

1.2.1 Switchboards are to be installed in easily accessible and adequately ventilated spaces in which no flammable gases can gather. They are to be protected against water and mechanical damage.

Switchboards on the floor plates over the bilges shall be closed from below.

Pipes and air trunks are to be so arranged that any leakage does not endanger the switchgear. Where the routing of pipes and trunks close to switchboards cannot be avoided, they are to have no flanged or screwed joints in this section.

Cabinets and recesses for housing switchboards shall be made of non-combustible material or shall be protected by a metal or other fireproof lining. The doors of cabinets and recesses are to bear a notice drawing attention to the switchboard installed therein. A service passageway at least 0,6 m wide is to be provided in front of switchboards.

The materials of switchboard shall have suitable mechanical strength and be durable, flame retardant and self-extinguishing, they shall not ne hygroscopic.

1.2.2 A service passageway of not less than 0,5 m behind the switchboard is called for only when required by its construction or maintenance.

1.2.3 In the case of voltages over 50 V, insulating ratings or mats shall be placed behind the switch boards and in front of their control sides. No live parts may be mounted on the front side of switchboards.

Parts located to the rear of an open switchboard and carrying voltages of more than 50 V shall be protected against contact up to a height of 0,3 m.

1.3 Distribution boards

1.3.1 The Rules set out in 1.1 apply in analogous manner.

1.3.2 Where a number of distribution boards are supplied via a common feeder cable without intermediate protection, the busbars and the connecting terminals shall be dimensioned to withstand the total load.

1.3.3 Distribution circuits shall be protected in accordance with 3.1 and 3.9 against damage due to short circuit and overload. Final subcircuits with fuses rated at more than 63 A shall be fitted with on-load switches. On-load switches may be dispensed with in final subcircuits with fuses rated up to 63 A provided that each connected consumer can be disconnected by a switch located nearby.

1.3.4 Distribution boards for the supply of mobile consumers, e.g. container plug sockets shall be individually supplied from the distribution board and shall be individually fused and individually disconnectable.

A pilot light or voltmeter is to be provided to show whether the distribution board is live.

1.3.5 Motor switchgear shall be accessible for the purposes of inspection and repair without the need to disconnect other important circuits.

Mechanical devices, ammeters or indicator lights shall show whether the motor is switched on.

Motor switchgear units or their control switches are normally to be located close to their respective motors. Where for operational reasons they are placed out of sight of the motor, personnel working on the motor shall be provided with means of protecting themselves against the unauthorized switching on of the motor.

Motors shall be disconnected on all poles as a matter of principle.

1.4 Switchboard testing

1.4.1 Before being installed on board, every switchboard together with all its equipment is to be subjected to the following test (1.4.2 to 1.4.4).

1.4.2 A test at the manufacturer's works in the presence of a BKI Surveyor is to be carried out on main switchboards and on all switchboards for emergency generator sets. BKI reserves the right to call for a works test on other switchboards where there are special reasons for this.

1.4.3 Functional test

As far as possible, the proper functional of the equipmentis to be checked in accordance with the design.

1.4.4 High-voltage test

High-voltage test is to be performed for a period of one minute at the test voltage shown in Table 2.11.

Measuring instruments and other ancillary equipment may be disconnected during the test.

1.4.5 Insulation resistance measurement

Insulation resistance measurement is to be performed using at least 500 V DC. For the purpose of this test, large switchboards may be divided into a number of test sections. The insulation resistance of each section shall be at least 1 Mega ohm.

Table 2.11 Test voltages for main circuits

Rated insulation voltage Ui [V]	Test voltage A.C. (r.m.s) [V]
$Ui \leq 60$	1000
$60 < Ui \leq 300$	2000
$300 < Ui \leq 690$	2500

2. Switchgear

2.1 General

As a general principle, switchgear shall be designed and constructed in accordance with standard IEC, or to other standards recognized by BKI.

2.2 Selection of switchgear

Switchgear is to be selected not merely by reference to its rated current but also on the basis of its thermal and dynamic strength and its making and breaking capacity.

On-load breakers shall be designed to carry at least the rated current of the series-connected fuse.

Circuit breakers shall act on all live conductors simultaneously. It shall be clearly apparent whether the breaker is in the open or closed position.
Installation switches in lighting systems up to 16 A are exempted from this rule.

2.3 Power circuit breaker

Power circuit breakers are to be provided with trip-free release. Their rated making and breaking capacity shall be sufficient to make or break short-circuit currents at the installation site.

2.4 Fuses

2.4.1 The fuse elements or cartridges shall have an enclosed fusion space. They shall be made of a ceramic material or a material recognized by BKI as equivalent. The fuse element shall be embedded in a heat-absorbing material.

2.4.2 It shall be possible to replace the fuse elements or cartridges without exposing the attendant to the danger of touching live components or suffering burns. Where grip-type fuses are used, a detachable grip is permissible. If high rupture capacity (HRC) fuses are installed in electrical switchboards, accessories and personal protective equipment shall be available for installing and removing such fuses.

3. Switchgear, protective and monitoring equipment

3.1 General

3.1.1 Generators, power consumers and circuits shall be protected in each one of their non-earthed poles or conductors against damage due to overload or short-circuit. In insulated DC and single-phase AC circuits and in insulated 3-phase circuits with balanced load, the overload protection may be dispensed with in one conductor.

3.1.2 The protective devices are to be coordinated in such a way that, in the event of a fault, only the defective circuit is disconnected and the supply to the sound circuits is maintained.

3.1.3 All non-earthed poles shall be connected and disconnected simultaneously. In earthed systems, lines are to contain neither switches nor fuses in their earthed pole or conductor.

3.2 Equipment for 3-phase AC generators

3.2.1 Switchgear and protective devices for individual operation 3-phase AC generators are to be provided with 3- pole power circuit breakers with delayed action overcurrent trip and short-delayed short circuit trip to obtain selectivity. This protective equipment is to be designed as follows:

a) The overload trip, which is to be set at an overcurrent of between 10 % and 50 %, shall open the power circuit breaker with a maximum time delay of two minutes. A setting of more than 50 % overcurrent may be approved if required by the operating conditions and compatible with the generator or prime mover design.

b) The short-circuit trip is to be set at an over current of more than 50 % but less than the sustained short-circuit current. It shall operate with a short delay of up to about 500 ms adjusted to suit the selectivity of the system.

c) On generators rated at less than 50 kVA, fuses and contactors or on-load switches may be used provided that the requirements of a) and b) are satisfied in an analogous manner. For this purpose the contactors shall also have a delayed drop-out.

The contactors are to be designed for at least twice the rated generator current.

3.2.2 Switchgear and protective devices for parallel

The following equipment is to be provided in addition to the switchgear and protective devices specified above 3.2.1.

a) 3-phase AC generators rated at 50 kVA and above shall be provided with reverse-power protection with a time delay of 2 to 5 seconds.

   The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4 % to 10 % of the rated current for diesel-driven generators. The protection should, wherever possible, be set to 50 % of the prime mover trailing power. A voltage drop to 60 % of the rated voltage shall not render the reverse-power protection ineffective within the specified range.

b) The generator switches shall be fitted with under voltage protection which prevents the contact assemblies from closing when the generator is de-energized. If the voltage drops to between70 % and 35 % of the rated voltage, the generator switch shall open automatically. Under voltage trips shall have a short time delay matched to the short-circuit trip called for in 3.2.1 b).

c) A synchronizing device is to be fitted. Where automatic synchronizing equipment is fitted, provision shall also be made for manual independent synchronization.

d) In the case of parallel operating generators with individual output rating of more than 50 kVA, protection is to be provided against the effects of paralleling the generators when in phase opposition.

For example, the following may be used for this purpose:

– A reactor which limits to a permissible degree the electrical and mechanical stresses arising from faulty synchronization. It is to be disconnected when the generator switch is closed or

– A synchronizing interlock which allows the generator switch to cut in only up to an angular deviation of 45° (electrical) maximum, and also blocks the connection in case of too large a difference frequency. The permissible difference frequency depends on the characteristics of the generator switch and its drive and shall not generally exceed 1 Hz.

3.3 Equipment for DC generators

3.3.1 Switchgear and protective devices for individual operation

a) DC generators are generally to be provided with power circuit breakers with delayed-action overcurrent trip and short-delayed short-circuit trip to obtain selectivity. The switchgear and protective devices are to conform to 3.2.1 (for individual operation) with the difference that the short circuit trip is to have a short time delay of up to about 200 ms.

b) A polarity-reversing facility, if necessary.

3.3.2 Switchgear and protective devices for parallel operation

The following equipment is to be provided in addition to the switchgear and protective devices specified in 3.3.1:

a) DC generators equipped for parallel operation with each other or with a storage battery shall befitted with reverse-current protection with no delay action or with a short delay of up to 1 second.

The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4 %to 10 % of the rated output for diesel-driven generators.

b) Under voltage protection as described in 3.2.2 b) for parallel operation.

c) In the case of compound-wound generators, the power circuit breaker shall be provided with an equalizer circuit contact assembly which, on making, closes simultaneously with, or in advance of, the contacts of the power circuit breaker and, on breaking, opens simultaneously with, or after, the contacts of the power circuit breaker, and is designed to carry at least half the rated current.

3.4 Special rules

On-load switches, power circuit breakers and, generally speaking, reverse-current cut-outs can be dispensed with in the case of generators with outputs of up to 10 kW (kVA) and a voltage of 50 V or less which, because of their control equipment, do not need to be subjected to switching operations in service. Further exemptions may be allowed depending on the design of the equipment.

3.5 Disconnection of non-essential consumers

It is recommended that a device be installed which, when the generator reaches its rated output, emits a warning signal after about 5 s and automatically cuts off consumers whose temporary disconnection will not jeopardize the safety of the ship and its machinery installation. The disconnection of the loads may be effected in one or more steps. The automatic disconnection of non-essential consumers is mandatory on larger passenger ships and on ships with automated engine operation.

3.6 Measuring and monitoring equipment

3.6.1 The measuring error of switchboard instruments may not exceed 1,5 % of the scale terminal value. Directionally sensitive instruments are to be used for DC generators and storage batteries.

The scale of voltmeters shall cover at least 120 % of the rated voltage, that of ammeters at least 130 % of the maximum amperage to be expected in continuous operation. Ammeters are to be designed to avoid damage due to motor starting currents.

The scale of watt meters shall cover at least 120 % of the rated power. For generators operating in parallel, the scale shall also cover at least 12 % of the reverse power. In the case of power meters with only one current path, the measurement shall be performed in the same phase on all generators. Where the total power input to all consumers connected to one phase reaches more than 10 % of the output of the smallest alternator, the power meters shall be equipped with multiple movements to register also the unbalanced load on the outer conductors.

Frequency meters are to be capable of registering deviations of down to ± 5 Hz from the rated frequency. Vibrating reed instruments with 21 reeds are recommended.

The main switchboard (main distribution board) is to be provided with ammeters for major consumers, unless these are mounted at the consumers them selves. One instrument may be used for more than one circuit. The rated currents are to be marked on the instrument scales, or on a separate panel in the case of multi circuit instruments with changeover switch. The rated service values are to be marked in red on the scales of all instruments.

3.6.2 Generator measuring and monitoring equipment

a) Each DC generator is to be provided with:

1 voltmeter

1 ammeter

1 blue/ white pilot light (generator live)

Where circuit breakers are used, the following additional lights are to be provided:

1 green pilot light (circuit breaker closed)

1 red pilot light (circuit breaker open)

b) Each 3-phase AC generator is to be provided with:

1 voltmeter, where necessary capable of switching to the other generators

1 ammeter, connectable to each phase conductor

1 wattmeter (active power meter) for generators with outputs of 50 kVA and over

1 frequency meter, where necessary capable of switching to the other generators

pilot lights as specified for DC generator here above

3.6.3 Special rules

Instead of the ammeter and the blue/ white pilot light specified in b), a charging pilot light may be provided for installations with an output of up to 10 kW/ kVA and a voltage of ≤ 50 V.

3.6.4 Protection of generator monitoring and control circuits

The following circuits are to be supplied by the generator direct and are to be individually fused (using fusible cut-outs):

- generator protective relay and generator switch under voltage trip
- measuring instruments
- synchronizing equipment
- pilot lights
- speed adjuster
- electrical generator switch drive

– automatic power supply system (measuring voltage)

3.6.5 Earth fault indication

Every non-earthed primary or secondary system is to be equipped with devices for checking the insulation resistance against ship's hull.

Where filament lamps are used as indicators, their power input may not exceed 15 W. The lamps may be earthed only during testing by means of a pushbutton switch.

An insulation monitoring system may be dispensed with in the case of secondary circuits such as control circuits.

3.6.6 Insulation monitoring equipment

Where insulation monitoring devices are used, they shall provide a continuous indication of the insulation resistance and shall trip an alarm if the insulation resistance of the network drops below 100 ohms per volt of the network voltage.

With a full earth fault the measuring current may not exceed 30 mA.

3.7 Transformer protection

The windings of transformers shall be protected against short circuit and overload by multi-pole power circuit breakers or by fuses and on-load switches in accordance with the above Rules. Transformers for parallel operation shall be fitted with isolating switches on the secondary side.

Overload protection primary side may be dispensed with where it is protected on the secondary side.

3.8 Motor protection

Motors rated at more than 1 kW shall be individually protected against overloads and short circuits.

For steering gear motors see H.1.

It is permissible to provide common short-circuit protection for a motor and its own individual supply cable.

The protective devices shall be suited to the particular operating modes of the motors concerned and shall provide reliable thermal protection in the event of overloads.

If the current-time characteristic of the overload protection is not compatible with the starting characteristics of a motor, the overload protection may be disabled during start-up. The short-circuit protection shall remain operative.

The switchgear of motors whose simultaneous restarting on restoration of the voltage after a power failure might endanger the operation of the installation shall be fitted with a facility which:

– interrupts the circuit in response to a voltage drop or power failure and prevents automatic restarting, or

– causes the motor to start up again automatically without any inadmissible starting current on restoration of the voltage. Where necessary, the automatic restarting of a number of motors is to be staggered in time.

The under voltage protection shall work reliable between70 % and 35 % of the rated voltage.

3.9 Circuit protection

Every distribution circuit shall be protected against damage due to overloads and short circuits by means of multi-pole power circuit breakers or fuses in accordance with the above Rules. Final subcircuits supplying power to a consumer fitted with its own overload protection may be provided with only short-circuit protection at the feed point. Under continuous service conditions fuses for this purpose may be two stages higher than for the rated service of the consumer in question; for short-period and intermittent service, the rated current of the fuse may not be greater than 160 %of the rated consumer current. The corresponding switches are to be designed for the rated amperage of the fuse.

For steering gear circuits see H.1. Automatic cut-outs and protective motor switches shall, where necessary, be backed up by the series-connected fuses specified by the manufacturer. In the case of important consumers, automatic cut-outs without selectively staggered disconnecting delay may not be arranged in series.

3.10 Storage battery protection

Batteries, except starter batteries, shall be provided with short-circuit protection situated near the batteries, but not in battery's cabinet or container. Emergency batteries supplying essential services may only be provided with short-circuit protection sufficient for their cables. The value of the fuses may be two stages higher than the corresponding values for the rated cable current shown in Table 2.13 and Table 2.14, column 3, or of power circuit breakers with suitably adjusted short-circuit protection.

3.11 Protection of measuring instruments,

Indicators, measuring instruments and pilot lights are to be protected by fuses. Pilot lights with operating voltage over 24 V are to be fused separately from control circuits in every case so that a short circuit in the lamp does not cause failure of the control circuits. Pilot lights connected via short-circuit-proof transformers may be fused jointly with control circuits.

3.12 Exciter circuits

Exciter circuits and similar circuits whose failure might endanger the operation of essential systems may not be protected, or may be protected only against short circuits.

3.13 Emergency disconnecting switches

Oil burner equipment, fuel pumps, boiler fans, separators, machinery space and pump room ventilators shall be provided with an individual emergency disconnecting switch located at a central position outside the machinery space unless other means are available for rapidly interrupting the fuel and air supply outside the room in which the equipment is installed.

4. Control and starting equipment

4.1 Operating direction of hand wheels and

Hand wheels and levers of starters and drum controllers not intended for reversing are to be arranged to turn clockwise for starting the motors. Motor speed and generator voltage control is to be so effected that clockwise rotation increases the speed/voltage. The linear movement of handles upwards or to the right shall produce the same effect as clockwise rotation.

4.2 Hand-operated controllers, resistors

The temperatures of handles and other parts which have to be touched in order to operate equipment may not exceed the following values in service:

– Metal parts 50 °C

– Insulating material 60 °C

Resistor casings whose temperature is liable to exceed 60 °C are to be so mounted that they cannot be touched by accident.

H. Steering Gears, Lateral Thrust Propeller Systems and Active Rudder Systems

1. Steering gear

1.1 General requirements

As a general principle, two steering gears, as constructionally independent as possible, are to be provided, i.e.:

– 1 main and 1 auxiliary steering gear system

– 2 main steering gear systems

1.2 Definitions

1.2.1 Main steering gear system

The main steering gear system comprises all the system components needed to steer the vessel under normal design conditions.

1.2.2 Auxiliary steering gear system

The auxiliary steering gear system generally comprises equipment which, if the main steering gear system malfunctions, is able to assume its duty with reduced or equal capacity.

1.3 Design features

1.3.1 In general, all parts of main and auxiliary steering gears shall be designed in conformity with Section 1, E.

1.3.2 The rated output of the electrical machinery is to be related to the maximum torque of the steering gear. For hydraulic steering gears, the rated output of the drive motors is to be determined by reference to the maximum pump delivery against the maximum pressure produced by the steering gear (safety valve setting) with due allowance for pump efficiency.

The stalling torque of the motor shall equal at least 1.6 times the rated torque.

Steering gear drive units shall comply at least with the following modes of operation:

a) Steering gears with intermitted power demand S 6: 25 % for converters and motors of electrohydraulic steering gears S 3: 40 % for motors of electromechanical steering gears

b) For steering gears with a constant power demand the machines are to be designed for 100% continuous service S 1.

Note

For definition of service factor S, see IEC 60034.

1.3.3 With power-driven steering gears, the auxiliary drive shall be largely independent of the main drive so that a failure in one system does not render the other one inoperative.

1.4 System requirements

1.4.1 Basically, systems may be differentiated as follows:

a) hydraulically driven main steering gear with electrohydraulic auxiliary steering gear

b) electrohydraulic main steering gear comprising two equivalent rudder drives

c) hydraulic main and auxiliary steering gear systems

1.4.2 Electrical and electrohydraulic power unit shall be supplied via separate cable. The necessary fuse junctions and switchgear devices are to be housed in separate switch containers. If installed together in switchboards, they are to be suitably isolated from the feeder panels of other consumers.

1.4.3 The systems are to be so designed that each drive unit can be put into operation either individually or jointly from the wheelhouse. The feed for the remote control of the motor switchgear shall be taken from the appropriate supply fuse.

1.4.4 Where a system is supplied from a battery, a voltage monitor is to be fitted which acts with a time delay to trip a visual and audible alarm signal on the bridge if the supply voltage drops more than 10 %.

1.4.5 If the auxiliary steering gear is supplied from a battery, the latter shall be capable of sustaining the supply for 30 minutes without intermediate recharging.

1.4.6 The changeover from the main to the auxiliary steering gear system shall be able to be effected within 5 seconds.

1.4.7 Following a power failure, the steering gear drive systems shall automatically re-start as soon as the power supply is restored.

1.4.8 If the steering gear is operated only by electrically driven power units or electrohydraulic power units, then at least one of the power units or rudder drives shall, in the event of failure of the vessel's network, be automatically supplied by a battery until an auxiliary diesel set has been started and has taken over the power supply.

The battery is not required in the case that the standby auxiliary diesel set starts automatically and takes over the power supply within 5 seconds after black-out.

1.4.9 Installations other than that described require BKI special approval.

1.5 Protective equipment

1.5.1 The control circuits and motors of steering gear systems are to be protected against short circuits only.

1.5.2 Where fuses are used, their rated current is to be two stages higher than that corresponding to the rated current of the motors. However, in the case of motors for intermittent service, the value shall not be greater than 160 % of their rated current.

1.5.3 Where power circuit breakers are used, their short-circuit quick release device shall be set at not more than 10 times the rated current of the electric drive motor. Thermal trips are to be disabled or are to be set to twice the rated current of the motor.

1.5.4 Control circuits shall be fused for at least twice the maximum circuit current rating. They are to be located on the load side of the main fuse of the electrical drive concerned.

1.5.5 The protective devices are to be coordinated in such a way that in the event of a fault only the defective circuit is disconnected while the supply to the intact circuits is maintained.

All non-earthed poles are to be fitted with fuses and are to be connected and disconnected simultaneously.

1.5.6 On relays and magnetic valves rectifiers or capacitors in parallel are to be fitted to quench arcs.

1.6 Indicating and monitoring equipment

1.6.1 As a general principle, separate indicators or monitors, as appropriate, are to be provided which respond to the operative/inoperative state of the control circuits, a drop in potential below the supply voltage (in the case of battery supply) and an inadmissible fall in the hydraulic oil level in the compensating tank.

1.6.2 A failure of the control voltage and any departure from the limit values prescribed for safe operation shall trip a visual and audible signal in the wheelhouse. It shall be possible to cancel the audible signal. The cancellation of an audible alarm shall not prevent the signalling of a fault affecting the other working parts of the steering gear systems.

1.6.3 Operative signals and alarms:

a) 1 green indicator light each for the main and auxiliary steering gears (or for each main steering gear, where applicable) showing that the equipment is operative

b) 1 red indicator light for the main and auxiliary steering gears to signal a failure or a fault

c) 1 red indicator light responding to a drop in potential of 10 % below the rated network voltage. The signal response is to be subjected to a time delay in order to bridge voltage dips caused by starting operations (where a system is supplied by a battery).

1.6.4 In addition, 3-phase AC systems are to be provided with yellow indicator light signalling overload and phase failure.

The phase failure monitor may be dispensed with if the system is supplied exclusively via power circuit breakers. The overload alarm may be dispensed with for drive systems used exclusively for inching duty. The alarm may also be combined with other steering gear alarms.

Where bimetallic relays are used to signal overloading of the motors, these are to be set at 0,7 times the rated current of the motor.

1.7 Rudder control

1.7.1 It shall be possible to control the main and auxiliary steering gears from the main steering station. The controls are to be so arranged that the rudder angle cannot be altered unintentionally.

1.7.2 Where more than one power drive is installed, the wheelhouse is to be provided with at least two mutually independent steering gear control systems.

Separate cables and lines are to be provided for these control systems.

The mutual independence of the steering gear control systems may not be impaired by the fitting of additional equipment such as autopilot systems.

1.7.3 A common selector switch is to be provided for switching from one control system to another.

1.8 Auto pilot systems

An indicator light showing that the autopilot is operative has to be installed.

A failure of the control voltage and a deviation of the rated rpm of the gyro shall trip a visual and audible alarm.

The auto pilot system and its associated alarms have tobe supplied separately from each other

1.9 Rudder angle indicator

The actual position of the rudder shall be clearly indicated in the wheelhouse and at every steering station.

In the case of electrical or hydraulic control systems, the rudder angle shall be indicated by a device (rudder angle transmitter) which is independent of the control system and actuated either by the rudderstock itself or by parts rigidly connected to it.

The system shall have a separate power supply and the indication shall be continuous.

Additionally installed transmitters for position indicators of autopilot systems shall have a separate power supply and shall be electrically isolated from the abovementioned system.

2. Lateral thrust propellers and active

2.1 General

2.1.1 The short-circuit protection of the supply is to conform to 1.5.

2.2 Drives

2.2.1 Active rudder systems are to be rated for continuous service.

Lateral thrust propeller systems are to be rated in accordance with the vessel's operating conditions, but at least for short-term duty (S 2 - 30 min).

Lateral thrust propellers and active rudder systems are to be protected against short circuits and overloads. The overload protection is to be so designed that in the event of an overload a warning is first given followed by a reduction of the output or the shutdown of the system should the overload persist.

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.

2.3 Monitoring

2.3.1 The wheelhouse is to be equipped with the monitors and indicators described in 2.3.2 to 2.3.6.

2.3.2 A blue indicator light signalling that the system is operative.

2.3.3 A yellow indicator light for signalling an overload.

2.3.4 Depending on the type of system, further indicators are to be provided for signalling operational level and the desired direction of movement of the vessel.

2.3.5 The controls of lateral thrust propeller systems shall take the form of pushbuttons or levers. The operating direction shall correspond to the desired direction of movement of the vessel. The electrical control system shall be fed from the supply to the main drive.

2.3.6 Where fuses are used for short-circuit protection, a phase monitor shall ensure that the system cannot be started up in the event of a phase failure.

I. Electric Heating Appliances

1. General

1.1 The use of portable, unsecured heating and cooking appliances is not permitted except for appliances which are under constant supervision when in use, e.g. soldering irons, flat irons and appliances where special precautions are taken to prevent the build-up of heat to ignition temperature (e.g. electric cushions and blankets).

1.2 The installation and use of electric heaters is not allowed in spaces where easily flammable gases or vapours may accumulate or in which ignitable dust may be deposited.

1.3 Electrical heating equipment and boilers should conform to IEC Publication, e.g. 60335 and particular attention to IEC 60092-307.

2. Space heaters

2.1 Arrangement of heaters

2.1.1 No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

2.1.2 Where heaters are fitted in the bulkhead lining, a trough made of non-combustible material shall be mounted behind each heater in such a way as to prevent the accumulation of heat behind the lining.

2.1.3 Only waterproof heaters according to IEC60335 may be used in washrooms, bathrooms and other damp spaces as well as in machinery spaces.

2.2 Enclosures

Heater enclosures are to be so designed that no objects can be deposited on them and air can circulate freely round the heating elements.

2.3 Thermal design of heaters

Electrical space heaters are to be so designed that, at an ambient temperature of 20 °C, the temperature of the outer jacket or cover and the temperature of the air flowing from the heater do not exceed 95 °C.

For the maximum permissible temperature of control components and their immediate vicinity, see G.4.2

2.4 Electrical equipment of heaters

2.4.1 Only heating elements with sheathed or ceramic encased coils may be used.

To prevent the build-up of heat leading to excessive temperature rises, every heater is to be equipped with thermal protection which interrupts the current as soon as the maximum permissible heater temperature is exceeded. Automatic restarting shall be prevented.

2.4.2 Self-regulating material in heating elements may be dispensed with.

2.4.3 The operating switches shall disconnect all live conductors when in the off position. The off position and the positions for the various operating levels shall be clearly marked on the switches.

2.4.4 Every space heater shall normally be connected to a separate circuit. However, a number of small space heaters may be connected to a common circuit provided that their total current input does not exceed 16 A.

3. Oil and water heaters

3.1 General

See Section 1, D.

4. Electric ranges and cooking equipment

4.1 Cooking plates

Only enclosed-type cooking plates may be used.

4.2 Switches

The switches of the individual cooking plates shall disconnect all live conductors when in the off position. The switch steps shall be clearly marked.

Switches and other control elements shall be so fitted that they are not exposed to radiant heat from the cooking plates or heating elements. The maximum permissible temperature limits specified in G.4.2 are applicable.

J. Lighting Installations

1. General

1.1 Lighting installations are to be designed incompliance with the paragraphs listed below:

– A.3.2, Voltages and frequencies

– F.3.1, Final subcircuits

– F.4.1, Navigation lights

– A.1.4.2, A.1.4.3 and A.1.4.5 to A.1.4.13, Explosion proofing

– For additional requirements on lighting installation son passenger ships, see the Rules for Additional Requirements for Notations – Inland Waterways (Part 2, Vol. V) Section 2, D.5.7.

2. Design of lighting installations

2.1 The number of lamps and their distribution shall be such as to ensure satisfactory illumination.

2.2 In machinery and service spaces, service passageways, cargo holds and commissary spaces, lighting fixtures are to be provided which are sufficiently robust for this application. The lighting fixtures shall be fitted with impact-resistant covers.

2.3 Wherever possible, separate circuits are to be provided for plug sockets.

2.4 The use of normal shore type light fittings is permitted in accommodation, day rooms and commissary spaces provided that they comply with the Rules contained in 3.

3. Design of lighting fixtures

3.1 Lighting fixtures shall have a base which reflects and dissipates the heat produced by the light source. The mountings used shall provide a gap of at least 5 mm to allow cooling air to circulate between the base of the fixture and a combustible surface to which it is fastened.

Lighting likely to be exposed to more than ordinary risk of mechanical damage shall be protected against such damage or to be of a special robust construction.

3.2 The temperature of lighting fixtures should not exceed 60 °C where they can be touched easily.

3.3 Heat-resistant leads are to be used for the internal wiring of lamp-holders.

3.4 Metal lighting fixtures shall be fitted with an earthing screw in the casing or base. All metal parts inside a lighting fixture are to be conductively connected to each other. The connecting terminals shall be directly fastened to the lighting fixture.

3.5 Every lighting fixture shall be permanently marked with the maximum permissible watt age of the lamps to be fitted.

4. Mounting of lighting fixtures

4.1 General

4.1.1 All lighting fixtures are to be mounted in such a way that combustible structural elements such as wood etc. will not be ignited by the heat produced and the lighting fixtures themselves are not exposed to damage.

4.1.2 In bathrooms and shower rooms lighting fixtures shall be mounted in accordance with IEC 60364-7-701.

4.1.3 Lighting appliances on open decks shall be so installed as not to impede the recognition of navigation lights.

5. Lighting in cargo holds

5.1 General

Where a lighting system is permanently installed, each final subcircuit or each section is to be equipped with switches having clearly marked settings or with pilot lamps showing whether the system is switched on. The switches are to be located outside the holds in positions where they are only accessible to authorized personnel.

The lighting fixtures are to be fitted with sufficiently robust wire guards or impact-resistant covers.

Their method of mounting is to ensure that they cannot be damaged while work is in progress.

For explosion protection see also A.1.4.5 to A.4.13.

K. Installation Material

1. Design and mounting

1.1 Installation appliances shall be adequately protected against mechanical damage and shall be made of corrosion- resistant materials.

Where appliances with casings of brass or other copper alloys are fixed to aluminium surfaces, they shall be insulated from the latter to protect them against corrosion.

1.2 The cable entries of the appliances shall be of a size compatible with the cables to be connected and shall be selected to suit the type of cable concerned.

1.3 The space inside appliances shall be sufficient to enable insulated conductors to be connected without having to make sharp bends. Corners, edges and projections shall be well rounded.

1.4 Mobile appliances are to be provided with means of relieving tension in the cable so that the conductors are not subjected to tensile load.

1.5 Terminals, screws and washers shall be made of brass or another corrosion-resistant material.

2. Plug connections and switches

2.1 The live contact components of sockets (outlets) and plugs shall be so enclosed that they cannot be touched under any circumstances, even during insertion of the plug.

2.2 The sockets for amperages over 16 A shall be interlocked with a switch in such a way that the plug can be neither inserted nor withdrawn as long as the socket contact sleeves are live.

2.3 Where a ship is provided with sockets for a variety of distribution systems differing in voltage or frequency, use is to be made of sockets and plugs which cannot be confused in order to ensure that an appliance cannot be connected to a socket belonging to the wrong system.

2.4 Plug connections shall conform to the required class of enclosure irrespective of whether or not the plug is in or out.

2.5 Wherever possible, appliances are to be so designed and mounted that the plugs are inserted from below.

2.6 Apart from the sockets standardized and specifically approved for use in shipbuilding practice, accommodation and day rooms may also be provided with sockets designed for use on shore provided that they are mounted in a dry position.

2.7 Only sockets with a permissible operating voltage in accordance with A., Table 2.6 are allowed in washrooms and bathrooms. No sockets or switches may be fitted in shower cubicles, shower cabinets or close to bathtubs. Exempted from this rule are razor sockets with an isolating transformer.

2.8 Switches shall simultaneously connect and disconnect all the non-earthed conductors of a circuit. Single-pole disconnection is permitted only in the accommodation area for the switches of lighting circuits not carrying more than 16 A.

2.9 No plug connections are normally to be provided in cargo holds. Where power sockets are essential in special cases, e.g. for supplying power to refrigerated containers, they are to be supplied from their own sub-distribution boards with fused outlet switches which can be centrally disconnected and are located outside the cargo holds.

The sub-distribution boards shall be provided with devices indicating when they are live and which outlets are connected/disconnected.

Sockets may only be installed at locations which give adequate protection against mechanical damage.

L. Cables and Insulated Wires

1. General

1.1 As a general principle, the use of the types of cables and wires according to IEC 60092 is permitted. In addition, equivalent cables and lines may be approved by BKI.

1.2 Except for lighting and space heating, only cables with multi-strand conductors are to be used.

1.3 The voltage rating of a cable may not be less than the rated working voltage of the relevant circuit. In insulated distribution systems the outer conductor voltage of the system is to be deemed to be the rated voltage of the cable between a conductor and the ship's hull, because in the event of a fault, e.g. outer conductor shorting to earth, this voltage may occur for a prolonged period between an intact outer conductor and the ship's hull.

2. Choice of cables

2.1 Temperatures

In positions liable to be subjected to high ambient temperatures, only cables whose permissible temperature is at least 10 K above the maximum ambient temperature to be expected may be used. A correction factor is to be applied to the permissible loading (see Table 2.12).

Cables on diesel engines, heaters etc. liable to be exposed to high temperatures are to be routed so that they are protected against excessive external heating. If this is not possible, oil-resistant cables with high heat resistance are to be used. Cables not previously used are to be submitted to BKI for approval before installation.

2.2 Fire resistance

Cables and insulated wires shall be flame-retardant and self-extinguishing (according to IEC 60332).

2.3 Cable sheaths

On open decks, in damp or wet rooms, in service rooms and wherever condensation or harmful vapours (oil vapours) may occur; only cables with impermeable sheaths resistant to the environmental influences may be used.

PVC (polyvinyl chloride), CSP (chlorosulphonated polyethylene) and PCP (polychloroprene) sheaths are deemed to fall into this category, although they are unsuitable for long-term immersion in liquids.

2.4 Movable connections

Machines or equipment mounted on rubber or spring vibration absorbers are to be connected via cables or wires with sufficient flexibility.

Mobile equipment is in all cases to be supplied by heavy, flame-retardant and oil-resistant rubber sheathed flexible cords such as HO7RN-F-CENELEC HD 22 or equivalent.

For working voltages above 50 V, the movable connecting cables or wires for non-double-insulated equipment shall include an earthed conductor, which is to be specifically marked.

In spaces in the accommodation area, lightweight flexible cords are also permitted.

3. Determination of conductor cross-sections

3.1 General requirements

3.1.1 The sizes of cables and wires are to conform to the details in Table 2.13 respectively in Table 2.14 unless other conductor cross-sections are necessitated by the permissible voltage drop for particular equipment items (see 3.1.3) or by the elevated ambient temperature or by a special permissible working temperature (see also 3.2.1 - Minimum cross-sections). See Table 2.12 for the correction factor.

Table 2.12 Correction factors for cables in higher ambient temperatures

Maximum permissible conductor operating temperature		Ambient temperature [°C]				
[°C]	**Table**	**40**	**45**	**50**	**60**	**70**
60	Table 2.13	1	0,87	0,71	-	-
85	Table 2.14	1	0,94	0,89	0,74	0,57

3.1.2 Parallel cables may be calculated with the sum of their permissible loads and may be fused in common provided that the current is equally shared between all the parallel cables. In every case, only cables of the same cross-sectional area and length shall be used as parallel cables.

3.1.3 The cross-section of cables and wires is to be determined not only by reference to the permissible current load but also according to the permissible voltage drop. The voltage drop between the main switchboard and the most unfavourable point of the system under consideration may not exceed 5 % for lighting or 7 % for power and heating circuits. In the case of transient loads, caused for example by startups, it is necessary to ensure that the voltage drop in the cable does not occasion any malfunction of the system.

3.2 Minimum cross-sections

The minimum cross-section of permanently laid cables and wires in power, heating, lighting systems and control circuits for power plants shall be 1,0 mm^2; in control circuits of safety systems 0,75 mm^2; in automation and telecommunication equipment 0,5 mm^2; in telecommunication systems not relevant to the safety of the ship and for data bus/data cables 0,2 mm^2.

Within accommodation and day rooms, flexible leads with a conductor cross-section of 0,75 mm^2 and over may also be used for the mobile connection of appliances with a current input of up to 6 A.

3.3 Hull return conductors

See F.2.1

3.4 Protective earth wires

See A.1.4.4

3.5 Neutral conductors of 3-phase systems

The cross-section of neutral conductors of 3-phase systems is to equal at least half that of the outer conductors. Where the cross-section of the outer conductors is 16 mm2 or less, the cross-section of the neutral conductor shall equal that of the outer conductors.

4. Cable overload protection

4.1 General requirements

4.1.1 All cables and wires with the exception of hull return, neutral and earthing conductors are to be fitted with fuses in accordance with Table 2.13 respectively Table 2.14.

4.1.2 Where protection is afforded by power circuit breakers with overcurrent and short-circuit trip, the overcurrent trip is to be set in accordance with the maximum permissible current loads shown in Table 2.13 respectively Table 2.14. The short-circuit trip shall be set to 4-6 times the indicated amperages. For short circuit protection, see also G.3.9.

4.1.3 The exciter conductors of DC motors and DC generators operating in parallel may not be fitted with fuses except in the case of special installations. The exciter conductors of individually connected DC generators and 3-phase synchronous machines may be fused only where there are special grounds for doing so, e.g. where the cables are run through several of the ship's main vertical zones.

5. Cable laying

5.1 General

5.1.1 Cables from generators and all cables going out from the main or emergency switchboard up to the distribution boards or the power consumers themselves shall be laid undivided and in a single length. The same applies to all connecting cables in essential systems. Exemptions are subject to BKI express approval (e.g. for ship extensions or barrier containers at the movable cable loop below the wheelhouse).

For elastically mounted machinery and equipment, adequate freedom of movement shall be ensured by compensation bends.

5.1.2 In DC systems without hull return multi-core cables are to be used for the smaller cross-sections. When using single-core cables for large cross-sections, the outgoing and return lines shall be laid as close as possible to each other over their entire length to avoid stray magnetic fields.

5.1.3 In 3-phase systems without hull return, 3- core cables are to be used for 3-phase connections; and 4-core cables are to be used for circuits with charged neutral. The use of a 3-core cable and a separate neutral conductor is only permissible if the current in the latter does not exceed 20 A.

5.1.4 In single or 3-phase AC systems, single-core cables carrying a current above 20 A are to be avoided. If such a method of installation cannot be avoided, the measures to be taken are to be agreed with BKI.

5.1.5 Cables whose maximum permissible temperature of the conductor differ by more than 5 K from each other may be laid in a common bundle only if the permissible loadings of the lowest capacity type are taken as the basis for all cables.

5.1.6 Should it be impossible to use multi-core cables in accordance with 5.1.3 in single or 3-phase AC systems because of the connection difficulties associated with high power ratings, approval may be given for the laying of single- core cables and wires subject to compliance with special requirements which are to be agreed with BKI in each case.

5.1.7 Table 2.15 indicates the minimum internal radius of curvature of cable bends according to the type and outside diameter of the cable concerned.

Table 2.13 Current rating of cables with a maximum permissible conductor temperature of 60 °C at an ambient temperature of 40 °C

1	2	3	4	5	6	7
Nominal cross section of the copper conductor [mm²]	**Continuous service**		**Short time service S 2 = 30 min**		**Short time service S 2 = 60 min**	
	Maximum permissible current	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**
	[A]	**[A]**	**[A]**	**[A]**	**[A]**	**[A]**
Single-core cables						
1,0	9	10	10	10	10	10
1,5	14	16	15	15	15	15
2,5	19	20	20	20	20	20
4	26	25	28	25	28	25
6	34	36	36	36	36	36
10	46	50	49	50	49	50
16	62	63	66	63	66	63
25	82	80	87	80	87	80
35	101	100	108	100	107	100
50	126	125	136	160	134	160
70	156	160	171	160	165	160
95	189	160	217	224	202	200
120	219	224	251	250	234	224
150	251	250	294	300	271	250
185	287	250	353	315	311	300
240	337	315	420	-	371	-
300	388	355	500	-	435	-
Two-core cables						
1,0	8	6	9	10	9	10
1,5	11	10	12	16	12	16
2,5	17	16	18	20	18	20
4	22	20	23	25	23	25
6	29	25	31	25	31	25
10	39	36	41	36	41	36
16	53	50	60	63	56	63
25	70	63	83	80	75	80
Three or four-core cables						
1,0	6	6	7	10	7	10
1,5	9	10	10	10	10	10
2,5	14	16	15	16	15	16
4	18	20	19	20	19	20
6	24	25	25	25	25	25
10	32	36	36	36	34	36
16	43	36	50	50	46	50
25	57	50	70	63	60	63
35	71	63	88	80	75	80
50	89	80	115	100	100	100
70	109	100	151	125	125	125
95	132	125	194	200	161	160
120	1	160	234	225	161	200
5 to 24-core cables 1,5 mm²						
5	8	6				
7	7	6				
10	6	6				
12	6	6				
14	6	6				
16	6	6				
19	5	4				
24	5	4				

Table 2.14 Current rating of cables with a maximum permissible conductor temperature of 85 °C at an ambient temperature of 40 °C

1	2	3	4	5	6	7
Nominal cross section of the copper conductor [mm²]	**Continuous service**		**Short time service S 2 = 30 min**		**Short time service S 2 = 60 min**	
	Maximum permissible current	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**
	[A]	**[A]**	**[A]**	**[A]**	**[A]**	**[A]**
Single-core cables						
1,0	17	16	18	16	18	20
1,5	22	20	23	20	23	20
2,5	30	25	32	25	32	36
4	40	36	42	36	42	50
6	52	50	55	50	55	63
10	72	63	76	63	76	80
16	96	100	102	100	102	100
25	127	125	135	125	135	160
35	157	160	168	160	166	224
50	196	200	212	224	208	250
70	241	224	264	300	255	300
95	292	300	327	315	311	315
120	338	315	387	-	362	-
150	389	400	455	-	420	-
185	443	425	532	-	481	-
240	522	500	650	-	574	-
300	600	630	765	-	672	-
Two-core cables						
1,0	14	10	15	16	15	16
1,5	19	20	20	20	20	20
2,5	26	25	28	25	28	25
4	34	36	36	36	36	36
6	44	36	47	50	47	50
10	61	63	65	63	65	63
16	82	80	93	100	87	100
25	108	100	127	125	115	125
Three or four-core cables						
1,0	12	10	13	16	13	16
1,5	15	16	16	16	16	16
2,5	21	20	22	25	22	25
4	28	25	30	36	30	36
6	36	36	38	36	38	36
10	50	50	56	63	53	50
16	67	63	75	80	71	63
25	89	80	110	100	96	80
35	110	100	138	125	120	100
50	137	125	178	160	153	125
70	169	160	235	224	194	160
95	205	200	300	300	250	250
120	237	224	365	315	296	300
5 to 24-core cables 1,5 mm²						
5	13	10				
7	11	10				
10	10	10				
12	10	10				
14	9	6				
16	9	6				
19	8	6				
24	8	6				

5.1.8 Terminations and joints in all conductors shall be made as to retain the original electrical, mechanical, flame-retardant and, where necessary, fire resistant properties. The number of joints shall be kept to a minimum.

6. Cable runs

6.1 General

6.1.1 Cable runs are to be so selected that cables can, wherever possible, be laid in straight lines and are not exposed to mechanical damage. Continuous cable runs shall not be routed along the shell plating and its frames.

6.1.2 Sources of heat such as boilers, hot pipes, etc. shall be by-passed to avoid exceeding the permissible end temperature of the cable conductors. Where this is not possible, the cables are to be shielded from radiant heat.

6.1.3 Where, for safety reasons, an installation is provided with double feeder cables, these are to be laid as far apart as possible.

Cable runs are to be protected against corrosion.

7. Fastening of cables and wires

7.1 General

7.1.1 Cables are to be fastened to trays or carriers. Individually run cables are to be fixed with clips.

7.1.2 Cables and wires are to be fastened with clips, straps or bindings made of galvanized steel strip, copper or brass strip.

Other established fastenings approved by BKI may also be used.

Cadmium coated or galvanized steel screws and galvanized clips or fastenings of other suitable materials are to be used for fixing cables to aluminium surfaces.

Clips used for mineral-insulated copper-sheathed cables shall be made of copper alloy if in electrical contact with the cable-sheath.

Table 2.15 Minimum internal radius of curvature

Outer diameter of cable, D [mm]	Cables without metal sheath or braid	Cables with metal sheath or braid
up to 25	4.D	6.D
over 25	6.D	6.D

8. Tension relief

8.1 General

Cables are to be fastened in such a way that any tensile loads are kept within the permissible limits. This is particularly applicable to cables with a small cross section and to those installed in vertical trays or vertical ducts.

9. Protection against mechanical damage

9.1 General

Cables in cargo holds, on deck and in locations where they are particularly exposed to the danger of mechanical damage, including especially cables laid up to a height of 500 mm above floor, are to be provided with additional protection in form of sheaths or ducts.

Cable coverings are to be conductively connected to the ship's hull.

10. Laying of cables and wires in conduits or enclosed metal ducts

10.1 General

10.1.1 Conduits and ducts shall be smooth on the inside and shall have ends shaped to avoid damaging the cable covering or sheath. They are to be provided with drainage holes measuring at least 10 mm in diameter.

Bores and bending radii shall be such as to enable the cables to be inserted without difficulty.

10.1.2 Cables may only occupy up to a maximum of 40 % of the clear cross-section of conduits and ducts, the aggregate cross-section of the cables being the sum of the individual cross-sections calculated from the cable diameters.

10.1.3 Extensive cable ducts and conduits are to be fitted with inspection and draw containers.

11. Laying in non-metallic conduits and ducts

11.1 General

The conduits or ducts shall be made of flame retardant material.

12. Bulkhead and deck penetrations

12.1 General

12.1.1 Where cables pass through bulkheads or decks, the cable penetrations shall not impair the mechanical strength, watertightness or fire resistance of the bulkheads and decks concerned.

12.1.2 Cable lead-throughs in watertight bulkheads or decks are to take the form of individual gland-type lead-throughs or, in the case of cable bundles, collective lead-throughs of a type approved by BKI. Sealing may be effect with casting resins or elastic plugs.

If casting resin is used, the cables shall be run and encased in the resin over a length of at least 150 mm inside the lead-through.

13. Cables laid in refrigerated spaces

13.1 General

Cables may be laid neither in nor directly upon the thermal insulation of these spaces. They are to be installed on perforated metal plates or spacing clips clear of the covering of the insulating layer. Excepted from this are individual cables with plastic outer sheathing, which may be laid directly on the insulation covering.

14. Cable laying to wheelhouses using extending cable feeds (moveable cable loops)

14.1 General

The following points are to be specially considered when selecting and laying the cables for variable height wheelhouse and control platforms:

– choice of cable types possessing the necessary flexibility and resistance to oil and to high and low temperatures (e.g. HO7RN-F)

– use of increased bending radii at locations subject to severe mechanical loads

– cable attachment using metal cable straps or clips

– suitable protection against mechanical damage

15. Cable junctions and branches

15.1 General

15.1.1 Branches from cables and wires may only be made inside containers.

15.1.2 Junction and distribution containers shall be located in easily accessible positions and shall be clearly marked.

15.1.3 As a general principle, only one circuit shall be led through any one box. Should it be necessary to lead a larger number of circuits through one box, the terminals are to be so arranged that similar circuits are adjacent to each other. The terminals for dissimilar systems or for systems with different working voltages are to be separated from each other by partitions. All terminals are to be clearly and indelibly marked. A terminal connection diagram is to be mounted on the box cover.

15.1.4 It is necessary to effect the continuous conductive connection of all metal cable sheaths, particularly inside cable distribution and junction containers.

Metal cable sheaths, armouring, screening and shielding shall normally be conductively connected to the ship's hull at both ends. In the case of single-core cables in single-phase AC systems, only one end is to be earthed. The earthing at one end only of cables and wires in electronic systems is recommended.

M. Control, Monitoring, Alarm and Safety Systems

1. Scope

1.1 General requirements

The following sets out requirements for the control, monitoring, alarm and safety systems necessary to operate essential equipment for ship's propulsion, steering and safety.

The requirements cover installations of the main propulsion and associated machinery, which are under manned supervision.

Requirements for automatic and remote control systems and equipment which shall be approved in lieu of continuous manning have to be agreed with the Rules for Automation (Part 1, Vol. VII).

1.2 Planning and design

1.2.1 The design of safety measures, open and closed loop controls and monitoring of equipment shall limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

1.2.2 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 recognise faults and test capability
- reproducibility of values

1.2.3 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

1.2.4 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.

1.2.5 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.

1.2.6 Where mechanical systems or equipment are either completely or partly replaced by electric/electronic equipment, the requirements relating to mechanical systems and electric/electronic equipment shall be met accordingly.

1.3 Design and construction

1.3.1 Machinery alarm systems, protection and safety systems, together with open and closed loop control systems for essential equipment shall be constructed in such a way that faults and malfunctions affect only the directly involved function. This also applies to measuring facilities.

1.3.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities shall be provided to permit independent manual operation.
Manual operation shall override all remote and automatic control.

1.3.3 In the event of disturbances automatically switched off plants shall not be released for restarting until having been manually unlocked.

It shall be possible to start, stop and reverse the ship's propulsion reliably and quickly.

1.4 Application of computer systems

If computer systems are used, P. has to be observed.

1.5 Maintenance

1.5.1 Access shall be provided to systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps etc. are to be provided to allow functional checks to be carried out and faults to be located.

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

1.5.3 Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign shall be fitted to indicate the risk.

1.5.4 Circuit boards and plug-in connections shall be protected against unintentional mixing up. Alternatively they shall be clearly marked to show where they belong to.

2. Machinery control and monitoring installations

2.1 General

2.1.1 Where ships have only one main engine, that engine shall not be shut down automatically except in order to protect against overspeed.

2.1.2 Where ships have only one main engine, that engine may be equipped with an automatic device for the reduction of the engine speed only If an automatic reduction of the engine speed is indicated both optically and acoustically in the wheelhouse and the device for the reduction of the engine speed can be switched off from the helmsman's position.

2.2 Protective Devices for Machinery Plants

2.2.1 Protective devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

2.2.2 When reaching dangerous limits, protective devices shall adapt the operation to the remaining technical capabilities.

2.2.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.2.4 Protective devices shall be so designed 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.

2.2.5 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

2.2.6 The monitored open-circuit principle is to be applied to protective devices which can activate an automatic shut-down. Equivalent monitoring principles are permitted.

2.2.7 The tripping of a protective device and faults shall be alarmed. The reason for the tripping shall be identifiable.

2.2.8 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

2.2.9 The adjustment facilities for protective devices shall be so designed that the last setting is traceable.

2.2.10 Protective devices which can activate an automatic shut down of the main propulsion plant shall be equipped with overriding facilities from the wheelhouse.

2.3 Reductions of the main propulsion plant

2.3.1 Reductions can be initiated automatically or by a request for manual reduction.

2.3.2 Reductions may be a function of the machinery alarm system.

2.3.3 Overriding capabilities have to be provided for automatic reductions from the wheelhouse.

2.4 Manual Emergency stop

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

2.4.2 The manual emergency stop shall not be automatically cancelled.

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

2.4.4 The monitored open-circuit principle is to be applied to manual emergency stops. Equivalent monitoring principles are permitted.

2.5 Safety Devices for Machinery Plants

2.5.1 Safety devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

2.5.2 When reaching dangerous limits, safety devices shall initiate an automatic shut-down.

2.5.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.5.4 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

2.5.5 The monitored open-circuit principle is to be applied to safety devices. Equivalent monitoring principles are permitted.

2.5.6 The tripping of a safety device and faults shall be alarmed and recorded. The reason for the tripping shall be identifiable.

2.5.7 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

2.5.8 The adjustment facilities for safety devices shall be so designed that the last setting is traceable.

2.5.9 Safety devices of the main propulsion plant may be equipped with overriding facilities. The overspeed protection is excluded.

2.6 Safety Systems for Machinery Plants

2.6.1 The safety system of a machinery plant is the subsumption of the protective and safety devices related to this machinery plant.

2.6.2 It is allowed to combine protective and safety devices for one individual system only.

2.7 Open-loop control

2.7.1 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 1.2.2.

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

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

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

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

2.7.6 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.

2.7.7 Open-loop control for speed and power of main engines are subject to mandatory type testing.

2.8 Closed-loop control

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

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

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

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

2.8.5 Closed-loop control for speed and power of main engines are subject to mandatory type testing.

2.9 Alarm systems

2.9.1 Alarm systems shall indicate unacceptable deviations from operating figures optically and audibly. The operative state of the system is to be indicated in the wheelhouse and on the equipment.

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

2.9.3 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.

2.9.4 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.

2.9.5 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.

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

2.9.7 The power supply shall be monitored and a failure shall cause an alarm. Test facilities are required for the operation of light displays.

The alarm system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.9.8 Alarms are to be given at manned location in the machinery control position, if any, or in the wheelhouse and are to take the form of individual visual displays and collective audible signals. The audible alarm shall sound throughout the whole machinery space, at manned location in the machinery control position and at the wheelhouse. If this cannot be ensured because of the noise level, additional visual alarms such as flash signals shall be installed.

Simultaneously with a collective alarm signal, an acknowledgeable audible alarm shall be given at manned location in the machinery control position and in the wheelhouse which, following acknowledgement, shall be available for further signals.

It shall be possible to silence audible signals independently of acknowledging the visual signal.

Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the concerned process is been given.

2.9.9 Where the alarm system contents individual visual displays in the machinery space, the visual fault signals in the wheelhouse may be arranged in at least three groups as collective alarms in accordance with their urgency, if this is necessary due the scope of the plant.

– Group 1: Alarms signalling faults which require immediate shutdown of the main engine (red light).
– Group 2: Alarms signalling faults which require a reduction in power of the main engine (red light).
– Group 3: Alarms signalling faults which do not require Group 1 or Group 2 measures (yellow light).

2.9.10 Alarm delays shall be kept within time limits to prevent any risk to the monitored system in the event of exceeding the limit value. Pressure alarms may in general not be delayed by more than 2 s. Level alarms are to be delayed sufficiently to ensure that the alarm is not tripped by brief fluctuations in level.

2.9.11 A failure of the power supply or disconnection of the system shall not alter the limit value settings at which a fault is signalled.

2.9.12 The fault signalling systems of main engines with engine-driven pumps are to be so designed that variations in operating parameters due to manoeuvres do not trip the alarm.

2.9.13 It is recommended that input devices approved by BKI should be used.

2.9.14 It is recommended that the alarm signals should be automatically suppressed when the main engine and auxiliaries are taken out of service.

2.10 Integration of systems for essential equipment

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

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

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

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

2.11 Remote control of machinery installations

2.11.1 Machinery installations are to be equipped with monitoring equipment as detailed in Table 2.16.

2.11.2 The remote control shall be capable to control speed, direction of thrust, and as appropriate torque or propeller pitch without restriction under all navigating and operating conditions.

2.11.3 Single lever control is to be preferred for remote control systems. Lever movement shall be in accordance to the desired course of the ship. Commands entered into the remote control system from the wheelhouse shall be recognizable at all control stations.

2.11.4 The remote control system shall carry out commands which are ordered, including emergency manoeuvres, in accordance with the propulsion plant manufacturer's specifications. Where critical speed ranges are incorporated, their quick passing is to be guaranteed and a reference input within them have to be inhibited.

2.11.5 With each new command, stored commands shall be erased and replaced by the new input.

2.11.6 In the case of set speed stages, a facility shall be provided to change the speed in the individual stages.

2.11.7 An overload limitation facility is to be provided for the propulsion machinery.

2.11.8 It shall be possible to stop the propeller thrust from the wheelhouse independently of the remote control system.

2.11.9 Following emergency manual shutdown or automatic shutdown of the main propulsion plant, a restart shall only be possible via the stop position of the command entry.

2.11.10 The failure of the remote control system and of the control power shall not result in any sudden change in the propulsion power nor in the speed and direction of rotation of the propeller. In individual cases, BKI may approve other failure conditions, whereby it is assumed that:

– there is no increase in ship's speed

– there is no course change

– no unintentional start-up processes are initiated.

Local control shall be possible from local control positions. The local control positions are to be independent from remote control of propulsion machinery and continue to operate 15 minutes after a black-out.

2.11.11 The failure of the remote control system and of the control power is to be signalled by an alarm.

2.11.12 Wheelhouse and engine room are to be fitted with indicators indicating that the remote control system is operative. The wheelhouse and the machinery space are to be provided with indicators showing:

– propeller speed and direction of rotation for propeller system with fixed propeller

– propeller speed and pitch for system with controllable pitch propeller

Table 2.16 Remote control of machinery installations

Symbol convention H = High, HH = Very high, L = Low, I = Individual alarm, G = Group alarm		**Monitoring**				
Identification of system parameter		Alarm	Indication local	Alarm wheelhouse[4]	Indication wheelhouse	Shut down
MAIN ENGINE						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Shaft revolution indicator			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature		H	x	G		
Leakage of fuel injection pipe [5]		H		G		
Failure in electronic fuel injection system		H		G		
Fresh cooling water system inlet pressure [1]		L	x	G		
Fresh cooling water system outlet temperature [1]		H	x	G		
Fuel oil temperature for engines running on HFO		L	x	G		
Exhaust gas temperature (single cylinder when the dimensions permit)			x			
Starting air pressure		L	x	G	x	
Charge air pressure			x			
Control air pressure			x		x	
Exhaust gas temperature at turbocharger inlet/outlet (where the dimensions permit)			x			
Manual emergency stop of propulsion		x			x	x [3]
Fault in the electronic governor		x	x	G		
REDUCTION GEAR						
Tank level			x			
Lubricating oil temperature			x			
Lubricating oil pressure			x			
AUXILIARY MACHINE [2]						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system [1]		L	x	G		
Fresh cooling water system outlet temperature [1]		H	x	G		
Lubricating oil pressure		L	x	G		
Fault in the electronic governor			x	G		
DIESEL BOW THRUSTER [2]						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system [1]		L	x	G		
Fresh cooling water system outlet temperature [1]		H	x	G		
Direction of propulsion			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature			x			
Fault in the electronic governor		x	x	G		
PROPULSION						
Propulsion remote control ready			x		x	
Pitch control			x		x	
ELECTRICITY						
Earth fault (when insulated network)		x	x	G		
Main supply power failure		x	x	G		

Table 2.16 Remote control of machinery installations *(continued)*

Symbol convention H = High, HH = Very high, L = Low, I = Individual alarm, G = Group alarm	**Monitoring**				
Identification of system parameter	Alarm	Indication local	Alarm wheelhouse[4]	Indication wheelhouse	Shut down
FUEL OIL TANKS					
Fuel oil level in service tank or tanks supplying directly services essential for safety or navigation	L	x	G		
STEERING GEAR					
Rudder angle indicator		x		x	
Level of each hydraulic fluid	L	x	I	x	
Indication that electric motor of each power unit is running		x		x	
Failure of rate of turn control	x		I	x	
Overload failure	x	x	I	x	
Phase failure	x	x	I	x	
Loss of power supply	x	x	I	x	
Loss of control supply	x	x	I	x	
STEAM BOILER OR HEATING OIL					
High pressure	HH				x
FIRE					
Fire detection	x			x	
Fire manual call point	x			x	
Automatic fixed fire extinguishing system activation, if fitted	x			x	
FLOODING					
Level of machinery space bilges/drain wells	x			x	
ALARM SYSTEM					
Alarm system power supply failure	x	x		x	

[1] A combination of level indication/alarm in expansion tank and indication/alarm cooling water temperature can be considered as equivalent with consent of the Society

[2] Exemptions can be given for diesel engines with a power of 50 kW and below

[3] Openings of clutches can, with the consent of the Society, be considered as equivalent

[4] Group of alarms are to be detailed in the machinery space or control room (if any)

[5] For diesel engines with more than two cylinders

2.11.13 Remote control systems for main propulsion plants are subject to mandatory type approval.

2.11.14 The transfer of control between the wheelhouse and machinery space shall be possible only in the machinery area.

2.11.15 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. A display at each control station shall indicate whether the control station in question is in operation.

2.11.16 Each local control position, including partial control (e.g. local control of controllable pitch propellers or clutches) is to be provided with means of communication with the remote control position.

2.12 Fire detection and alarm

2.12.1 General

2.12.2 Any required fixed fire detection and fire alarm system shall be capable of immediate operation at all times.

2.12.3 The fixed fire detection and fire alarm system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

2.12.4 The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

2.12.5 The system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.13 Detector requirements

2.13.1 Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

2.13.2 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 per cent obscuration per metre, but not until the smoke density exceeds 2 per cent obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

2.13.3 Heat detectors shall be certified to operate before the temperature exceeds 78 °C but not until the temperature exceeds 54 °C, when the temperature is raised to those limits at a rate less than 1 °C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

2.13.4 At the discretion of the Society, the permissible temperature of operation of heat detectors may be increased to 30 °C above the maximum deck head temperature in drying rooms and similar spaces of a normal high ambient temperature.

2.13.5 All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

2.13.6 The detectors are to 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 is expected, shall be avoided.

2.13.7 Detectors mounted to the ceiling shall generally be placed at least 0,5 m away from bulkheads, except in corridors, lockers and stairways.

2.13.8 The maximum monitored area, respectively the maximum distance between detectors shall not exceed the following values:

– Heat detectors 37 m^2 or distance not more than 9 m

– Smoke detectors 74 m^2 or distance not more than 11 m

2.13.9 The distance from bulkheads shall not exceed:

– 4,5 m for heat detectors

– 5,5 m for smoke detectors

2.13.10 The society may require or permit different spacing of detectors based upon test data which demonstrate the characteristics of the detectors.

2.14 System requirements

2.14.1 The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in the wheelhouse, the accommodation and the space to be protected.

2.14.2 Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

2.14.3 Accommodation and service spaces of cargo carriers shall be protected by a fixed fire detection and fire alarm system.

2.14.4 Machinery installations which have been designed for automatic and remote control in lieu of continuous manning have to be protected by a fixed fire detection and fire alarm system.

2.14.5 Additional demands are laid down within the Type and Service Notation of the ship.

N. Power Electronics

1. General

For power electronics in electrical propulsion plants, see O.

2. Construction

2.1 General

2.1.1 The rules set out in A. to M. are to be observed, wherever applicable.

2.1.2 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 fuse-contactor may be used. In all other cases a circuit breaker shall be provided on the mains side.

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

2.1.4 Control and alarm electronics shall be galvanically separated from power circuits.

2.1.5 External pulse cables are to be laid twisted in pairs and screened, and kept as short as possible.

3. Rating and Design

3.1 General

3.1.1 Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation, see D.1. and H.1.

3.1.2 Rectifier systems shall guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see D.1. In the event of unacceptably large frequency and/or voltage variations in the supply voltage, the system shall shut-off or remain in a safe operating condition.

3.1.3 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.

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

3.1.5 If the replacement of plug-in printed circuit boards while the unit is in operation can cause the destruction of components or the uncontrolled behavior of drives, a caution label shall be notifying to this effect.

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

3.1.7 Control-circuit supplies are to be safe guarded against unintended disconnection, if this could endanger or damage the plant.

3.1.8 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.

3.1.9 Special attention shall be paid to the following points:

– mutual interference of static converters connected to the same busbar system

– calculation of commutating impedances reacting to voltage distortion and reacting to other consumers

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

– consideration of reactions from rectifier installations on the commutation of DC machines

– influence by harmonics and high-frequency interference

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

– reaction on the mean and peak value of the system voltage in case of frequency fluctuations

– inadmissible effects on the voltage regulation of generators

4. Cooling

4.1 General

4.1.1 Natural cooling is preferred.

4.1.2 The safety in operation shall be proved for liquid cooling and forced cooling.

4.1.3 An impairment of cooling shall not result in unacceptable over temperatures, an over temperature alarm shall be provided.

5. Control and monitoring

5.1 General

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

6. Protection equipment

6.1 General

6.1.1 Power electronic equipment shall be protected against exceeding of their current and voltage limits.

For protective devices, it shall be ensured that upon actuating:

– the output will be reduced or defective part systems 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

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

6.1.3 Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semi conductor components.

7. Tests

7.1 General

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 BKI Surveyor.

7.2 Extent of routine tests

7.2.1 Voltage test

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

$U = 2 \cdot Un + 1000 \geq 2000$ [V]

duration = 1 minute

Un = maximum nominal voltage between any two points on the power electronics device [V]

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 hall 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.

7.2.2 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. The resistance shall be at least 1 k Ohm/V.

7.2.3 Operational test

The function shall be demonstrated as far as possible.

O. Electrical Propulsion Plants

1. General

1.1 A ship has an electrical main propulsion plant if the main drive to the propeller is provided by at least one electrical propulsion motor.

1.2 If a propulsion plant has only one propulsion motor and the ship has no additional propulsion system which ensures sufficient propulsive power, this plant shall be so structured that following a fault in the static converter or in the regulation and control system at least a limited propulsion capability remains.

1.3 Auxiliary propulsion plants are additionally propulsion systems.

1.4 The engines driving the generators for the electrical propulsion plant are main engines. Motors driving the propeller shaft or the thruster are propulsion motors.

1.5 If electrical main propulsion plants are supplied from the ship's general mains, the Rules in this Section apply also to the generators and the associated switchgear. For auxiliary propulsion plants, the Rules of this Section are to be met correspondingly.

2. Drives

2.1 Basis for dimensioning

2.1.1 The electrical machinery and plants shall, in accordance with their service and operating conditions, be designed for short periods of overload and for the effect of manoeuvres.

2.1.2 The lubrication of machinery and shafting shall be designed to be adequate for the entire speed range of rotation in both directions including towing.

2.2 Main engines

2.2.1 The main engines shall also conform to the requirements of Volume 3, Section 1.

2.2.2 The diesel governors shall allow safe operation over the whole speed range and under all running and manoeuvring conditions, this for both, single operation and parallel operation.

2.2.3 The main engines shall be so constructed that under the consideration of the plant conception they can absorb the reverse power arising during reversing manoeuvres.

2.3 Propulsion motors

2.3.1 The propulsion motors shall also conform to the requirements of A. to H.

2.3.2 The effects of the harmonics of currents and voltages are to be taken into consideration for the design of the propulsion motors.

2.3.3 The winding insulation shall be designed to withstand the over voltages which may arise from manoeuvres switching operations.

2.3.4 Machines with forced ventilation shall be so dimensioned that in case of ventilation failure a limited operation is still possible. Versions deviating from this principle require an agreement with BKI.

2.3.5 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. Static converter installations

3.1 Power-electronic equipment shall also conform to the requirements of N.

3.2 Static converters shall be designed for the load to be expected under all operating and manoeuvring conditions, including overloads and short circuits.

3.3 If static converters are separately cooled, the plant shall be capable to continue operation at reduced power level if the cooling system fails.

3.4 The circuits for main power supply and exciter equipment shall be supplied directly from the switchboard and shall be separate for each motor and each winding.

3.5 Exciter circuits whose failure can endanger the operation shall only be protected against short circuit.

3.6 The static converters shall be easily accessible for inspection, repair and maintenance.

4. Control stations

4.1 Should the remote control system fail, local operation shall be possible. Changeover shall be possible within a reasonably short time. This operation can be made, e.g. from the control cabinet of the propulsion plant. Voice communication with the bridge shall be provided.

4.2 The main control station on the bridge shall be provided with an emergency stop device independent of the operating elements of the main control system. Also an emergency stop device in the engine room shall be provided.

4.3 All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

4.4 A defect in a system for synchronising or in a position equalisation device for control operating levers of several control stations shall not result in the failure of the remote control from the main control position.

5. Ship's mains

5.1 It shall be possible to connect and disconnect generators without interrupting the propeller drive.

5.2 If a power management system is available, the automatic stop of main engines during manoeuvring shall be prevented.

6. Control and regulating

6.1 If computer systems are used, the requirements of P. shall be observed.

6.2 An automatic power limitation of the propulsion motors shall ensure that the ship mains will not be overloaded.

6.3 The reverse power during reversing or speed reducing manoeuvres shall be limited to the acceptable maximum values.

7. Protection of the plant

7.1 Automatic stop of the propulsion plant, which impairs the ship's manoeuvring capability, shall be limited to such failures which would result in serious damage within the plant.

7.2 Protection devices shall be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring.

7.3 Defects in reducing and stopping devices shall not impair the limited operation in accordance with 1.2.

7.4 In the event of failure of an actual or reference value it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will be not reversed or dangerous operating conditions arise. The same applies to failure of the power supply for control and regulating.

7.5 The following additional protection equipment shall be provided:

– where drives uncontrolled can be mechanically blocked, they shall be provided with protection devices which prevents damage to the plant

– overspeed protection

– protection against overcurrent and short circuit

– differential protection and earth fault monitoring for propulsion motors with an output of more than 1500 kW

7.6 The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition shall remain recognisable even after switching-off.

8. Measuring, indicating, monitoring and alarms equipment

8.1 General

Failures in measuring, monitoring and indicating equipment shall not cause a failure of control and regulating.

8.2 Measuring equipment and indicators

8.2.1 Propulsion motors and generators shall be provided with at least the measuring equipment and indicators at control stations in compliance with 8.2.2 and 8.2.3.

8.2.2 At local control station:

– 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 generators used for propulsion or the reserve power that is still available

– plant ready for switching on

– plant ready for operation

– plant disturbed

– power reduced

– control from the bridge
– control from local control station

8.2.3 At main control station on the bridge:

– revolution indicator per shaft
– indication of the power remaining available for the propulsion plant in relation to the total available ship's main power; the indication of remaining power may be omitted in the case of power management system
– plant ready for switching on
– plant ready for operation
– plant disturbed
– power reduced
– request to reduce
– control from the bridge
– control from the local control station

8.3 Monitoring equipment

Abnormal values of the different parameters of the equipment listed here below should trigger an alarm which has been signalled optically and audibly:

a) Monitoring of the ventilators and temperatures of the cooling air for forced-ventilation of machines, transformers and static converters.

b) Monitoring of the flow rate and leakage of coolants of machines and static converters with closed cooling systems.

c) Instead of the monitoring of air flow and flow rate (a and b) of machines and transformers, winding-temperature monitoring can be provided.

d) For machines above 1500 kW, temperature monitoring for the stator windings and the bearings.

e) Pressure or flow monitoring for the lubricating oil of friction bearings (except in the case of ring).

f) Insulation resistance in the case of unearthed networks.

8.4 Power reduction

In the case abnormal operating power may be automatically reduced, this information is to be indicated at the propulsion control position.

9. Cables and cable installation

9.1 General

The cable network for electrical propulsion plants shall comply with the requirements of L. 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.

10. Testing and trials

10.1 General

10.1.1 A quality assurance plan has to be submitted to BKI.

10.1.2 Tests of machines, static converters, switchgear, equipment and cables shall be carried out at the maker's works in accordance with applicable requirements of A. to N.

10.1.3 Shaft material for generators and propulsion motors

Tests of the shaft material for generators and propulsion motors. Steel and Iron Materials, shall be made by a shaft material test as for ship's shafting.

10.1.4 The testing of other important forgings and castings for electrical main propulsion plants, e.g. rotors and pole shoe bolts, shall be agreed with BKI.

10.2 Tests after installation

Newly-constructed or enlarged plants require testing and trials on board. The scope of the trials is to be agreed with BKI.

10.2.1 Dock trial

For scope and extent of dock trials, see Q.3.8.

10.2.2 River trial

For river trial programme, see Q.4.2.

P. Computer Systems

1. General

1.1 Scope

These Rules apply additionally, if computers are used for tasks essential to the safety of the ship, cargo, crew or passengers and are subject to classification.

1.2 References to other Rules and Regulations

IEC 61508 "Functional safety of electrical/ electronic/programmable electronic safety related systems".

1.3 Requirements applicable to computer systems

1.3.1 Computer systems shall fulfil the requirements of the process under normal and abnormal operating conditions. The following shall be considered:

– danger to persons

– environmental impact

– endangering of technical equipment

– usability of computer systems

– operability of all equipment and systems in the Process

1.3.2 If process times for important functions of the system to be supervised are shorter than the reaction times of a supervisor and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

1.3.3 Computer systems shall be designed in such a way that they can be used without special previous knowledge. Otherwise, appropriate assistance shall be provided for the user.

1.3.4 When alternative design or arrangements deviating from Rules are proposed, an engineering analysis, evaluation and approval of the design and arrangements shall be carried out in accordance with a relevant International and/or National Standard acceptable to BKI. such cases, details are to be submitted for consideration.

2. Requirement classes

2.1 General requirements

2.1.1 Computer systems are assigned, on the basis of a risk analysis, to requirement classes as shown in Table 2.17. This assignment shall be accepted by BKI. Table 2.18 gives examples for such an assignment.

2.1.2 The assignment is divided into five classes considering the extent of the damage caused by an event.

2.1.3 Considered is only the extent of the damage directly caused by the event, but not any consequential damage.

2.1.4 The assignment of a computer system to a corresponding requirement class is made under the maximum possible extent of direct damage to be expected.

2.1.5 In addition to the technical measures stated in this section also organizational measures may be required if the risk increases. These measures shall be agreed with BKI.

2.2 Risk parameters

2.2.1 The following aspects may lead to assignment to a different requirement class, see Table 2.17.

a) Dependence on the type and size of ship:
   - number of persons endangered
   - transportation of dangerous goods
   - Ship’s speed

b) Presence of persons in the endangered area with regard to duration respectively frequency:
   - rarely
   - often
   - very often
   - at all times

c) Averting of danger

   To evaluate the possibility of danger averting, the following criteria shall be considered:
   - operation of the technical equipment with or without supervision by a person
   - temporal investigation into the processing of a condition able to cause a damage, the alarming of the danger and the possibilities to avert the danger

d) Probability of occurrence of the dangerous condition. This assessment is made without considering the available protection devices.

   Probability of occurrence:
   - very low
   - low
   - relatively high

e) Complexity of the system:
   - integration of various systems
   - linking of functional features

2.2.2 The assignment of a system into the appropriate requirement class shall be agreed on principle with BKI.

2.3 Measures required to comply with the requirement class

2.3.1 The measures to comply with the requirements of classes 4 and 5 may require for computer equipment and conventional equipment a separation or for the computer equipment a redundant, diversified design.

Note

As a failure of a requirement class 3, 4 and 5 system may lead to an accident from significant to catastrophic severity, the use of unconventional technology for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of BKI.

2.3.2 Protection against modification of programs and data The measures required depend on the requirement class and the system configuration (see Table 2.19).

Computer systems shall be protected against unintentional or unauthorised modification of programs and data.

For large operating systems and programs, other storage media such as hard disks may be used by agreement.

Significant modifications of program contents and system specific data, as well as a change of version, shall be documented and shall be retraceable.

For systems of requirement class 4 and 5 all modifications, the modifications of parameters too, shall be submitted for review/approval.

The examples of program and data protection shown in Table 2.19 may be supplemented and supported by additional measures in the software and hardware, for example:

- user name, identification number
- code word for validity checking, key switch
- assignment of authorizations in the case of common use of data/withdrawal of authorizations for the change or erasing of data
- coding of data and restriction of access to data, virus protection measures
- recording of workflow and access operations.

Note

A significant modification is a modification which influences the functionality and/or safety of the system.

3. System configuration

3.1 General requirements

3.1.1 The technical design of a computer system is given by its assignment to a requirement class. The measures listed below for example, graded according to the requirements of the respective requirement class, shall be ensured.

3.1.2 For functional units, evidence shall be proved that the design is self-contained and produces no feedback.

3.1.3 The computer systems shall be fast enough to perform autonomous control operations and to inform the user correctly and carry out his instructions in correct time under all operating conditions.

Table 2.17 Definition of requirement classes

Requirement class	Extent of damage		
	Effects on persons	Effect on the environment	Technical damage
1	none	none	insignificant
2	slight injury	insignificant	minor
3	serious, irreversible injury	significant	fairly serious
4	loss of human life	critical	considerable
5	much loss of human life	catastrophic	loss

Table 2.18 Examples of assignment into requirement classes

Requirement class	Examples
1	Supporting systems for maintenance Systems for general administrative tasks Information and diagnostic systems
2	"Off line" cargo computers Navigational instruments Machinery alarm and monitoring systems Tank capacity measuring equipment
3	Controls for auxiliary machinery Speed governors "On line" cargo computers, networked (bunkers, draughts, etc.) Remote control for main propulsion Fire detection systems Fire-extinguishing systems Bilge draining systems Integrated monitoring and control systems Control systems for tank, ballast and fuel Rudder control systems Course control systems Machinery protection systems/equipment
4	Burner control systems for boilers and thermal oil heater Electronic injection systems
5	Systems where manual intervention to avert danger in the event of failure or malfunction is no longer possible and the extent of damage under requirement class 5 can be reached

3.1.4 Computer systems shall monitor the program execution and the data flow automatically and cyclically e.g. by means of plausibility tests, monitoring of the program and data flow over time.

3.1.5 In the event of failure and restarting of computer systems, the process shall be protected against undefined and critical states.

3.2 Power supply

3.2.1 The power supply shall be monitored and failures shall be indicated by an alarm.

3.2.2 Redundant systems shall be separately protected against short circuits and overloads and shall be selectively fed.

3.3 Hardware

3.3.1 The design of the hardware shall be clear. Easy access to interchangeable parts for repairs and maintenance shall be provided.

3.3.2 Plug-in cards and plug-in connections shall be appropriately marked to protect against unintentional transposition or, if inserted in an incorrect position, shall not be destroyed and not cause any malfunctions which might cause a danger.

3.3.3 For integrated systems, it is recommended that subsystems be electrically isolated from each other.

3.3.4 Computers shall preferably be designed without forced ventilation. If forced ventilation of the computers is necessary, it shall be ensured that an alarm is given in the case of an unacceptable rise of temperature.

3.4 Software

3.4.1 Examples of software are:

– operating systems
– application software
– executable code
– database contents and structures
– bitmaps for graphic displays
– logic programs in PAL's
– microcode for communication controllers

3.4.2 The manufacturer shall prove that a systematic procedure is followed during all the phases of software development.

3.4.3 After drafting the specification, the test scheduling shall be made (listing the test cases and establishment of the software to be tested and the scope of testing). The test schedule lays down when, how and in what depth testing shall be made.

3.4.4 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests shall be retraceable.

Table 2.19 Program and data protection measures in relation to the requirement class

Requirement class	Program/Data memory
1	Protection measures are recommended
2	Protection against unintentional/unauthorized modification
3	Protection against unintentional/unauthorized modification and loss of data
4	No modifications by the user possible
5	No modifications possible

3.4.5 The version of the Software with the relevant date and release have to be documented and shall be recognizable of the assignment to the particular requirement class.

3.5 Data communication links

3.5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and specified accordingly.

3.5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

3.5.3 The data communication link shall be continuously self-checking, for detection of failures on the link itself and for data communication failure on the nodes connected to the link. Detected failures shall initiate an alarm.

3.5.4 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

3.5.5 The characteristics of the data communication link shall be such as to transmit that all necessary information in adequate time and overloading is prevented.

3.5.6 When the same data communication link is used for two or more essential functions, this link shall be redundant.

3.5.7 Means are to be provided to ensure protect the integrity of data and provide timely recovery of corrupted or invalid data.

3.5.8 Switching between redundant links shall not disturb data communication or continuous operation of functions.

3.5.9 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

3.5.10 If approved systems are extended, prove of trouble-free operation of the complete system shall be provided.

3.6 Additional requirements for wireless data links

3.6.1 These requirements are in addition to the requirements of 5. Data communication links apply to requirement class 2 using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

3.6.2 Functions that are required to operate continuously to provide essential services dependent on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

3.6.3 Wireless data communication shall employ recognized international wireless communication system protocols that incorporate the following:

– Message integrity:

  Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

– Configuration and device authentication: Shall only permit connection of devices that are included in the system design;

– Message encryption. Protection of the confidentiality and or criticality the data content;

– Security management. Protection of network assets, prevention of unauthorized access to network assets.

Note

The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements. Consideration should be given to system operation in the event of national local port regulations.

3.7 Integration of systems

3.7.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

3.7.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

3.7.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

3.8 User interface

3.8.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

3.8.2 The status of the computer system shall be recognizable.

3.8.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

3.8.4 For using computer systems, a general comprehensible user guide shall be provided.

3.9 Input devices

3.9.1 The feedback of control commands shall be indicated.

3.9.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

3.9.3 Operator panels located on the bridge shall be individually illuminated. The lighting shall be adapted non glare to the prevailing ambient conditions.

3.9.4 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices.

3.9.5 If the operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

– use of a special key lock

– use of two or more keys

3.9.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

3.9.7 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

3.10 Output devices

3.10.1 The size, colour and density of text, graphic information and alarm signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

3.10.2 Information shall be displayed in a logical priority.

3.10.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

3.11 Graphical user interface

3.11.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

3.11.2 When general-purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

3.11.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

3.12 Remote access

3.12.1 Remote access during a voyage of a ship shall be used for monitoring purposes and the prior acknowledgment by the ship's responsible crew member only.

3.12.2 If remote software maintenance is arranged for onboard, the installation of software requires the following items and or actions to be fulfilled:

- no modification shall be possible without the acceptance and acknowledgement by the ship's responsible crew member (for example the captain) and shall be carried out in a harbour only;
- any revision which may affect compliance with the rules shall be approved by BKI and evidence of such shall be available onboard;
- an installation procedure shall be available;
- the security of the installation process and integrity of the changed software shall be verified after the software update is complete;
- a test program for verification of correct installation and correct functions shall be available;
- evidence for the reason for updating a software shall be documented in a software release note;
- in case that the changed software has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

4. Testing of computer systems

4.1 General

4.1.1 Computer systems of requirement class 3 and higher are subject to mandatory type approval.

4.1.2 Evidence, tests and assessments of computer systems have to be carried out in accordance to the requirement class.

4.1.3 By the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

4.1.4 If other proofs and tests are provided by the manufacturer which are of an equivalent nature, they may be recognized.

4.1.5 The test schedule of system testing has to be specified and submitted before the hardware and software test will be carried out.

4.1.6 Modifications after completed tests which have influence on the functionality and/or the safety of the system have to be documented and retested in accordance to the requirement class.

4.2 Tests in the manufacturer's works

BKI reserve the right to demand tests for systems which have safety implications or in case of extensive computer systems or where individual systems are integrated. This test might be a factory acceptance test (FAT) with presence of BKI, where function tests, operating conditions simulation, fault simulation and simulation of the application environment will be conducted.

4.3 Tests on board

4.3.1 Complete system tests

4.3.1.1 Integration tests

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 external electromagnetic interference during expected operating conditions.

Note

Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for requirement class 3, 4 and 5 systems, the layout and / or equipment shall be changed to prevent further failures occurring.

Q. Tests on Board

1. General

The tests are divided into:

– tests during construction

– tests during commissioning/dock trial

– tests during river trial

2. Tests during construction

2.1 During the period of construction of the ship, the installations shall be checked for conformity with the documents reviewed by BKI and with the Rules for construction.

2.2 Test certificates for tests which have already been performed shall be presented to the Surveyor on request.

2.3 Protective measures

a) protection against foreign bodies and water

b) protection against electric shock, such as protective earthing, protective separation or other measures as stated in A.

c) measures of explosion protection

2.4 Testing of the cable network

Inspection and testing of cable installation and cable routing with regard to:

a) acceptability of cable routing with regard to:
   – separation of cable routes
   – fire safety
   – reliable supply of emergency consumers (where applicable)
b) selection and fixation of cables
c) construction of bulkhead and deck penetrations
d) insulation resistance measurement

3. Testing during commissioning/dock trial of the electrical equipment

3.1 General

Proofs are required of the satisfactory condition and proper operation of the main and emergency power supply systems, the steering gear and the aids of manoeuvring, as well as of all the other installations specified in the Rules for construction. Unless already required in the Rules for construction, the tests to be performed shall be agreed with BKI's Surveyor in accordance with the specific characteristics of the subject equipment.

3.2 Generators

A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on appropriate form.

3.3 Storage batteries

The following shall be tested:

a) installation of storage batteries
b) ventilation of battery rooms, cupboards/ containers, 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 under observance of:

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 main and emergency switchboards with insulated handrails, gratings and insulating floor coverings
d) correct settings and operation of protection devices and interlocks
e) independent 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)

BKI reserves 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 Power 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) emergency remote shut-down of equipment such as engine room fans, 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 plant

Functioning of the propulsion plant shall be proved by a dock trial before river trials.
At least the following trials/measurements shall be carried out in the presence of BKI 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

– verification of propeller speed variation and all associated equipment

– verification of protection, monitoring and indicating/ alarm equipment including the interlocks for sufficient functioning

– verification of insulation condition of the main propulsion circuits

3.9 Computer systems

Regarding scope of tests see P.

4. Testing during river trial

4.1 General

Proof is required that the power supply meets the requirements under the various operating conditions of the ship. All components of the system shall function satisfactorily under service conditions, i.e. at all main engine speeds and during all manoeuvres.

4.2 Electrical propulsion plant

4.2.1 Trial programme

The trial programme shall at least include:

a) Continuous operation of the ship at full propulsion load until the entire propulsion plant has reached steady-state temperatures.

The trials shall be carried out at rated engine speed and with an unchanged governor setting:

- at 100 % power output (rated power): at least 3 hours
- with the propeller running astern during the dock test or during the river trial at a minimum speed of at least 70 % of the rated propeller speed: 10 minutes

b) Reversal of the plant out of the steady-state condition from full power ahead to full power astern and maintaining of this setting until at least 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

c) performance of typical manoeuvres

d) checking of the machinery and plant in all operating conditions

e) checking of the network qualities in the ship's propulsion network and mains