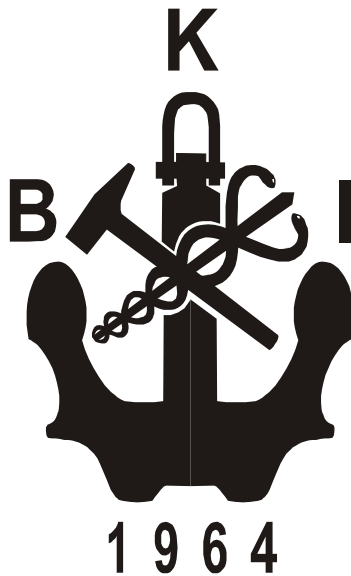

BIRO KLASIFIKASI INDONESIA

**RULES
FOR THE CLASSIFICATION
AND CONSTRUCTION OF
OFFSHORE INSTALLATIONS**



VOLUME 5

RULES FOR ELECTRICAL INSTALLATIONS

EDITION 2011

The following Rules come into force on..... 2011

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Section 1

General Requirements and Instructions

A. General

1. Scope

1.1 These Rules apply to electrical and electronic equipment on fixed offshore installations and mobile offshore units in accordance with Volume 1.

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

1.3 Deviations from these Rules may be approved where there are special reasons.

2. References to other rules and regulations

2.1 Where the requirements for electrical equipment and facilities are not laid down in these Rules, agreement shall be reached, wherever necessary, regarding the use of other regulations and standards. These include, e.g. IEC publications, especially all IEC 60092 and 61892 publications.

2.2 The provisions of the "International Convention for the Safety of Life at Sea 1974, as amended (SOLAS 74)" and the "Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code)" are taken into account in these Rules.

2.3 If necessary, in addition to the BKI Rules, national regulations are to be observed as well.

2.4 The standards, codes, etc. quoted in this Volume are listed in Annex A.

3. Design

Electrical installations shall be designed so that

- the maintaining of normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power
- the operation of the equipment required for safety will be ensured under various defined emergency conditions
- the safety of personnel and units/installations from electrical hazards will be ensured

B. Definitions

1. Power supply installations

The power plant comprises all equipment for the generation, transformation and storage of electrical energy.

2. Essential equipment

2.1 Principal requirements

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

- propulsion, manoeuvrability, navigation of mobile offshore units
- safety of mobile offshore units and fixed offshore installations
- safety of the crew
- functioning of all equipment, machinery and appliances needed for safe operation, like flooding control, fire fighting, ventilation, life saving appliances, etc.
- functioning of all equipment, machinery and appliances needed to an unrestricted extent for the primary duty of the offshore unit or installation

These requirements apply for the electrical part of the equipment and complete equipment units supplied by subcontractors.

Essential equipment is subdivided into:

- primary essential equipment according to 2.2
- secondary essential equipment according to 2.3

2.2 Primary essential equipment

Primary essential equipment is that required to be operative at all times to maintain the manoeuvrability as regards propulsion and steering of a mobile unit or the safe stability of a fixed installation and that required directly for the primary duty of units or installations.

It comprises e.g.:

- steering gear of mobile units
- main propulsion plant with internal combustion engines and gas turbines, gears, main shafting, propellers of units
- controllable pitch propeller installation of units
- scavenging air blowers, fuel oil supply pumps, fuel booster pumps, fuel valve cooling pumps, lubricat-

ing oil pumps, cooling water pumps for main and auxiliary engines necessary for propulsion of units

- dynamic positioning system of floating and semi-submersible units, including various propulsion elements and related auxiliary systems, like lubricating oil pumps, cooling water pumps, etc.
- jacking system
- anchoring and mooring systems for exact position keeping as used for tension leg platforms, pipe-laying units, FPSO, FSO, etc.
- forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for auxiliary boilers where steam is used for equipment supplying primary essential equipment
- burner equipment for auxiliary steam boilers where steam is used for equipment supplying primary essential equipment
- safety systems, such as gas detection, fire detection, shut down system
- electric generator units and associated power sources supplying primary essential equipment
- hydraulic pumps for primary essential equipment
- equipment directly involved in keeping the primary duty of the unit/installation in operation
- drilling safety equipment, if applicable
- electrical supply for process system

2.3 Secondary essential equipment

Secondary essential equipment is that required for the safety of unit/installation and crew, and is such equipment which can briefly be taken out of service without the propulsion, steering, position keeping and equipment needed for the primary duty of the unit or installation, being unacceptably impaired.

It comprises e.g.:

- windlasses and capstans not directly used for exact position keeping
- dynamic positioning equipment, if it is auxiliary equipment
- fuel oil transfer pumps and fuel oil treatment equipment
- lubrication oil transfer pumps and lubrication oil treatment equipment
- starting air and control air compressors
- other starting installations for auxiliary and main engines
- turning device for main engines
- bilge, ballast and heel-compensating installations
- fire pumps and other fire fighting installations
- ventilating fans for engine and boiler rooms

- equipment considered necessary to maintain endangered spaces in a safe condition
- equipment for watertight closing appliances
- generator units supplying secondary essential equipment, if this equipment is not supplied by generators as described in 2.2
- hydraulic pumps for secondary essential equipment
- parts of the installations for helicopter operation
- auxiliary equipment assisting the primary duty of the unit/installation

3. Non-essential equipment

Non-essential equipment is that, where temporary disconnection does not impair the principal requirements defined in 2.

4. Emergency consumers

Emergency consumers are mandatory consumers which, after breakdown of the main energy supply, shall be fed by the emergency energy supply.

5. Electric network

5.1 An electric network comprises all the equipment items connected together at the same rated voltage.

5.2 Isolated electric network

This term refers to a system in which neither a conductor nor the neutral is connected to the structure in normal operation. If it is earthed via measuring or protective devices with very high impedance, the system is likewise deemed to be isolated.

5.3 Electric network with earthed neutral

This is a system in which the neutral is connected to the structure in normal operation.

6. Rated voltage of an electric network

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

7. Low voltage systems

Systems operating with rated voltages of more than 50 V up to 1000 V inclusive and with rated frequencies of 50 Hz or 60 Hz or direct current systems where the maximum instantaneous value of the voltage under rated operating conditions does not exceed 1500 V.

8. Safety (extra low) voltage

An AC voltage not exceeding 50 V RMS, or a DC voltage not exceeding 120 V

at any point, and electrically isolated from the primary distribution system by means stated in IEC 60364-4-41.

9. High voltage systems

Systems operating with rated voltages of more than 1 kV and with rated frequencies of 50 Hz or 60 Hz, or direct current systems, with the maximum instantaneous value of the voltage under rated operating conditions over 1500 V.

10. Service spaces

10.1 Service spaces in general are machinery spaces (e.g. engine rooms) accessible only to authorized persons.

10.2 Wet service spaces

Wet service spaces are spaces in which facilities may be exposed to moisture.

10.3 Dry service spaces

Dry service spaces are spaces in which no moisture normally occurs.

10.4 Locked electrical spaces

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

10.5 Category A machinery spaces

Category A machinery spaces are spaces which contain internal combustion engines having a total power output of at least 375 kW, or which contain an oil-fired boiler or an oil-treatment plant. The trunks to such spaces are included.

11. Type test

A type test is a special test which is conducted in the presence of a BKI representative either in the manufacturer's works or, by agreement, in other suitable institutes, and whose scope is laid down by the BKI Head Office, see also the applicable BKI Regulations for the Performance of Type Tests.

12. Types of lighting

12.1 Main lighting

The main lighting system shall be supplied by the main source of electrical power and shall illuminate all areas normally accessible to and used by personnel.

12.2 Emergency lighting

The emergency lighting system shall be supplied by the emergency source of electrical power and shall

illuminate all spaces necessary for emergency operation of the installation/unit, the escape routes, muster stations, etc. as defined in Section 3, D.2.1.2.

12.3 Additional emergency lighting

Additional emergency lighting may be provided on request of the operator for start-up operations and the illumination should be approximately 30 % of the main lighting.

12.4 Transitional emergency lighting

The transitional emergency lighting is based on an accumulator battery and shall illuminate special areas for at least ½ hour in the event of failure of the main or the emergency lighting, see also Section 3, D.

13. Types of cables

13.1 Fire-resistant cables

Fire-resistant cables are those cables which have properties according to the standard IEC 60331.

13.2 Flame-retardant cables

Flame-retardant cables are those cables which have properties according to the standard IEC 60332.

13.3 Flame-proof coating

Cables with flame-proof coating will resist to flames as is being determined in accordance with a standard acceptable to BKI

14. Dead ship condition

Dead ship condition means that the complete machinery plant including the main source of electrical power is out of operation and auxiliary energy as compressed air, starting current from batteries, etc. are not available for the restoration of the main power supply, for the restart of the auxiliaries and for the start-up of the propulsion plant. It is however assumed that the equipment for start-up of the emergency diesel-generator is ready for use.

C. Documents for Approval

1. Newbuildings

1.1 The drawings and documents listed below are to be submitted in triplicate¹ for examination. They shall be available to the Surveyor in the approved state at the beginning of manufacture or installation of the electrical equipment.

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

¹

For Indonesian flag units in quadruplicate, one for Government

The drawings and documents shall make it clear that the requirements set out in this Volume have been complied with.

1.3 Any non-standard symbols used are to be explained in a key.

1.4 All documents are to be indicated with the yard number and the name of the yard.

1.5 Where electric systems are operated at variable frequency, relevant documents have to be submitted.

1.6 All documentation shall be submitted in Bahasa Indonesia or English.

1.7 BKI reserve the right to demand further documents and drawings if those submitted are insufficient for an evaluation of the installation or unit.

1.8 Required documents

The required documents for the different types of offshore units and installations are defined in Table 1.1.

2. Modifications and extensions

Major modifications to the electrical installations of an installation or unit under construction or in service are subject to approval. Appropriate documentation is to be submitted in ample time prior to the execution of the work.

D. Delivery Documentation

When the unit or installation is commissioned, or following major modifications and extensions of the electrical equipment, at least the documents subject to approval, specified in C. and showing the final arrangement of the final equipment, are to be supplied on board. The documents are to be marked with the name or the yard number of the unit or installation, the name of the yard and the date of preparation of the documents.

E. Ambient Conditions

1. General

1.1 The selection, layout and arrangement of all machinery, equipment and appliances shall be such as to ensure faultless continuous operation under the ambient conditions specified in Tables 1.2 - 1.6 where applicable. Therefore the manufacturer/-supplier shall be informed by the owner / operator about the expected environmental conditions

1.2 Products are classified according to their applications into the environmental categories as stated in Table 1.6. In type approval Certificates will be referred to the respective category.

1.3 Care has to be taken of the effects on the electrical installations caused by distortions of a unit's hull.

1.4 For units/installations intended for operation only in specified zones, BKI may approve deviating ambient conditions.

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

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

- the equipment is not for use for emergency power supply (see Section 3, D.) and is located outside of the machinery space(s)
- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit is capable of satisfactorily maintaining the design temperature
- the equipment is able to be initially set to work safely within 45 °C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45 °C ambient temperature
- audible and visual alarms are provided, at a continually manned control station, to indicate any malfunctions of the cooling units

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

1.5.3 The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, in accordance with B.2.3.

2. Vibrations

2.1 General

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

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

2.1.2 Where an electrical machine or device generates vibrations when in operation, the intensity of the vibration shall not exceed defined limits. The purpose is to protect the vibration exciter themselves, and the connected assemblies, peripheral equipment and structural components, from excessive vibration stresses liable to cause premature failures or malfunctions.

Table 1.1 Documents subject to approval relating to electrical equipment

Serial no.	Documents	Offshore units		Offshore installations
		Barges	Selfpropelled	
1.	Forms			
1.1	Form "Details of the scope and type of electrical"	X	X	X
1.2	List of electrical equipment in hazardous areas (including a copy of the test Certificate), Form "Details of the construction of electrical equipment in hazardous areas"	X	X	X
2.	Power supply equipment			
2.1	Electrical power balance	X	X	X
2.2	Generators, UPS units, transformers	X	X	X
2.3	Power electronics	X	X	X
2.4	Short circuit calculation	X	X	X
2.5	Calculation of load distribution	X	X	X
2.6	Proof of selectivity	X	X	X
2.7	General diagrams of distribution systems	X	X	X
2.8	General plan of earthing/equipotential system			
	Layout plan and circuit diagrams for			
2.8.1.	Main switchboard	X	X	X
2.8.2	Energy switchboard	X	X	X
2.8.3	Sub-distribution boards	X	X	X
2.9	Plan of main cable ways	X	X	X
2.10	Cable list	X	X	X
2.11	Hazardous areas layout	X	X	X
3.	Safety systems (circuit diagrams and functional descriptions, compare Section 9)			
3.1	General alarm systems	X	X	X
3.2	Technical officer's alarm system	X	X	X
3.3	Fire detection system	X	X	X
3.4	Gas detection system	X	X	X
3.5	Watertight doors operating and position monitoring system	X	X	-
3.6	Emergency shut-down systems	X	X	X
3.7	Power electronic systems	X	X	X
3.8	Platform identification systems	X	X	X
3.9	Navigational aids	X	X	X
3.10	Communication systems/alarm devices	X	X	X
3.11	Automatic/manual controls for fire extinguishing/fire protection equipment	X	X	X
3.12	Machinery alarm systems	X	X	X
3.13	Miscellaneous safety systems (computer based or hard wired)	X	X	X
3.14	Cause and effect charts	-	-	X
3.15	Location diagram of safety systems sensors	X	X	X
3.16	Location diagram of visual and audible signalling devices	X	X	X
3.17	Automatic or manual control for systems to maintain stability	X	X	-

Table 1.1 Documents subject to approval relating to electrical equipment (continued)

Serial no.	Documents	Offshore units		Offshore installations
		Barges	Selfpropelled	
4.	Propulsion equipment			
4.1	Propulsion motors	-	X	-
4.2	Static converters	-	X	-
4.3	Control, adjustment, monitoring	-	X	-
4.4	Trial program	-	X	-
5.	Manoeuvring equipment			
5.1	Anchor winches and control	X	X	-
5.2	Positional mooring winches and control	X	X	-
6.	Lighting			
6.1	Main lighting arrangement	X	X	X
6.2	Emergency lighting	X	X	X
6.3	Additional emergency lighting, if applicable	(X)	(X)	X
6.4	Low level escape direction system	X	X	X
7.	High voltage installations	(X)	(X)	X
8.	Trial program	X	X	X

Table 1.2 Inclinations of barge type units

Equipment, components	Angle of inclination [°] ²			
	Athwartships		Longitudinally	
	Static	Dynamic	Static	Dynamic
Main engines and auxiliary	15	22,5 10 s ⁴	5	7,5
Unit's safety equipment including, for example, emergency source of power, emergency fire pumps and other drives	22,5 ³	22,5 ³	10	10
Switchgear, electric and electronic equipment ¹ , remote controls				
¹ no unintended switching operations or functional changes shall occur up to an angle of inclination of 45° ² inclinations may occur simultaneously athwartships and longitudinally ³ on units carrying liquified gases, the emergency power supply shall also remain operational with the unit flooded up to a maximum final athwartship inclination of 30° ⁴ rolling period				

Table 1.3 Inclinations of column-stabilized units

Elements of machinery	Angle of inclination in any direction [°] ¹	
	Static	Dynamic
Main and auxiliary machinery essential to the propulsion and safety of the unit	15	22,5
Emergency machinery and equipment, fitted in accordance with statutory requirements	25	25
¹ Athwartships and fore and aft inclinations may occur simultaneously		

Table 1.4 Inclinations of self-elevating units

Elements of machinery	Angle of inclination in any direction [°] ¹	
	Static	Dynamic
Machinery in elevated condition	10 ¹	-
Machinery in floating condition	See Table 1.2	
Emergency source of power	15	15

¹ Athwartships and fore and aft inclinations may occur simultaneously

Table 1.5 Water temperature

Coolant	Temperature
Seawater	-1 °C to +32 °C ¹
¹ BKI may approve lower water temperatures for units/ installations with special operational areas	

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

2.2 Assessment

2.2.1 Electrical machines and equipment for use on board of mobile units shall be designed at least for a vibration load corresponding to Table 1.6. With the agreement of BKI, a lower endurance limit may be permitted in exceptional cases. In such cases, suitable countermeasures (vibration damping, etc.) shall be taken to compensate for the increased sensitivity.

Reference is made to IEC 60068-2, test F_C.

2.2.2 If an electrical machine or equipment generates mechanical vibrations when in service, e.g. because it is out of balance, reference is made to Volume 4 – Rules for Machinery Installations, Section 7.

2.2.3 Electrical appliances and equipment operating in positions where they are exposed to severe vibration loads, e.g. in the immediate vicinity of reciprocating machines and in steering gear compartments, shall be designed for these severe vibration loads.

2.3 Proofs

2.3.1 A vibration test in accordance with Regulations for the Performance of Type Tests, Part 2 : Test Requirements for Electrical / Electronic Equipment and Systems is deemed to constitute proof. The test shall conform to the operational requirements.

2.3.2 Other forms of proof, e.g. calculations, may be accepted upon agreement with BKI.

2.4 Measurements

Where such measures are justified, BKI reserve the right to demand that measurements be performed

under operating or similar conditions. This applies both to proof of the vibration level and to the assessment of the self-generated exciter spectrum.

F. Operating Conditions

1. Voltage variations and frequency variations

1.1 All electrical equipment shall be so designed that it remains operational during the voltage and frequency variations occurring in the normal course of operation. The variations indicated in Table 1.8 are to be taken as a basis.

1.2 Any larger variations likely because of the differing conditions in distribution systems supplied by storage batteries and static converters are to be taken into account. Measures are to be taken to stabilize the input voltage of specific systems, e.g. electronic equipment which cannot operate satisfactorily within the stated limits.

2. Quality of distribution systems

2.1 In distribution systems without converter loads, which are supplied by synchronous generators, the harmonic content of the system voltage shall not exceed 5 %.

2.2 In systems fed by static converters, and systems in which the static converter load predominates, for single harmonics in permanence the limit values indicated in Fig. 1.1 apply.

The total harmonic distortion shall not exceed 8 %.

2.3 If in particular cases, e.g. electrical propulsion plant systems, the above mentioned limits are exceeded, the faultless function of all electrical devices shall be ensured.

G. Electric Network

1. Direct current and single-phase alternating current

The following types of distribution systems are permissible:

- two-conductors system, insulated
- two-conductors system with one earthed conductor

Table 1.6 Environmental conditions/environmental categories

Environmental category	Environmental conditions						Comments
	Closed area			Open deck area			
	Temperature	Relative humidity	Vibrations ¹	Temperature ²	Relative humidity	Vibrations ¹	
A	0 °C to +45 °C	to 100 %	0,7 g (Curve 1) ³				For general applications except category B, C, D, F, G, H
B	0 °C to +45 °C	to 100 %	4 g (Curve 2) ³				For application at a higher level of vibration strain
C	0 °C to +55 °C	to 100 %	0,7 g (Curve 1) ³				For application at a higher degree of heat
D	0 °C to +55 °C	to 100 %	4 g (Curve 2) ³				For application at a higher degree of heat and higher level of vibration strain
E	0 °C to +40 °C	to 80 %	0,7 g (Curve 1) ³				For use in air-conditioned areas. With BKI's special consent only
F				-25 °C to +45 °C	to 100 %	0,7 g (Curve 1) ³	For use on masts, with the additional influence of salt mist and temperature inundation are to be expected
G				-25 °C to +45 °C	to 100 %	2,3 g	For use on masts, with the additional influence of salt mist
H	According to manufacturer's specification only in combination with environmental categories A – G						The provisions contained in the Certificates shall be observed

¹ Columns with vibrations not valid for fixed offshore installations
² At the open deck area other temperature ranges may be agreed if an offshore installation/unit shall be applied only in certain climate zones
³ Definition of Curves 1 and 2 is given in Table 1.7

Table 1.7 Definition of curves 1 and 2

Curve	Frequency range	Displacement	Acceleration
1	2 (+3/-0) Hz up to 13,2 Hz	+/- 1.0 mm	-
1	13,2 Hz up to 100 Hz	-	0,7 g
2	2 (+3/-0) Hz up to 25 Hz	+/- 1,6 mm	-
2	25 Hz up to 100 Hz	-	4 g

Table 1.8 Voltage and frequency variations

Equipment, components	Parameter	Variations	
		continuous	transient
General	Frequency	+/- 5 %	+/- 10 % (5 s)
	Voltage	+ 6 % - 10 %	+/- 20 % (1,5 s)
Storage batteries and static converters	Voltage	+/- 20 %	-

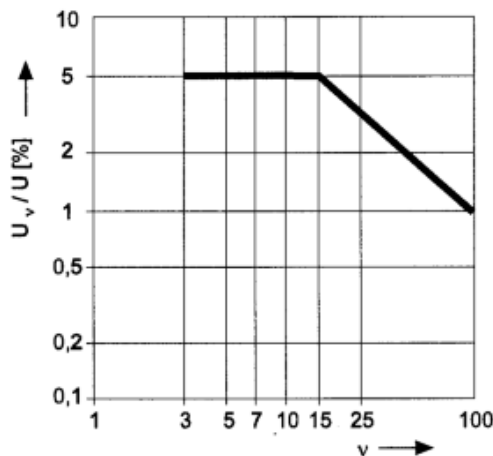


Fig. 1.1 Limit values for the single harmonics in supply voltage. U_v is the RMS value of the v -th order harmonic voltage

2. 3-phase alternating current

The following types of distribution system are permissible

- three-conductor system, insulated
- three-conductor system with earthed neutral conductor, without main structure return
- four-conductor system with earthed neutral conductor, but without main structure return

3. Main structure return

The use of return via the main structure is not permitted.

Exceptions if any resulting current does not flow directly through any gas hazardous spaces:

- main structure return of the currents of passive or active corrosion protection of the shell plating or corrosion protection of plant components located outside hazardous areas
- main structure return of currents for installations of limited extent outside hazardous areas, e.g. starters and preheaters of internal combustion engines
- main structure return of currents originating from devices used to measure insulation resistance, provided that these currents do not exceed 30 mA under the most unfavourable conditions

4. Systems with earthed neutral

4.1 Where additional resistors are inserted between generator neutral and the main structure, e.g. limit single-phase short-circuit currents, this shall not impair the selective shut-off of faulty circuits.

4.2 Where generators with earthed neutral are operated in parallel, it has to be considered that high-frequency equalizing currents can occur, especially when machines of different design are used.

4.3 A system shall normally be earthed at one point only. The earth connection shall be easily accessible and checkable. For the performance of insulation measurements it is recommended that the earth connection is disconnectable. Where an earthed system is divided into two or more sections, means for neutral earthing shall be provided for each section.

4.4 For voltages above 1000 V reference is made to IEC 61892-2.

5. Instructions regarding systems with non-earthed neutral

5.1 In systems which are not effectively earthed, generator neutrals shall not be connected.

5.2 The insulation resistance for non-earthed distribution systems is to be monitored, and a visual and audible alarm is to be given at a manned position if the insulation falls too low.

H. Voltages and Frequencies

The use of standardized voltages and frequencies is recommended. The maximum permitted rated mains voltages shall be as shown in Table 1.9.

I. Visual and Acoustical Signalling Devices

1. For panels and switchboards it is recommended to use colours for visual signals according to Table 1.10.

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

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

4. General platform lights

It is recommended to symbolize the shut-down levels with easily observable lamps of different colours at the working platform. The definitions shall be agreed with BKI.

J. Materials and Insulation

1. General

1.1 Material used for electrical machines, cables and apparatus shall be resistant to sea air containing moisture and salt, and to oil vapours. They shall not be hygroscopic and shall be flame-retardant and self-extinguishing.

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

1.3 The usage of halogen-free materials is strongly recommended

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

1.5 Materials with high tracking resistance are to be used for the supports of live parts.

2. Air and creepage distances

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

- rating operating voltage U_e
- overvoltage category III
- fouling grade 3
- insulation material group IIIa (in case of no information about the material actually used)

2.2 For the clearance and creepage distances of main-busbars in main, emergency and propulsion switchboards, see Section 5, F.3.

2.3 Smaller air and creepage distances may be accepted by BKI provided less pollution is proven (degree of protection).

K. Protective Measures

1. Protection against foreign bodies and water

1.1 The protection of electrical equipment against foreign bodies and water shall be appropriate to the particular place of installation.

The minimum degrees of protection for low-voltage switchgear are listed in Table 1.11.

The grade of protection of the equipment shall also be ensured during operation. Covers fitted at the place of installation are also regarded as a means of protection.

1.2 Exceptions to the indications in Table 1.11:

- high-voltage equipment, see Section 6, Table 6.3
- the minimum degree of protection of the terminal boxes of machines in wet operating spaces is IP 44.
- In drain wells and other installation places, where temporary flooding has to be assumed, the minimum degree of protection required for all electrical equipment is IP 56.
- Spaces subject to an explosion or fire hazard shall additionally comply with the provisions of 3.

2. Protection against electric shock

2.1 Protection against direct contact

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

2.1.2 Electrical facilities shall be so designed that, when they are used properly, persons cannot touch, or come dangerously close to live parts. For exceptions, see 2.1.3 and 2.1.4.

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

2.1.4 In systems using safety voltage, protection against direct contact may be dispensed with.

2.2 Protection against indirect contact

Electrical facilities shall be made in such a way that persons are protected against dangerous contact voltages in the event of an insulation failure.

For this purpose, the construction of the facilities shall incorporate one of the following protective measures:

- protective earthing, see 2.3
- protective insulation (double insulation)
- electrical facilities are operated at voltages causing no danger even in case of a fault
- in case where special precautions against electric shock will be necessary, the additional usage of residual current protective devices ≤ 30 mA (not for essential equipment)

Table 1.9 Maximum permitted rated mains voltages

Voltage	Types of electrical installation
17500 V ¹	for permanently installed power plants
750 V	for power circuits
500 V	<ul style="list-style-type: none"> - for permanently installed power and control circuits - for devices with plug-and socket connections which are earthed either via their mounting or through a protective earth conductor - the power supply to system requiring special electric shock prevention measured shall be provided via earth-leakage circuit breaker ≤ 30 mA (not applicable to essential equipment)
250 V	<ul style="list-style-type: none"> - for installations and devices, as laid down for 500 V, see above - for permanently installed lighting systems - for permanently installed control, monitoring and safety systems - for devices supplied via plug-and-socket and requiring special electric shock prevention measures, the power supply is to take place via a protective isolating transformer, or the device shall be double insulated
50 V safety voltage	<ul style="list-style-type: none"> - for portable devices for working in confined spaces where special electric shock prevention measures are required
¹ higher voltages are to be discussed with BKI	

Table 1.10 Colour code for signalling devices

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

2.3 Protective earthing

2.4 Touchable conductive parts of equipment which are normally not live, but which may present a dangerous contact voltage in the event of a fault, are to be connected (earthed) to the unit's hull / installation's structure.

Where such earthing is not effective by fastening or mounting, protective earthing conductors are to be used.

For the earthing of cable shielding, armouring and braids, see Section 11, D.

2.5 Protective earthing conductors

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

- An additional cable or an additional wire with a green/yellow coded core shall be provided as an earthing conductor, or the connection cable shall contain a green/yellow coded core.
- In distribution networks a conductor normally carrying current shall not be used simultaneously as an earthing conductor, nor may it be connected with the latter to the structure. The green/yellow coded core shall not be used as a current-carrying conductor.

Table 1.11 Minimum degrees of protection against foreign bodies and water (in conformity with publication IEC 60529)

Equipment Location	Generators, motors, transformers ¹	Switchgear, electronic equipment and recording devices ¹	Communication equipment, display and input units, signalling equipment, switches, power sockets, junction boxes and control elements ¹	Heating appliances, heaters and cooking equipment	Lighting fittings
Locked dry electrical service rooms	IP 00	IP 00	IP 20	IP 20	IP 20
Dry spaces, service rooms, dry control rooms, accommodation	IP 20	IP 20	IP 20	IP 20	IP 20
Wheelhouse, radio room, control stations	IP 22	IP 22	IP 22	IP 22	IP 22
Wet spaces (e.g. machinery spaces, bow thruster room), ventilation ducts (internal), pantries, provision rooms, store rooms	IP 22	IP 22	IP 44 ²	IP 22	IP 22
Machinery spaces below floor (bilge), separator and pump rooms, refrigerated rooms, galleys, laundries, bathrooms and shower rooms	IP 44	IP 44	IP 55 ^{2,3}	IP 44 ³	IP 34 ³
Pipe tunnels, ventilation trunks (to open deck), cargo holds	IP 55	IP 55	IP 55 ²	IP 55	IP 55
Open decks	IP 56	IP 56	IP 56	IP 56	IP 55
<p>¹ For the degree of protection for the equipment of watertight doors see Volume 6, Section 7, G.</p> <ul style="list-style-type: none"> - Motors and associated control and monitoring equipment: IP X7 - Door position indicator: IP X8 - Door-closure warning devices: IP X6 <p>² For the degrees of protection for measuring chamber of smoke detectors: IP 42</p> <p>³ For the degrees of protection for bathrooms and shower rooms see Section 10, C.</p>					

Table 1.12 Cross-sections for earthing conductors

Type of earthing connection	Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper earthing connection
1. PE conductor in flexible cable or flexible cord	up to 16 mm ²	same as current-carrying conductor
	above 16 mm ²	one-half of current-carrying conductor but at least 16 mm ²
2. PE conductor incorporated in fixed cable a) insulated PE conductor b) bare PE conductor in contact with metallic covering	up to and including 16 mm ²	same as current-carrying conductor up to and including 16 mm ² but at least 1,5 mm ²
	over 16 mm ²	50 % of the current-carrying conductor but at least 16 mm ²
	1 mm ² to 2,5 mm ²	1 mm ²
	4 mm ² to 6 mm ²	1,5 mm ²
3. Separate fixed earthing conductor	not exceeding 3 mm ²	same as current-carrying conductor subject to minimum of 1,5 mm ² for stranded earth conductor, or 3 mm ² for solid earth conductor
	exceeding 3 mm ² but not exceeding 125 mm ²	one-half of the cross-sectional area of the current-carrying conductor, subject to a minimum of 3 mm ²
	exceeding 125 mm ²	64 mm ²

- The cross-section of the earthing conductor shall at least conform to the values indicated in Table 1.12.
- Machines and devices which are insulated mounted are to be earthed by flexible cables, wires or stranded copper straps.
- The connection of the earthing conductor to the structure shall be located at a point where it can easily be checked. Connections of earthing conductors shall be protected against corrosion.
- Insulated mounted structures and aluminium structures shall be connected to the structure by special conductors at several points. The connections shall have a high electrical conductivity and shall be corrosion-resistant. The minimum cross-section is 50 mm² per conductor.

3. Explosion protection

For definition of hazardous areas see Volume 4 - Rules for Machinery Installations, Section 2. The requirements for explosion protection are defined in Section 13.

4. Electromagnetic compatibility (EMC)

4.1 Electrical and electronic equipment shall not be impaired in their function by electromagnetic

energy. General measures are to extend with equal importance over:

- decoupling of the transmission path between source of interference and equipment prone to interference
- reduction of the causes of interference sources
- reduction of the susceptibility to interference

4.2 The IEC publications 60533 and 60945 for the bridge and deck zone are to be observed.

4.3 The requirements for electrical and electronic equipment regarding immunity and emissions of electromagnetic influence can be taken from Regulations for the Performance of Type Tests, Part 2 : Test Requirements for Electrical / Electronic Equipment and Systems.

4.4 Process computer system

The installation of the process computer system has to avoid any disturbances from the electrical equipment of the installation/unit.

5. Lightning protection

Reference is made to IEC publication 60092-401

Section 2

Arrangement of Electrical Facilities

A. Power Generation

1. Main generators

1.1 Main generators with their own prime movers, independent of a unit's main propulsion plant

The main generators are to be installed in the main engine room or in separate auxiliary engine rooms, e.g. within the space bounded by the watertight main bulkheads. Partition bulkheads between these main bulkheads are not considered as separations provided they have access openings.

On mobile units generators shall not be installed forward of the collision bulkhead below the bulkhead deck.

1.2 The arrangement shall ensure faultless operation under all ambient conditions, even in heavy weather, particularly with regard to the supply of fresh air and the removal of exhaust air.

The aggregates be capable of being started, connected, disconnected and monitored from the main switchboard.

2. Main switchboards

2.1 Under normal conditions main switchboards shall be so placed relative to the main generators that, as far as practicable, the normal supply with electrical power may be affected only by a fire or other incidents arising in the same space.

2.2 The installation of the switchboard in a control room in the same fire section or in a room separated by a partition bulkhead with sufficient access opening is not to be considered as separating the switchboard from the generators.

2.3 The main switchboard shall be located as close as practicable to the main generators, within the same machinery space and the same vertical and horizontal "A 60" fire boundaries.

3. Distribution switchboards

If primary essential equipment is supplied from distribution switchboards, the same conditions regarding arrangement as required for main generators / main switchboards apply to the distribution switchboards, associated transformers, converters and similar equipment. Exceptions are possible for all cases, where distribution switchboards, associated trans-

formers, converters and similar equipment and the primary essential equipment are located in the same fire section respectively in the same watertight compartment.

4. Emergency source of electrical power

4.1 Arrangement

The emergency source of electrical power, i.e. generator, battery, etc., is to be arranged above the worst damage line on mobile units. The room, in which the emergency generator is installed, shall be accessible from the open deck and shall be so located that the operation of the emergency generator is not impaired by a fire or another incident:

- in a room containing the main generator and/or the main switchboard, or
- in any Category A machinery space.

As far as is practicable, the room containing the emergency source of power, the associated transformers, converters if any, the transitional source of emergency power and the emergency switchboard shall not adjoin the boundary surfaces of Category A machinery spaces or of those spaces containing the main power source, the associated transformers, converters if any, or the main switchboard.

If a location adjoining the above mentioned areas or areas in Zone 1 or Zone 2 is unavoidable, the boundary surfaces shall be gastight and conform to type "A 60".

4.2 Deviations of arrangement requirements

The aforementioned arrangement of the emergency generator sets and the provision of an emergency power supply using an independent emergency power source in accordance with Section 3 may be dispensed with, if

- the main generators including their switchboards are distributed between at least two rooms, and
- the systems can be operated with complete functional independence of each other, and
- each room contains at least 2 sets, each one meeting the output, availability and functional criteria laid down for an emergency generator set in Section 3, and
- the rooms in which the equipment is installed conform to this Section and are so arranged in relation to each other that a fire or other accident in one of these rooms does not impair power generation in the other room.

In any case, deviations from these requirements have to be approved by BKI.

4.3 Emergency switchboard

4.3.1 The emergency switchboard shall be arranged as near as is practicable to the emergency source of power and where the emergency source of power is a generator, the emergency switchboard shall preferably be located in the same space.

4.3.2 No accumulator battery fitted in accordance with this requirement for emergency or transitional power supply shall be installed in the same space as the emergency switchboard, unless appropriate measures to the satisfaction of BKI are taken to extract the gases discharged from the said batteries. An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of power or the transitional source of power are being discharged.

4.3.3 The emergency switchboard shall be supplied in normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short circuit. The arrangement at the emergency switchboard shall be such that the interconnector feeder is disconnected automatically at the emergency switchboard upon failure of the main power supply. Where the system is arranged for feedback operation, the interconnector feeder shall also be protected at the emergency switchboard at least against short circuit.

4.3.4 In order to ensure ready availability of emergency supplies, arrangements shall be made where necessary to disconnect non-emergency circuits automatically from the emergency switchboard to ensure that power is available automatically to the emergency circuits.

B. Storage Batteries

1. Installation

1.1 Storage batteries are to be installed in such a way that persons cannot be endangered and equipment cannot be damaged by exhaust gases or electrolytes leaking out.

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

1.3 Storage batteries shall not be installed in positions where they are exposed to excessively high or low temperatures, water spray or other influences liable to impair their serviceability or shorten their service life.

1.4 When installing storage batteries, attention is to be paid to the capacity of the associated chargers. The charging power is to be calculated as the product of the maximum charger current and the rated voltage of the storage battery.

Depending on the operating mode, application and duty of the storage battery to be charged, and on the mode of charging (charger characteristic), and by agreement with BKI, the calculation of the charging capacity need not be based on the maximum current. Where a number of storage batteries are grouped together, the total sum of charging power is to be taken into account.

1.5 Storage batteries with a charging capacity of up to 2 kW may be installed unenclosed below deck in a well ventilated battery cubicle or container. The unenclosed installation of storage batteries in well ventilated positions in machinery spaces is permitted.

1.6 Storage batteries with a charging capacity of more than 2 kW installed below deck are to be accommodated in an enclosed cubicle/container or room with means of ventilation to the open deck, see also 3.

1.7 On mobile units storage batteries shall be prevented from sliding. The constraints shall not hinder ventilation.

2. Battery room equipment

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

- explosion group II C
- temperature class T 1

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

2.1 Where leakage is possible, the inner walls of battery rooms, boxes and cubicles, and all supports, troughs, containers and racks, shall be protected against the injurious effects of the electrolyte.

3. Ventilation of spaces containing batteries

3.1 General requirements

All battery-installations, except for gastight batteries, in rooms, cabinets and containers shall be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

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

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

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

- the batteries are valve regulated (VRLA), provided with solid electrolyte, and
- the battery cases are not closed completely (IP 2X is suitable), and
- the charger is regulated automatically by an IU-controller with a maximum continuous charging voltage of 2,3 V/cell and the rated power of the charger is limited to 0,2 kW

3.3 Ventilated spaces with battery charging power up to 2 kW

Batteries may be installed in ventilated cabinets and containers arranged in ventilated spaces (except rooms mentioned in 1.2)

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

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

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

$$P = U \cdot I$$

$$I = 8 \cdot K / 100 \quad \text{for Pb-batteries}$$

$$I = 16 \cdot K / 100 \quad \text{for NiCd-batteries}$$

P = charging power [W]

U = rated battery voltage [V]

I = charging current [A]

K = battery capacity [Ah]

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

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

$$V = 2,5 \cdot Q$$

$$Q = f \cdot 0,25 \cdot I \cdot n$$

V = room free air volume [m³]

Q = air quantity [m³/h]

N = number of battery-cells in series connection

f = 0,03 for lead batteries with solid electrolyte

f = 0,11 for batteries with fluid electrolyte

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

Where the room volume or the ventilation is not sufficient, enclosed battery cabinets or containers with

natural ventilation into suitable rooms or areas shall be used.

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

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

A = cross-section [cm²]

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

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

3.4 Ventilated rooms with battery charging power more than 2 kW

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

Battery rooms shall be arranged according to 2.

3.5 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.

In battery rooms devices which obstruct the free passage of air, e.g. fire dampers and safety screens, shall not be mounted in the ventilation inlet and outlet ducts of battery rooms. 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 cupboard/boxes. The inclination of air ducts shall not exceed 45° from vertical.

3.6 Forced ventilation

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

The air quantity Q shall be calculated according to 3.3.

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.

Table 2.1 Cross-section of ventilation ducts

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

Wherever possible, forced ventilation exhaust fans shall be used.

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

Fans are to be of non-sparking construction.

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

4. Emergency power supply

The location in which storage batteries for the emergency power supply are installed shall fulfil the same conditions as required for the installation of the emergency generator, see A.4.

5. Installation of sealed batteries in switchboard rooms on fixed offshore installations

The installation of sealed batteries in switchboard rooms on fixed offshore installations is to be discussed and agreed with BKI. Reference is made to EN 50272-2.

Note

The calculation of ventilation and safety distance based on EN 50272-2 has to be carried out with a safety factor 10 and the total number of cells independently of being wired in parallel or in series.

6. Batteries for starting of internal combustion engines

6.1 Batteries for starting of internal combustion engines shall be installed near the engine, so as to minimize the voltage drop in the power lines.

6.2 For the rating of batteries reference is made to Volume 4 - Rules Machinery Installations, Section 3, H.

7. Caution labels

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

C. Power Transformers

1. Transformers shall be installed in adequately ventilated compartments, accessible only to authorized personnel. The one exception to this rule is that on fixed offshore installations air-cooled transformers provided with means of protection against accidental contact with live parts need not be installed in special compartments, compare IEC 61892-6, 7.2.1.

2. The use of oil filled transformers is limited to fixed offshore installations and has to be agreed with BKI. Beneath oil filled transformers special precautions have to be taken to collect spilled oil in case of leakage. If the insulation oil is liable to burn, reliable facilities for extinguishing the burning oil shall be provided. Spilled oil shall not be drained into the unit's water drainage system.

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

4. The installation of transformers in stores and accommodation areas is not permitted.

5. The location in which transformers for the emergency power supply are installed shall satisfy the same conditions as apply to the installation of the emergency generator.

D. Electronics

1. Power electronics equipment and computerized equipment are to be installed in readily accessible and adequately ventilated dry spaces.

2. The heat developed in the equipment is to be carried off by suitable means. The amount of dissipated heat is to be specified by the manufacturer. Where electronic equipment is installed in engine rooms or other spaces with enhanced danger of pollution and corrosion, air filters are to be provided where necessary.

E. Low Voltage Switchboards (up to 1000 V AC resp. 1500 V DC)**1. Main switchboards**

1.1 The main switchboard and one main generator shall be placed in the same fire zone so that, as far as practicable, the power supply may be affected only by fire or other incidents in the same fire zone.

The installation of the switchboard in a control room in the same fire section or in a room separated by a partition bulkhead with sufficient access opening is not to be considered as separating the switchboard from the generators.

The main switchboard shall be located as close as practicable to the main generators, within the same machinery space and the same vertical and horizontal A 60 fire boundaries.

1.2 Pipework and air ducts are to be run in such a way that the switchgear is not endangered in the event of leaks. If the installation of these pipes and ducts close to the switchboard is unavoidable, the pipes shall not have any flanged or screwed connections in this area.

1.3 The heat generated in the switchgear shall be removed.

1.4 The walkway in front of the main switchboard shall be at least 0,9 m wide. An ample view shall be provided for the operation of the board.

Where free-standing panels are required to be accessible from behind for operation and maintenance, a walkway at least 0,6 m wide is to be provided. The distance may be reduced to 0,5 m in the area of reinforcements and frames.

1.5 The floor in front of, and where necessary behind, main switchboards with an operating voltage of more than 50 V shall be provided with an insulating covering, or insulating gratings or mats are to be supplied.

1.6 The operational space behind open switchboards shall take the form of a locked electrical service room. A label notifying this fact shall be fitted.

2. Emergency switchboards

The emergency switchboard shall be arranged close to the emergency generator and/or the emergency battery. The requirements of B. shall be observed. The place of installation shall satisfy the same conditions as apply to the installation of the emergency generator. The installation of the emergency switchboard is subject to the same conditions as those stated in 1.2, 1.3, 1.5 and 1.6 for the main switchboard.

F. Appliances for High Voltages (> 1 kV AC)

Higher voltages than 17,5 kV are to be discussed with BKI.

1. Arrangement

1.1 Facilities should preferably be installed in locked electrical service rooms. The following variants are permitted for installation, if the degree of protection corresponds to the location.

1.2 Where equipment with a degree of protection lower than that stated in Section 6, Table 6.3 is installed, the access doors are to be locked in such a way that they can be opened only when the equipment has been switched off and earthed.

1.3 The degrees of protection stated in Section 6, Table 6.3 are to be adhered to for equipment in service rooms.

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

2. Access doors to service rooms

The access doors to spaces in which high-voltage equipment is installed shall be provided with warning labels.

3. Switchgear**3.1 Pressure release**

3.1.1 If the gas pressure resulting from accidental arcs within the switchboard is to be vented via pressure-release flaps, the installation space shall be as specified by the switchgear manufacturer and shall have an adequate volume. Suitable measures shall be taken to ensure that the overpressure occurring within

the space is limited to physiologically acceptable limits. The overpressure shall be taken into account for the structural design of the room. It is recommended to lead the accidental-arc gases by ducts of sufficient cross-section out of the place of operation.

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

3.2 SF6 switchgear

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

Note

It shall be taken into consideration that the coming out gases in case of accidental arcing have toxic and corrosive effects.

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

3.3 Insulation of locations in front of/behind switchgear

3.3.1 For locations in front of switchboards, or if accessible from the rear behind the switchboard, insulation shall be provided.

3.3.2 The insulation shall be done by an approved insulating mat.

Note

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

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

4. Safety equipment

At least the following safety equipment has to be provided for high-voltage facilities:

- a voltage detector for the rated voltage of the equipment
- a sufficient number of earthing cables, together with insulated fitting tools,
- an insulating floor cover appropriate to the test voltage of the equipment
- a sufficient number of warning labels bearing the words "Do not operate switch"

5. Marking

All parts of high voltage installations are to be fitted with permanent warning labels drawing attention to the voltage level and the danger.

Section 3

Power Supply Installations

A. General Design Requirements

1. The primary plant is to be designed in accordance with the requirements set out in Section 1.

B. Power Demand

1. Power balance

1.1 A power balance of the electrical equipment has to be submitted to prove, whether the rating of equipment for the generation, storage and transformation of electrical energy is sufficient.

1.2 The maximum power requirement for the type of duty performed by the unit, e.g. as a drilling, production or process platform, is to be determined.

1.3 Separate power balances are to be established for parts of installations/units having their own generating plant, e.g. drill drives, electric propeller drives, and especially, the emergency power supply.

1.4 Extreme environmental conditions, e.g. arctic or tropical conditions, according to the installation's/unit's area of operation are also to be taken into account.

1.5 In compiling the power balance, all installed electrical consumers are to be tabulated, together with an indication of their power ratings.

2. For each relevant operating condition, consideration shall be given to the following items:

- The full power demand of all consumers continuously required for operation, except for those consumers which remain on standby and are used only when a similar consumer fails.
- The power demand of all temporarily used consumers multiplied by a diversity factor. The diversity factor may be applied only once during the calculation.
- The full power demand of consumers with high power consumption relative to the primary plant, e.g. lateral thrusters of mobile units.
- Short time peak loads caused e.g. by automatic start of large motors.

C. Main Power Supply

1. Design

1.1 Every installation/unit is to be provided with a main source of electrical power of sufficient capacity. This main source of electrical power shall consist of at least two separate independent generating sets.

1.2 The capacity of the generating sets mentioned in 1.1 shall be such that, if any one generating set should fail or be shut down, the remaining generating capacity is sufficient to supply those services necessary to maintain normal operating conditions in respect of the functioning and safety of the installation/unit. In addition, when operating at sea the minimum conditions of habitability shall be ensured in these circumstances. This includes the reasonable operation of lighting, cooking, heating and domestic refrigeration, mechanical ventilation and the supply of fresh water and water for sanitary purposes.

1.3 Where transformers, storage batteries, static converters, etc. constitute an essential part of the main electrical supply system, the availability of the entire supply system stipulated in 1.2 shall be ensured should any one system part fail.

1.4 In individual cases exemptions may be granted in consultation with the competent national authorities for units with a restricted area of operation or for special-purpose units.

1.5 The power generating plant shall be so designed that it can be started and put into operation, even if main and emergency sources of electrical power are not in operation and no power is available to start-up the main source of electrical power.

1.6 The emergency source of electrical power may be used for a short period for starting-up the main source of electrical power, provided that its capacity is at the same time sufficient to supply the necessary emergency power consumers.

2. Rating of main generators

2.1 Apparent power

The apparent power of three-phase generators shall be such that no inadmissible voltage drops occur in the installation's/unit's mains due to the normal starting currents of motors. The start-up of the motor with the

greatest starting current shall not give rise to a voltage drop causing other consumers to malfunction. Where a number of generators operate in parallel, this condition shall continue to be met when the largest generator is not in operation.

2.2 Waveform

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

If the star points of generators running in parallel are earthed, the waveforms of the phase voltages should coincide. It is to ensure that the transient current due to harmonics in the starpoint connection does not exceed 20 % of the rated current of the machine with the lowest output.

2.3 Exciter equipment

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

- the generator can be loaded for two minutes at 150 % of its rated current with a power factor of 0,5 lagging (inductive) and still deliver approximately its rated voltage
- the equipment is short-circuit-proof even having regard to the time lag of the generator circuit breakers necessary to the selectivity of the system

2.4 Regulating conditions

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

2.4.1 Steady regulating conditions

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

2.4.2 Transient regulating conditions

With the generator running at rated speed and rated voltage, the voltage shall neither fall below 85 % nor exceed 120 % of the rated value when symmetrical loads of specified current and power factor are suddenly applied or removed. The voltage shall regain its rated value ± 3 % in 1,5 seconds.

If no particular requirements are specified for the load changes, the above conditions are to be satisfied when the generator, running idle and excited to its rated voltage, is suddenly loaded to 60 % of its rated current with a power factor of $< 0,4$ (lagging), and, after steady-state operation has been achieved, the load is suddenly switched off again.

2.4.3 Steady short-circuit current

With a terminal short circuit on three phases, the steady short-circuit current shall not be less than three times or not greater than six times the rated current. The generator and its exciter shall be capable of withstanding the steady short-circuit current for two seconds without damage.

2.5 Load sharing during parallel operation

Where generators of the same output are operated in parallel, the reactive load of each machine shall not differ from its proportionate share by more than 10 % of its rated reactive power when the active load is shared equally.

In the case of generators running parallel with different ratings, the deviation from the proportionate share shall not exceed the lesser of the following values, assuming proportionately equal sharing of the active load:

- 10 % of the rated reactive power of the largest machine
- 25 % of the rated reactive power of the smallest machine

2.6 Direct-current generators

Compound generators or shunt wound generators with automatic voltage regulators are to be preferred for sets supplying the installation's/unit's mains.

Technical details and limiting values are to be agreed with BKI.

3. Design and equipment of prime movers

3.1 The design and equipment of the prime movers of generators and starters are to conform to Volume 4 – Rules for Machinery Installations, Section 3 – Internal Combustion Engines and Air Compressors and Section 4 – Gas Turbines and Exhaust Gas Turbochargers

3.2 Each prime mover of generators supplying the installation's/unit's mains shall be equipped with a speed controller enabling synchronization to be effected in a sufficiently short time.

3.3 Electric/electronic governors

3.3.1 If electric/electronic governors are fitted, these as well as the control elements of the engine are to be approved by BKI.

3.3.2 The engine shall not assume a dangerous operating condition in the event of faults in the control system.

3.3.3 Where engines have electric starters, the governor may be supplied from the battery allocated to the engine.

Where engines are not started electrically, each governor including the control element is to be provided with a separate battery and charger.

The capacity of each battery shall be sufficient to enable the governor and control elements to operate for at least 60 minutes without recharging.

Each charger shall be capable of supplying, for a short period, the likely maximum current of the system.

3.3.4 When an engine is taken out of service, the supply to its governor is to be automatically disconnected.

3.3.5 If the battery voltage falls below the minimum permissible value, this shall trip a visual and audible alarm.

3.4 Parallel operation

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

The governing characteristics of prime movers of units 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.

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

- 15 % of the rated active power of the largest machine
- 25 % of the rated active power of the smallest machine

3.5 Cyclic irregularity

The permissible cyclic irregularity is to be agreed between the manufacturers of the prime movers and the generators. The following points have to be ensured:

- faultless parallel operation of three-phase generators
- Load variations shall not give rise to fluctuations in active power output exceeding 10 % of the rated output of the machine concerned.

D. Emergency Power Supply

1. General requirements

1.1 An independent emergency source of electrical power is to be provided on all offshore installations/units. The emergency source of electrical power shall be able to take over the supply of the emergency consumers, should the main power supply fail.

1.2 The electrical power available from the emergency source shall be sufficient to supply all those services which are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously.

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

1.4 For all equipment forming part of the emergency source of electrical power provision shall be made for periodic functional tests, including especially testing of the automatic switching and starting devices. Such testing shall be possible without interference with other aspects of the offshore installation's/unit's operation.

1.5 For the rating and control of emergency generators, the same principles apply as for the main generators in accordance with C.2., but with the following exception. Voltage deviations of $\pm 3,5$ % under steady conditions and ± 4 % under transient conditions after 5 s are acceptable.

2. Scope of the emergency power supply

2.1 Services to be supplied

2.1.1 The emergency source of electrical power shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the services listed under 2.1.2 to 2.1.8, for the periods specified, if they depend upon an electrical source for their operation.

2.1.2 For a period of 18 hours, emergency lighting

- at all lifesaving appliances launching stations on deck and along the sides of the installation/unit as stipulated in the International Convention for the Safety of Life at Sea (SOLAS) and in the IMO MODU Code
- in all service and accommodation alleyways, on stairways, at exits, in personnel lift cars and in lift shafts
- in machinery spaces and main generating stations including their control positions
- in all control stations of the drilling and/or process plant, the machinery control rooms, the emergency remote shut-down stations and at each main and emergency switchboard
- at all escapes
- at all stowage positions for firemen's outfits

- in the steering gear compartment, the CO₂ room, the galleys, the day rooms, messes and hospital
- at the emergency fire pump, the sprinkler pump and the emergency bilge pump and at the starting position of their motors
- on the helicopter landing area, including the boundary lighting and the wind sock lighting

2.1.3 For a period of 18 hours, navigation lights of mobile units

Navigation lights and other lights of units required by the current national and international regulations for preventing collisions at sea.

2.1.4 For a period of 18 hours, communications and alarms, etc.

Unless these items of equipment can be independently supplied during these 18 hours by their own emergency storage battery

- all internal signalling and communications equipment required in an emergency
- radio, direction-finding and other navigation aids of mobile units where required by national authorities or by regulation V/12 of the 1974 SOLAS Convention
- fire detection and fire alarm system
- gas detection and gas alarm system
- intermittent operation of the daylight signalling lamp, the alarm sirens, the manually operated fire alarms and all the internal signals required in an emergency, e.g. general alarm, CO₂ alarm
- the power for closing the blow-out preventer and for isolating the unit from the well, if electrically operated
- the power to operate all the electrically driven valves of the process and production plant which have to be closed or opened in an emergency

and all emergency remote shut-downs.

2.1.5 For a period of 18 hours, pumps and other equipment

- one of the required fire pumps, if dependent upon the emergency generator for its source of power
- the automatic sprinkler pump
- for mobile units, the emergency bilge pump and all the equipment essential for operation of electrically powered remote-controlled bilge valves
- the auxiliary equipment for the emergency diesel unit
- permanently installed diver's equipment, where this depends on the installation's/unit's electrical power supply
- the steering gear of mobile units (for a period of 10 minutes the steering gear shall be operated by

power for maximum steering angles at the standard time)

2.1.6 For 4 days, signals

- all signal lights and
- sound signal transmitters which are necessary of the identification of offshore structures (see also the "Recommendations for the Warning off Offshore Structures", International Association of Lighthouse Authorities - IALA).

2.1.7 For half an hour, emergency systems

- all watertight doors with remote-controlled power operation together with their indicators and warning signals; but not necessarily all of them simultaneously, unless an independent temporary source of stored energy is provided
- emergency arrangements to bring the personnel lift cars to the nearest exit point for escape purpose. Where more than one personnel lift car is provided, these may be brought to the escape station in succession in an emergency.
- emergency shut-down system(s)

2.1.8 For a period of 18 hours, column-stabilized units

- ballast control and indicating systems at the central ballast control station
- ballast pumps, only one of the connected pumps need to be considered to be in operation at any time

2.2 Design requirements

2.2.1 The emergency source of electrical power may be either a generator set or an accumulator battery.

2.2.2 Generator set

Where the emergency source of electrical power is a generator set, it shall be driven by a suitable prime mover with its own independent fuel supply and an independent cooling system. The set shall start automatically if the main source of electrical power fails, and shall automatically take over the supply to the emergency consumers unless a transitional source of emergency power in accordance with 2.2.3 is available.

The emergency power supply shall be connected not later than 45 seconds after the failure of the main power supply.

2.2.3 Transitional source of emergency power

The transitional source of emergency electrical power shall be an accumulator battery which, in the event of failure of the main power supply, automatically and immediately supplies the consumers listed below until the emergency generator set described in 2.2.2 is in operation and connected. Its capacity shall be sufficient to supply the consumers without intermediate recharging for the period specified below. During that time the battery voltage shall remain within $\pm 12\%$ of the rated voltage.

Where their operation depends upon an electrical source, the following services are to be supplied:

- for a period of half an hour, the emergency lighting, lamps and lights specified in 2.1.2 and 2.1.3 together with all the services required by 2.1.4 (except item 2 of the list) unless such services have an independent supply for the prescribed period from their own emergency accumulator batteries.
- for mobile units, power for closing the watertight doors - though simultaneous closure of all doors is not required - together with power for their indicators and warning signals.

2.2.4 Accumulator battery

Where the emergency source of electrical power is an accumulator battery, it shall be capable, in the event of failure of the main source of electrical power, of automatically and immediately supplying power to the

consumers listed in 2.1 for the stipulated period without intermediate recharging. During this period the battery voltage shall remain within $\pm 12\%$ of the rated voltage.

3. Emergency consumers for the protection of important equipment

Where necessary, the rating of the emergency source of electrical power shall take account of other consumers which are needed to protect important equipment in case of a failure of the main electrical power supply. This category may include, for example, the emergency lubricating oil supply. The measures to be taken are to be agreed with BKI in each individual case.

4. Starting arrangements for emergency generators

4.1 The requirements for the starting of emergency generators are defined in Volume 4 – Rules for Machinery Installations, Section 3, H.4.

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

Section 4

Installation Protection and Power Distribution

A. Three-Phase Main Generators

1. General

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

1.1 Independent operation

Independent operation means that each generator supplies a busbar system assigned to it. Where this method is used, it shall be possible to connect the consumers or consumer groups to at least two different busbar systems or generators by means of selector switches.

1.2 Parallel operation

In parallel operation, the generators supply a common busbar system of the main switchboard, to which the consumer feeders are connected.

2. Protection equipment

2.1 General

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

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

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

2.2 Short-circuit protection

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

2.2.2 The short circuit protection shall not be disabled by undervoltage.

2.2.3 Generators with a rated output of 1500 kVA or more are to be equipped with a suitable protective device which in the event of a short circuit inside the generator or in the cable between generator and circuit-breaker opens the breaker and de-energises the generator.

Examples of suitable protective equipment are differential protection or generator-neutral-point monitoring.

2.3 Overload protection

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

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

On installations/units with unattended machinery spaces the automatic disconnection of non-essential consumers is mandatory.

2.4 Reverse-power protection

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

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

2.5 Undervoltage protection

Generator circuit-breakers are to be provided with under-voltage protection. In the event of a decrease of the voltage to 70 % - 35 % of the rated voltage, the generator circuit-breaker shall open automatically.

Undervoltage releases shall have a short-time delay adapted to the short circuit protection.

2.6 Overvoltage protection

The mains shall be protected against overvoltage. The voltage shall be limited to 130 % U_N and max. 5 s, even in the case of failure of the voltage regulators.

2.7 Underfrequency protection

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

2.8 Testing

See Section 16, E.2.

3. Switchgear

3.1 General

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

3.1.2 When tripped due to overcurrent, generator circuit breakers shall be ready for immediate reconnection. The use of thermal bi-metallic release for generators used to supply essential consumers is not permitted.

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

3.2 Single operation

The following devices are to be provided:

- a three-pole circuit breaker with time-delayed overcurrent- and short-time-delayed short-circuit release
- for generators with a rated output below 50 kVA, fuses and load switches or fuses with contactors are also permitted

All generator contactors that may be used are to be provided with a dropout delay (up to approx. 500 ms) and shall be rated for double of the generator current.

3.3 Parallel operation

The following devices are to be provided:

- for each generator, a three-pole circuit breaker with delayed overcurrent- and short-time-delayed short-circuit and undervoltage release
- In the case of generators intended for parallel operation, the generator switch is to be provided with undervoltage protection which prevents closing of the switch if the generator is dead.

4. Synchronizing equipment

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

4.1 Equipment to prevent faulty synchronizations

Generators intended for parallel operation shall be provided with automatic synchronizing equipment. Instead of automatic equipment, manual synchronizing equipment combined with a check synchronizer may be provided. The conditions of Section 15, E, shall be complied with in order to prevent faulty synchronization.

4.2 Manual synchronization

Manual synchronization (e.g. synchronizing dark method installed within sight of the generator-switch actuating position) shall be possible if the appliances listed in 4.1 fail.

B. Emergency Three-Phase Generators

Emergency generator supply the emergency switchboards and the connected emergency consumers.

1. Protective equipment and switchgear

Generator protection shall consist of at least:

- short circuit protection
- overload protection
- under voltage protection

However it is permissible for the overload protection not to disconnect the generator automatically but instead to trigger an optical and acoustical warning signal at the emergency switchboard and at the main switchboard.

2. Overload shedding

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

C. Direct Current Generators

1. Single operation

The following devices are to be provided:

- for each generator, a circuit breaker which simultaneously switches all non-earthed poles, with a delayed overcurrent release and a short-time-

delayed short-circuit release, or a fuse in each non-earthed pole and a spring-operated load-switch with sufficient breaking capacity

- circuit breakers are always to be used for generators with outputs of 50 kW and over.

2. Parallel operation

The following facilities are to be provided:

- for each generator, a circuit breaker which simultaneously switches all non-earthed poles, with a delayed overcurrent release and a short-time-delayed short-circuit release, together with a reverse-current protection and short-time-delayed undervoltage protection
- For compound generators, the switch shall contain a switching element for the equipotential line which, when switching on, closes simultaneously or earlier and, when switching off, opens simultaneously or later, and is rated for at least half the rated current.
- a polarity-reversing facility for each generator

D. Power Transformers

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

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

3. Transformers shall be switchable on the primary side.

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

E. Storage Batteries

Storage batteries are to be provided with overload and short-circuit protection nearby where they are installed.

Exceptions are made for batteries for preheating and starting of internal combustion engines, but their cabling shall be made short-circuit proof.

F. Power Electronics

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

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

G. Supply of Electrical Energy from Outside

1. Shore connection for mobile units

If mobile units are in a harbour, it shall be possible to supply electrical energy from the shore to the unit. The supply connection has to meet the following requirements.

1.1 Terminal boxes for shore supply shall be linked to the unit's system by permanently laid cables.

1.2 A device for connecting a protective conductor or a potential equalizer has to be provided, if required.

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

1.4 The shore connection shall be switchable and it shall be protected against short circuit and overload.

The terminal box for shore connection shall be provided at least with short-circuit protection.

1.5 A voltage indicator shall be provided in the main switchboard.

1.6 Facilities shall be provided to compare the polarity (in the case of direct current) and the phase sequence (in the case of three-phase alternating current) of the shore supply with those of the unit's mains.

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

2. Supply of electrical power from the shore for fixed installations

For fixed offshore installations which are situated near the shore it may be possible to avoid a main power generation on the installation itself, but to get the main energy via underwater cables from the shore. Such a solution has to meet the following requirements.

2.1 The supply centre on the shore shall be able to satisfy the power demand of the fixed installation under all circumstances, if the fixed installation is not equipped with a main power generation.

2.2 The supply cable shall be laid in a way on the seabed that damage by environmental influences, ship traffic, etc. can safely be avoided.

2.3 The terminal at the fixed installation shall be switchable and it shall be protected against short circuit and overload. The terminal switchboard for shore connection shall be provided at least with short-circuit protection.

2.4 A direct communication line between the supply centre on the shore and the fixed installation has to be permanently established.

2.5 An emergency source of electric power has still to be provided on the fixed installation for the case that the cable connection from the shore is damaged or out of function. The performance of the emergency power supply has to be in accordance with the requirements defined in Section 3, D.

H. Power Distribution

1. Electrical supply systems

1.1 Regarding permissible supply systems see Section 1, G.

1.2 Supply systems with hull/main structure return

1.2.1 All final supply circuits shall have all-pole insulation. The return conductors are to be connected in the associated distribution switchboard to an insulated busbar, which is connected to the hull.

1.2.2 The connections to the hull/main structure shall have at least the same cross-section as the supply cable.

Bare wires shall not be used. Casings or their mounting bolts shall not be used as return conductors or to make their connection.

1.3 Up to 3 distribution switchboards may be supplied by a common supply cable.

2. Load balancing in three-phase systems

Where, in three-phase systems, AC-consumers are connected between two outer conductors or one outer conductor and the neutral, the consumers are to be distributed in such a way that, under normal operating conditions, the loads on the individual outer conductors do not differ from each other by more than 15 %, for special requirements for hull return see Section 11, C.5.

3. Essential supply cables

3.1 Primary and secondary essential equipment shall be preferably supplied directly from the main or emergency switchboard in accordance with the Rules. Supply via distribution panels is only permissible, if an equivalent safety of supply is guaranteed, see also Section 2, A.3.

3.2 Primary and secondary essential equipment for the same function (e.g. main and stand-by lubricating oil pumps) are to be fed via two separate cables

from the main switchboard or from two independent sub-distribution panels.

Regarding supply to steering gear see Section 12, A.

4. Emergency supply cables

4.1 Emergency consumers shall be supplied directly from the emergency switchboard or via sub-distribution panels, to which only consumers in the relevant fire zone are connected.

4.2 In normal operation, the emergency switchboard shall be supplied by an interconnection feeder from the main switchboard. The feeder is to be protected against overcurrent and short circuits at the main switchboard, and the feeder shall be automatically disconnected in the emergency switchboard if the supply from the main switchboard fails.

4.3 A return supply from the emergency switchboard to the main switchboard, e.g. when starting operation from dead ship condition or under observance of Section 3, D. is permitted. For return supply operation, the automatic feeder disconnection called for in 4.2 may be temporarily overridden.

5. Supply of lighting systems

5.1 Main lighting installations shall be supplied from the main switchboard, emergency lighting installation from the emergency switchboard.

5.2 The number of lighting points (lamps) connected to one final circuit shall not exceed:

- 10 lamps for voltages up to 55 V
- 14 lamps for voltages over 55 V
- 24 lamps for voltages over 125 V

5.3 Switches shall simultaneously switch all non-earthed conductors. Single-pole switching of final circuits for lighting in systems with all conductors insulated is permitted only in the accommodation area.

5.4 Sockets outside the accommodation area shall be connected to separate circuits. When calculating the permissible connected load, one socket is equivalent to two lighting points.

5.5 In the areas listed below, the lighting shall be supplied by at least two separate fused circuits:

- main engine rooms, service spaces and control stations
- large galleys
- passageways
- stairways leading to the boat deck
- messes for the crew

5.6 The lighting fixtures shall be so arranged that sufficient illumination for orientation is maintained should one circuit fail.

6. Navigation and signalling lights

6.1 The masthead, side and stern lights of units respectively the lights prescribed for installations are to be supplied separately from the navigation lights panel. Each circuit shall be protected against overload and short circuit. The individual main and reserve lights may have separate circuits in a common cable.

6.2 The navigation lights panel may be extended for the supply of the signalling lights specified in the "International Regulations for Preventing Collisions at Sea" (COLREG).

Other consumers shall not be connected to this panel.

6.3 Navigation and signal lights shall be supplied from the main and emergency electrical power source.

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

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

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

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

7. Control, monitoring and safety systems

The supply of control-, monitoring- and safety systems shall comply with the following requirements (see additionally Section 9):

7.1 These systems shall be supplied by their own circuits.

Provision shall be made for the selective disconnection of the separate circuits in case of a short circuit.

7.2 A common distribution network with back-up batteries may be used to supply systems which are required to remain operative even if the main source of electrical power fails. Such a network shall have two supply units comprising either:

7.2.1 a power supply unit with a capacity sufficient for all the connected consumers together with a charger which, acting in buffer operation with the

back-up battery, is capable of supplying continuously all the connected consumers and maintain the battery in the charged condition or

7.2.2 two chargers, which meet the conditions stated in 7.2.1.

7.3 With regard to residual ripple, the supply facilities specified in 7.2.1 and 7.2.2 shall be designed to ensure trouble-free operation of the connected systems even when the battery is temporarily disconnected.

7.4 One of the power supply units or chargers shall be supplied directly from the main switchboard.

7.5 Failure of the power supply units and chargers shall be signalled visually and audibly.

7.6 Battery chargers with a charging capacity of $P \geq 2$ kW shall be tested at the maker's works in the presence of the BKI Surveyor.

8. Radio and navigational equipment

8.1 General

8.1.1 The main and emergency electrical power sources shall at any time maintain a sufficient supply of power to operate the radio equipment and to charge all reserve power sources for the radio equipment.

8.1.2 The radio and navigational equipment shall be directly supplied from both the main source of electrical power and the emergency source of electrical power by separate power supply circuits.

8.1.3 The power distribution for radio equipment shall be independent of that for the navigational equipment. The circuits from both the main and the emergency source of electrical power shall be terminated either in one or two distribution panels. If one distribution panel is used, the two circuits supplying the panel shall be provided with splitter feeding into two separate bus bars, one for the radio equipment and one for the navigational equipment. The panel(s) shall be located at the navigating bridge or other suitable position on the bridge deck.

8.1.4 Facilities shall be provided in each distribution panel for changing over between the main source of electrical power and the emergency source of electrical power. It is preferable that change-over be initiated automatically. If a single distribution panel is used for both the radio and the navigational equipment, separate change-over switches shall be provided.

8.1.5 Failure of any power supply shall initiate an alarm at the navigational bridge.

8.2 Radio equipment

8.2.1 The design of the radio equipment is in every case subject to the relevant national regulations. If no regulations exist, the requirements of these Rules apply.

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

8.2.3 For units further stipulations for the reserve source of energy are to be taken from the SOLAS Convention, Chapter IV and relevant IMO guidelines. For fixed installations the requirements of national regulations are to be observed.

8.3 Navigational equipment of mobile units

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

8.3.2 Where duplicated equipment is installed, it has to be arranged that each equipment can be permanently assigned to the main respectively to the emergency source of electrical power.

I. Electrical Protective Devices

For electrical protection equipment see Section 5, E.

Section 5

Low-Voltage Switchgear Assemblies

A. General

1. The requirements of this Section apply to low-voltage switchgear with operating voltages of up to 1000 V AC or 1500 V DC.
2. Electrical installations are to be protected against damage due to overloading and short-circuit.
3. The thermal and electro-dynamic stresses due to overcurrents shall not cause damage to parts of the system during the response time of protective devices or during the total operating time of switches.
4. Overcurrent protective devices are to be selected on the basis of the following criteria:
 - overload current
 - short-circuit current
 - reclosing capability
5. Regarding design, construction and testing of low-voltage switchgear assemblies, attention is drawn to IEC publication 60092-302.
6. For further notes see Section 4.

B. Calculations

1. Calculation of short-circuit currents

- 1.1 Short-circuit current calculations are to be carried out in accordance with a standard accepted by BKI, e.g. IEC 61363-1.
- 1.2 When calculating the maximum short-circuit currents to be expected, the following installations are to be taken into account:
 - all generators which operate in parallel to provide the maximum power demand
 - all motors whose simultaneous operation shall be expected

All data used for the short-circuit current calculation are to be submitted.

To be determined are:

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

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

$$1.3.1 \quad I''_{kG} = I_{rG} \cdot 100 / x_d''$$

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

I_{rG} = rated current of the generator

x_d'' = subtransient reactance of the generator [%]

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

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

I_{rM} = rated current of the motor

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

1.3.4 The value of the peak short-circuit current i_p can be calculated by multiplying the total initial symmetrical short-circuit current I''_k by the factor 2,3.

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

- generator short circuits
- short circuits on main busbars
- short circuits on the busbars of emergency switchboards and main distribution panels

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

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

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

2. Heat losses (heat balance)

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

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

3. Dynamic and thermal loading

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

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

C. Construction

1. General

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

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

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

1.4 On mobile units main and emergency switchboards shall be fitted with insulated hand rails or handles.

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

1.6 Large doors in switchboards shall be fitted with arresting devices.

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

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

1.9 Operating devices and fuses shall be safely accessible.

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

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

1.12 Where access is required inside cubicles during operation, protection shall be provided to prevent accidental contact with live parts.

2. Main switchboards

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

2.2 If the total installed power of all generators exceeds 3 MW, the generator panels shall be separated from each other by arc-resistant partitions. Busbar penetrations shall be flame-retardant and self-extinguishing.

2.3 In plants of mobile self-propelled units, where the main source of the electrical power is necessary for the propulsion, the main busbar shall be capable to be subdivided into at least two parts which shall normally be connected by circuit breakers or easily to open disconnecting links. As far as is practicable, the connection of generators and duplicated consumers shall be equally divided between the main busbar sections.

2.4 The consumers may for instance, be grouped as follows, see also Fig. 5.1:

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

2.5 Switchgear and synchronizing equipment for generators

See Section 15, A.

2.6 Measuring and monitoring devices for generators

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

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

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

- 1 voltmeter which can, if necessary, be switched to the other alternators
- 1 ammeter, switchable to all phases
- 1 frequency meter which can, if necessary, be switched to the other alternators

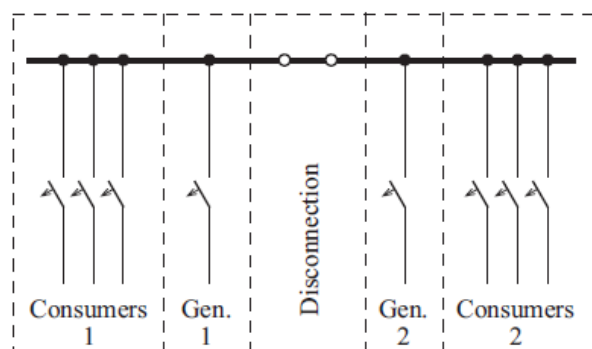


Fig. 5.1 Example for arrangement of a main busbar connection and division of consumers

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

- 1 voltmeter
- 1 ammeter

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

- generator protection devices, and an undervoltage trip of the generator circuit breaker
- measuring instruments
- indicating lights
- diesel engine speed-adjusting equipment
- motor drive for circuit breaker

2.7 Switchgear and fuses for equipment

2.7.1 Each supply line run from the main switchboard shall be provided with a circuit breaker with over-current and short-circuit protection, or with a fuse for each non-earthed conductor and an all-pole switch, or with a contactor with control switch. Where fuses and switches are used, the sequence busbar-fuse-switch is to be used. The specified sequence may be changed where motor switches of utilization category AC-23 A are used as load switches, provided that the switches are weldproof in the event of a short circuit, see B.3.

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

2.8 Measuring instruments

The main switchboard and the main distribution panel have to be fitted with ammeters for major consumers, unless these are already mounted on the consumers themselves. It is permissible for one ammeter to be switched over to a number of circuits.

3. Emergency switchboards

3.1 The requirements for main switchboards apply in analogous manner to emergency switchboards.

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

- in a space housing the main generators and/or the main switchboards, or
- in a category A machinery space

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

4. Distribution panels

4.1 Distribution panels are to be equipped with the necessary devices for the protection of the connected circuits and for the supply of consumers, see Section 4.

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

4.3 For navigation light panels, see Section 12, K.

4.4 For container connections, see Section 10, B.3.

5. Motor starters

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

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

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

5.4 Motors are to be provided with starters if:

- currents or voltage drops higher than those permissible for the system are liable to occur, if connected directly
- this is necessary for the start-up of the motor or the driven machine
- this is required by the design of the generators

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

D. Selection of Switchgear

1. General

1.1 Every non-earthed conductor is to be switched and to be protected against short circuit and overload.

1.2 Switchgear shall conform to IEC publications, or to another standard approved by BKI.

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

The following shall be observed:

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

1.3.2 The rated service short-circuit breaking capacity shall be not less than the AC component of the short-circuit $I_{ac}(t)$ at the moment

$$t = T / 2$$

2. Circuit breakers

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

2.1.1 Utilization category A

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

Application examples:

As consumers circuit breakers and distribution feeders.

2.1.2 Utilization category B

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

Application example:

As generator circuit breakers.

2.2 Additional requirements for generator circuit breakers:

- Following tripping due to an overcurrent, the breaker shall immediately be ready for reclosing. For this reason thermal tripping devices are not permitted.
- A reclosing block shall prevent automatic remaking of the breaker onto a still persisting short circuit following tripping due to a short circuit.

3. Load switches

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

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

3.3 If the sequence busbar - switch - fuse is chosen, the making/breaking capacity shall match category AC-23 A or DC-23 A (IEC 60947-3), and attention is to be paid to increased insulation quality of the switching unit.

4. Fuses

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

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

Exceptions to this rule are subject to approval by BKI.

E. Choice of Electrical Protection Equipment

1. General

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

2. Short-circuit protection equipment

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

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

2.3 The peak short-circuit strength of a switching unit and its components shall correspond to the maxi-

mum short-circuit current which can arise at the place where it is fitted.

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

3. Selective arrangement

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

- the tripping time of protective devices connected in series shall be carefully co-ordinated
- the switching devices being capable of carrying the short-circuit current during the total break time of the device plus the time lag required for selectivity
- Exceptions may be permitted in the case of circuits feeding redundant plants or non-essential equipment if selectivity relative to the generator switch is maintained.

4. Overcurrent protection devices

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

5. Allocation of short-circuit and overcurrent protection devices

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

5.2 Overcurrent protection is required for at least one conductor in insulated DC and single-phase AC circuits.

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

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

5.4 Determined for the overcurrent protection of the entire circuit (switchgear, switchboard wiring, supply cables and equipment) according to regulations is the rated current I_n of the connected equipment or in the case of grouped supply cables the evaluated total rated current.

6. Motor protection

6.1 Motors with a power rating of more than 1 kW shall be individually protected against overloads and short-circuits. For steering-gear motors, see Section 12, A.

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

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

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

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

7. Control circuits

7.1 The control circuits of essential systems have to be independent of other control circuits.

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

7.3 For emergency shutdowns see Section 9, E.

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

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

8. Measuring and signalling circuits

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

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

9. Exciter circuits

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

10. Monitoring of insulation resistance

Each non-earthed primary or secondary system serving power, heating or lighting installations shall be fitted with an equipment which monitors the insulation resistance relative to the unit's hull / installation's main structure and gives an optical and audible alarm if the insulation resistance value is abnormally low, see also Section 15, E.

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

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

Electronic or computerised protection devices for generators and large consumers shall be so designed that the function of the protection equipment can be tested on board, see Section 9, D.

Especially attention shall be given to:

- arrangements to readily identification of the last final settings, in the event of possible change
- facilities and instructions for testing the settings and functions on board

F. Conductors and Busbar Carriers

1. Busbars, bare or painted

1.1 General

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

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

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

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

1.2 Connections to equipment

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

2. Busbar carriers

Busbars are to be mounted in such a way that they withstand the stresses caused by short circuit currents and maintain the required clearance and creepage

distances relative to other voltage-carrying or earthed components.

3. Clearance and creepage distances

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

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

- switchgear of standard design
- quality system approved by BKI
- reduction of pollution by appropriate installation and degree of protection
- type-tested switchboard system

4. Insulated wires

4.1 Insulated wires shall be of the stranded type, and shall satisfy the requirements for cables and wires set out in Section 11. The cross section of the conductor shall be at least sufficient for the rated current of the connected equipment. Conductors are to be selected in accordance with Table 5.3.

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

These wires shall not be run and mounted together with other wires.

4.3 Control wires for essential equipment shall be run and protected in such a way that they cannot be damaged by short circuit arcs if at all possible.

G. Measuring Instruments and Instrument Transformers

1. Measuring instruments

1.1 The measuring error of switchboard instruments shall not exceed 1,5 % of the full scale value.

Instruments with directional response are to be used for DC generators and batteries.

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

1.3 The scale range of power meters shall be at least 120 % of the rated power. For generators connected in parallel, the scale range shall also register at least 15 % reverse power. Where power meters have only a single current path, all generators shall be

measured in the same phase. If the total value of all consumers connected to a single phase exceeds 10 % of the power of the smallest generator, the power

meters have to be equipped with multiple movements in order to record the unbalanced load on the outer conductors.

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

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

Note
The maximum permissible loading applies to switchboards not closed at the rear. In the case of fully enclosed switchboards adequate ventilation is to be ensured, or the loading values stated are to be reduced.

Table 5.2 Clearance and creepage distances

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

Table 5.3 Current rating of wires in switchgear

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

Note

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

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

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

2. Current and voltage transformers

2.1 Current and voltage transformers shall conform to class 1 as a minimum requirement.

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

H. Testing of Switchboards and Switchgear

1. Type-approvals

For mandatory type approval of devices and components see Section 16, E.2.

2. Tests in manufacturer's works

2.1 All switchboards are to be tested in the manufacturer's works.

2.2 The following installations are subject to testing in the presence of the BKI Surveyor:

- main switchboards
- emergency switchboards
- distribution switchboards with connected power ≥ 500 kW
- switchboards for electrical propulsion plants
- starters and controls for boiler and thermal oil systems

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

2.3 Scope of test

2.3.1 Visual inspection

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

2.3.2 Functional test

Testing of functional performance on the basis of a test schedule and of the approved drawings, as far as it is feasible.

2.3.3 High-voltage test

The test voltage specified in Tables 5.4 and 5.5 is to be applied between the conductors, and between the conductors and the switchboard frame. The duration of the test is one minute in each case.

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

- Test voltage for main circuits:

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

- Test voltage for auxiliary circuits:

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

- Test voltage for type-approved switchgear:

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

Table 5.4 Test voltage for main circuits

Rated insulation voltage U_i DC and AC [V]	Test voltage (AC) (rms) [V]
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 690$	2500
$690 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500
$1000 < U_i \leq 1500$ ¹	3500

¹ only for DC voltage

Table 5.5 Test voltage for auxiliary circuits

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

2.3.3 Insulation resistance measurement

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

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

Section 6

High Voltage Installations

A. Scope

The requirements of this Section apply to three-phase networks with rated (phase-to-phase) voltages of > 1 kV and rated frequencies of 50 Hz or 60 Hz. Voltages above 17,5 kV are to be discussed specially with BKL.

B. General Provisions

1. Reference to other requirements

The general provisions of this Volume also apply, as and where appropriate, to high voltage installations, except where more particular requirements are laid down in this Section.

2. Rated main voltages

The values indicated in Table 6.1 are recommended as standard rated voltages and frequencies.

Table 6.1 Rated voltages and rated frequencies

Rated voltage [kV]	Highest voltage for equipment [kV]	Rated frequency [Hz]
3,0	3,6	50
3,3		60
6,0	7,2	50
6,6		60
10,0	12,0	50
11,0		60
15,0	17,5	50
16,5		60

3. Clearances and creepage distances

3.1 Clearances

Clearances (phase-to-phase and phase to unit potential) for switchgear shall not be smaller than indicated in Table 6.2

Table 6.2 Minimum clearances for high voltage installations

Rated voltage [kV]	Minimum clearances [mm]
1	25
3	55
6	90
10	120
17,5	160

Intermediate rated voltage values can be allowed, provided that the next higher minimum clearance is adopted.

Where necessary, these clearances should be increased.

If the clearances are smaller, impulse withstand voltage tests in accordance with the relevant IEC publication have to be carried out.

3.2 Creepage distances

Creepage distances between live parts and between live and earthed components shall be designed in accordance with the rated voltage of the system, allowance being made for the nature of the insulating material and for transient over-voltages due to switching operations and faults.

3.2.1 In the busbar area, creepage distances shall not be less than 25 mm/kV for non-standardized components.

3.2.2 Insulators shall conform to IEC publication 60168 and 60273.

3.2.3 The creepage distances at busbar penetrations shall be in compliance with IEC publication 60137.

3.2.4 The minimum creepage distance behind current limiting circuit breakers and fuses shall not be less than 16 mm/kV.

4. Degrees of protection

The degrees of protection specified in Table 6.3 are to be complied with, in addition to the provisions of Section 1, Table 1.11.

Table 6.3 Minimum degrees of protection against bodies and water (in accordance with IEC 60529)

Equipment Location	Switchboards	Electrical machinery		Power transformers
		Motors, generators	Terminal boxes	
Locked electrical service spaces ¹	IP 32	IP 23	IP 44	IP 23
Generally accessible operational compartments (category A machinery spaces) and zones below deck (e.g. passageways, thrusters rooms)	IP 44	IP 44	IP 44	IP 44
Open deck	-	IP 56	IP 56	-

¹ Accessible only to trained specialist personnel. Subject to implementation of appropriate safety measures, lower degrees of protection are possible by agreement with BKI

4.1 If the required degree of protection is not fulfilled by the unit itself, adequate protection has to be ensured through appropriate structural measures.

4.2 Protective measures

4.2.1 An unacceptable hazard to persons through electrical shock and accidental arcs shall be excluded independently of the required protection against foreign bodies and water.

4.2.2 For switchgear installations shall be proven that an internal arc test according to IEC publication 60298 Appendix AA6 had been passed. The criteria 1 to 6 has to be satisfied. This can be omitted if the switchgear has to be isolated before access is given to the place of installation. (For installation, see Section 2, F.1.4.)

4.2.3 Terminal boxes shall be equipped with a device for the calculated expansion of the accidental arc gases.

5. Equipotential bonding

5.1 All conductive, but in normal operation non-live, components of a high voltage installation or equipment shall be provided with an electrically conductive connection to the hull respectively structure.

5.2 All metal components in the electrical operational compartments shall be included in the equipotential bonding.

6. Earthing

6.1 Metal parts not belonging to electrical equipment shall be earthed if, in the event of a fault,

they are liable to come into contact with live components either by direct contact or arcing.

Attention shall be paid to adequate dimensioning of the earthing conductors (e.g. for copper conductors the current density shall not exceed a value of 150 A/mm² in the event of a fault).

6.2 Metal components that have permanent and electrically conductive connections to the hull need not be separately earthed.

Bolted connections for the fixing of units or components are not considered electrically conductive connections.

7. Selectivity

For essential systems, selectivity is to be ensured independently of the neutral point design.

C. Network Design and Protective Equipment

1. Electrical operating systems

1.1 In principle, the following arrangements are permitted:

- 3 conductors, insulated from the structure
- 3 conductors with earthed neutral

Note

In high voltage systems with insulated neutral, transient overvoltages relative to the hull / main structure may occur which are greater than in networks with earthed neutral. Even if these do not destroy the insulation, they shorten its service life.

1.2 High voltage systems are permitted only for permanently installed power plants.

1.3 Subject to prior testing, flexible interconnecting cables may be approved by BKI in special cases. The necessary measures are to be decided in accordance with the particular application.

2. Systems with earthed neutral

2.1 The neutral point connection shall incorporate a resistance or other current limiting device, so that in case of a fault the earth-fault current is limited to the full-load current of the largest generator connected to the switchboard. However, the earth-fault current shall not be less than three times the minimum threshold current of the earth-fault monitor.

2.1.1 In order to fulfil the selectivity requirement expressed in B.7., measures shall be taken for installations with current-limited neutral earths to ensure selective disconnection of earth-faulted outputs (e.g. differential protection relays in all switchboard inputs and outputs).

2.1.2 Electrical equipment shall be designed so that, pending the response of the protective device, it is able to withstand a short-circuit current produced by a single-pole fault against the hull respective structure.

2.2 Highly resistive earthed mains, which outputs will not be isolated in case of an earth fault, are permitted, if the insulation of the equipment is designed according to 3.2.

2.3 Directly earthed networks without current-limiting device require the prior approval of BKI.

2.4 Electrical equipment shall be so designed that they withstand a short-circuit current produced by a single-pole fault relative to the structure until the protective device will be tripped.

2.5 Isolating links with neutral earthing

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

2.6 Design of the neutral point connection

2.6.1 All earth resistances are to be connected to the structure.

To prevent possible effects on electronic systems, it is recommended that the individual earth resistances should be conductively linked by cables on the earth side.

2.6.2 Generators for parallel operation may have a common connection for the neutral point.

For each isolatable busbar section directly supplied by generators, a separate neutral point connection shall be provided.

3. Systems with isolated neutral

3.1 Since intermittent earth-faults can cause transient overvoltages in networks with an isolated neutral, endangered equipment shall be fitted with over-voltage protection for overvoltages of at least 3,3 times U_N .

3.2 All insulation (of cables, consumers, transformers, generators etc.) shall be designed for the phase-to-phase voltage, if earth-faults will not be isolated without delay.

4. Protection equipment

The provisions of Sections 4 and 5 shall apply, as and where appropriate, to the selection of protective devices.

4.1 Faults on the generator side of circuit breakers

Protective devices are to be provided for phase-to-phase faults in the generator connection line, interturn short circuits within the generator and phase-frame faults in earthed networks. The protective device (differential protection) shall trip the generator circuit breaker and de-excite the generator.

4.2 Earth fault monitoring

Every earth fault in the system shall be visually and audibly signalled.

4.3 Power transformers

4.3.1 The protective devices of power transformers are subject to the provisions of Section 4, D.

4.3.2 Installation/unit supply transformers shall be fitted with differential protection.

4.3.3 Transformers used for supplying primary essential consumers shall be fitted with winding temperature monitors.

4.3.4 Liquid-cooled transformers shall be fitted with protection against outgassing of oil.

4.3.5 The liquid temperature shall be monitored. An alarm shall be actuated before the maximum permissible temperature is attained. When the temperature limit is reached, the transformer shall be disconnected.

4.3.6 The liquid filling level shall be monitored by means of two separate sensors. The monitoring system shall actuate an alarm at the first stage and then cause disconnection at the second, when the permissible limit is exceeded.

4.4 Voltage transformers for control and measuring purposes

4.4.1 Voltage transformers shall be protected on the secondary side against short-circuits and overload.

4.5 HVHRC fuses

The use of HVHRC fuses for overload protection is not permitted. They shall be used for short-circuit protection only.

4.6 Low-voltage networks

Low-voltage networks fed via transformers from a high-voltage network are to be protected against the overvoltages which may result from an insulation failure between the primary and secondary windings.

D. Electrical Equipment

1. General

1.1 Standstill heating

All equipment which may occasionally be taken out of service and is not located in heated and ventilated areas is to be equipped with a standstill heater. This heater should switch on automatically when the equipment is switched off.

1.2 Installation

See Section 2, F.

2. Switchgear

2.1 Construction

2.1.1 High voltage switchboards shall have metal clad enclosures which are fully partitioned and closed on all sides.

Incorporated low voltage compartments for control and monitoring systems shall be separated from the high voltage part in such a way as to render impossible any contact with parts having a rated supply voltage of more than 1000 V.

For main high-voltage switchboards and distribution switchboards, type approval according to IEC publication 60298 shall be verified.

Switchgear supplying secondary essential or non-essential equipment may be of metal enclosed type.

2.1.2 Fully partitioned switchboards

All sections of an air-insulated high-voltage switchboard shall be partitioned with respect to each other and the surroundings so that they are arc-resistant. Continuous busbar compartments or switch compartments are inadmissible.

Each section shall be subdivided into at least three arc-resistant, partitioned function compartments: the terminal compartment, the switch compartment and the busbar compartment.

2.1.3 Partly partitioned switchboards

If the main high-voltage switchboard is subdivided into two independent and autonomous installations, a continuous busbar compartment is permissible, provided that a protection system (arc monitor, busbar differential protection) is installed which detects internal faults and isolates the affected part of the installation within 100 ms, respectively accidental arcing is reliably prevented by design measures (e.g. solidly insulated busbar systems).

2.1.4 A sufficient number of isolating links, earthing and short circuit devices shall be provided to enable maintenance work to be safely performed on parts of the equipment when it is impossible, for operational reasons, to de-energize the switchboard completely.

2.1.5 Where drawout switchgear components are used, the following conditions shall be met:

- Functional testing and maintenance shall be capable of being performed in safety, even when the busbar is live.
- Drawout switchgear components are to be fitted with mechanical interlocking devices effective in the operating and disconnected position. A key interlock is permitted for maintenance purposes. Drawout switchgear components are to be locked in the operating position.
- The fixed contacts for drawout switchgear components are to be so arranged that, in the withdrawn position, the live contact components are automatically covered over or else, before a complete removal, preferably automatically, a cover has to be fitted.

2.2 Auxiliary systems

2.2.1 Where electrical and/or mechanical energy is required for the operation of switches, a means of storing such energy shall be provided, which is designed for at least two ON/OFF switching cycles of all the connected components.

Tripping due to overload, short-circuit or under-voltage has to be independent of any stored electrical energy.

2.2.1 Number of energy sources

For the supply of auxiliary circuits two independent uninterruptible power supplies shall be provided. If one of these uninterruptible power supplies fails, the remaining unit shall supply all switchboard sectors. The switch-over to the reserve source of energy shall be automatically and actuate an alarm. One uninterruptible power supply shall be fed from the emergency switchboard, and the other one from the main switchboard.

2.3 Tests

2.3.1 An individual test in accordance with IEC 60298 shall be performed in the manufacturer's works in the presence of the BKI Surveyor.

A functional test of the interlocking conditions, protective functions, synchronization and the various operating modes shall be performed.

A test schedule shall be compiled and submitted for approval.

2.3.2 It is recommended that a partial-discharge test is performed in accordance with IEC publication 60298, Appendix FF, if organic insulating materials or gas-insulated busbar penetrations are used.

2.3.3 High voltage test

A voltage test at power frequency is to be performed on every switchgear and control unit.

The value of the alternating withstand voltage is to be selected in accordance with Table 6.4. The duration of the test is 1 minute in each case.

The following tests have to be carried out in every case:

- conductor to earth
- between conductors

For this purpose, each conductor of the main circuit is connected in turn to the high-voltage connection of the test unit. All the other conductors of the main and auxiliary circuits are to be connected to the earth conductor, or to the frame and the earth connection of the test unit.

The electrical tests are to be performed with all switching devices in the closed position, and with all withdrawable parts in the operating position.

Table 6.4 Test voltages for switchgear

Rated voltage [kV]	Test voltage (rms value) AC withstand voltage [kV]	Impulse test voltage [kV]
$1,0 < U \leq 3,6$	10	40
$3,6 < U \leq 7,2$	20	60
$7,2 < U \leq 12,0$	28	75
$12,0 < U \leq 17,5$	38	95

Voltage transformers or fuses may be replaced by dummies which simulate the field distribution of the high voltage layout. Overvoltage protection devices may be isolated or removed.

2.3.4 Impulse voltage test

An impulse voltage test in accordance with Table 6.4 may be accepted as equivalent to the high voltage test. The duration of the test comprises 15 successive pulses.

2.4 Low voltage switchgear design

2.4.1 If the unit/installation's low-voltage network is supplied from the high-voltage system, a circuit breaker for the longitudinal separation of the main busbar shall be provided.

2.4.2 The arrangement of supply and consumer sections shall be in accordance with Section 5, C.2.

2.4.3 The feeder sections of the low-voltage switchboard shall be partitioned with arc-resistant segregations.

2.4.4 The unsynchronized connection of subnetworks and the feedback on the high-voltage side shall be prevented by means of interlocking.

3. Switchboard equipment

3.1 General

Control circuit equipment is subject to the conditions laid down for low voltage switchgear (see Section 5).

Note

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

3.2 Circuit breakers

Circuit breakers are to conform to IEC publication 60056.

3.2.1 Additional requirements

For drawout circuit breakers, see 2.1.5.

3.2.2 Circuit breakers shall be interlocked with the associated earthing switch.

3.3 Load switch-disconnectors and isolating switches

Load switch-disconnectors and isolating switches shall conform to IEC publication 60265.

3.3.1 Isolating switches shall be interlocked so that they can only be switched under no load. The use of load switch-disconnectors is recommended.

3.3.2 Earthing switches shall have making capacity.

3.4 HVHRC fuses

HVHRC fuses shall conform to IEC publication 60282.

3.5 Power contactors

Power contactors shall conform to IEC publication 60470.

3.6 Transformers

3.6.1 Transformers shall conform to the following IEC publications:

- current transformers, IEC publication 60044-1
- voltage transformers, IEC publication 60044-2

3.6.2 Earthing of current and voltage transformers

The secondary winding of every current and voltage transformer shall be earthed by means of a copper conductor of at least 4 mm² in cross-section. Open delta windings shall only be earthed at one point.

3.7 Relays

Relays for measuring and protective devices shall conform to IEC publication 60255.

4. Electrical machines

4.1 Construction

4.1.1 Generator stator windings

The ends of all stator windings are to be run to terminals in the terminal box.

4.1.2 Winding temperature monitors

The stator windings of electrical machines are to be equipped with temperature detectors. Inadmissible temperature rises are to actuate visual and audible alarms. Measures are to be taken which protect the measuring circuit against overvoltage.

4.1.3 Coolers

The water/air heat exchangers of electrical machines have to be fitted with double-walled tubes. Leakages are to be signalled visually and audibly.

4.2 Terminal boxes

Terminals with operating voltages under 1000 V are to be provided with their own terminal boxes. Terminals are to be clearly marked.

4.3 Tests

The tests specified in Section 16 apply to high voltage machines, as and where appropriate.

5. Power transformers

5.1 Design

5.1.1 Power transformers shall conform to IEC publication 60076.

5.1.2 In general dry-type transformers shall be used. They are to conform to IEC publication 60726. Exceptions are to be agreed with BKI.

5.1.3 Only transformers with separate windings shall be used. Exceptions are auto-transformer starters.

5.1.4 Transformers producing a low voltage from a high voltage shall be equipped with an earthed shielding winding between the low voltage and high voltage coil.

5.1.5 If oil-cooled transformers are used, measures shall be taken to ensure that the windings are completely covered by oil, even for inclinations of 22,5°.

5.2 Supply transformers

5.2.1 If the installation's/unit's low-voltage network is supplied from the high voltage network, at least two independent supply transformers, which fulfil the conditions expressed in Section 3, C.1., shall be installed.

5.2.2 Supply transformers shall be provided with instrumentation comprising a voltmeter and an amperemeter. It shall be possible to indicate the current and voltages of all three phases.

5.3 Tests

Power transformers shall be individually tested in the manufacturer's works in the presence of a BKI Surveyor.

5.3.1 The scope of the tests is as stated in Section 15, B.

5.3.2 The test voltages shall be selected in accordance with Section 15, Table 15.7.

6. Cables

6.1 General

6.1.1 High voltage cables are to conform to IEC publication 60092-354 or 60092-502.

6.1.2 High voltage cables shall be marked.

6.2 Selection of cables

6.2.1 The rated voltage of a cable shall not be less than the rated operational voltage of the circuit in question.

6.2.2 In insulated-neutral networks, the phase-to-phase voltage (U) of the network shall be deemed to be the rated voltage (U₀) of the cable between one conductor and the hull respectively structure.

6.3 Tests

Tests are to be performed in accordance with Section 16.

The voltages for the high voltage test are indicated in Table 6.5

E. Installation**1. General**

See Section 2, F.

2. Cable installation**2.1 Cable routes**

High voltage cables shall not be run through the accommodation area. Cable layouts not adhering to this rule are to be approved by BKI prior to the start of installation.

2.2 Segregation from low voltage cables

Cables for high voltage systems are to be laid at a distance of at least 50 mm from low voltage cables.

2.3 Installation design

2.3.1 High voltage cables laid in open cable trays shall be provided with a continuous metal shield or armourings against mechanical damage; shields and armourings shall have an electrically conductive connection to the hull respectively structure.

2.3.2 High voltage cables without shield or armouring shall be laid in closed metal ducts or cable conduits, which are to have an electrically conductive connection to the hull respectively structure.

For the installation of single core cables for AC wiring the metal ducts shall be made of non magnetic material, unless the cables are installed in trefoil formation.

2.3.3 For bends, the minimum-bending radius permitted by the manufacturer shall be observed; if not specified then the bending radius shall be not smaller than 12 times of the outer diameters of the cables.

2.4 Marking of cable ducts and conduits

Ducts and conduits for high voltage cables are to be marked in accordance with Section 2, F.

2.5 Connections

2.5.1 As far as is feasible, all high voltage cable connections have to be covered with suitable insulating materials.

2.5.2 In terminal boxes, where the conductors are not insulated, the phases are to be separated from each other and from the structure's potential by me-

chanically robust barriers of suitable insulating material.

2.6 Sealing ends, joints and kits

2.6.1 For high voltage kits from 3,6 to 6 kV measures shall be taken to attenuate the electrical fields which occur at points where cable insulations are removed. (sealing ends)

2.6.2 The materials of sealing ends and joints shall be compatible to the corresponding cables.

2.6.3 The construction of joints has to permit the separate through-connection of all shields and armourings.

2.6.4 Sealing ends shall enable shields and armouring to be brought out.

2.6.5 The technical documentation and test Certificates of sealing ends and joints shall be submitted.

3. Tests**3.1 Tests following installation**

When the installation work has been concluded, high voltage cables are to undergo voltage tests in the presence of the BKI Surveyor. Therefore the joints and sealing ends have to be tested also.

The test is to conform to IEC publication 60502.

Note

Compliance with the safety regulations for tests at high voltage is the responsibility of the testing laboratory.

3.2 The following tests are recognized:

- high voltage test at 70 % of the DC voltage test value shown in Table 6.5 for a period of 15 minutes between conductor and shield, or
- test using the rated (phase-to-phase) voltage/frequency between conductor and shield for a period of 5 minutes, or
- test using the operating voltage of the system for a period of 24 hours

3.3 The insulation resistance is to be measured before and after the high voltage test. ($\geq 200 \text{ M}\Omega$ at 500 V)

Table 6.5 Test voltages for high voltage cables

Max. system voltage U_m	kV	1,2	3,6	7,2	12	17,5	24,0
Rated voltage U_0 / U	kV / kV	0,6 / 1,0	1,8 / 3,0	3,6 / 6,0	6,0 / 10,0	8,7 / 15,0	12,0 / 20,0
AC test voltage	kV	3,5	6,5	11,0	15,0	22,0	30,0
DC test voltage	kV	8,4	15,6	26,4	36,0	52,8	72,0

Notes

U_0 : rated voltage between conductor and earth or metal shield.

U : rated voltage between the conductors for which the cable is designed.

Section 7

Power Electronics

A. Scope/Definitions

For power electronics in electrical propulsion plants, see Section 12.

B. Construction

1. The requirements set out in Section 5 are to be observed, wherever applicable.

2. Every power electronics system is to be provided with separate means for disconnection from the mains.

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

3. Equipment is to 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.

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

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

C. Rating and Design

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

Attention is drawn to the BKI Regulations for the Electromagnetic Compatibility of Electrical Equipment.

2. Rectifier systems shall guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see Section 1, F. 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. For the supply of mains, number and rating of electronic facilities are to be so scaled that in the event of failure of any one power electronics facility the remainder of the installation is sufficient to

- feed all essential equipment which may be in simultaneous operation with the propulsion plant at full power
- start the biggest consumer without exceeding the maximum permissible voltage and frequency variations

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

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

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

6. Electrical charges in power electronics 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.

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

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

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

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

10.1 Special attention shall be paid to the following points:

- mutual interference of static converters connected to the same busbar system
- calculation of commutating impedances reacting to voltage distortion and 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
- consideration of voltage drops in the mains due to inverter operation
- influence by harmonics and high-frequency interference
- influence on the installation's/unit's mains by energy feeding back

10.2 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

D. Cooling

1. Natural cooling should be chosen where possible.
2. The safety in operation is to be proven for liquid cooling and forced cooling.
3. An impairment of cooling shall not result in unacceptable over-temperatures; an overtemperature alarm shall be provided.

E. Control and Monitoring

1. Control, adjustment and monitoring shall ensure that the permissible operating values of the facilities are not exceeded.
2. The power supply to all control circuits is to be monitored for voltage failure.
3. For the monitoring of individual modules and assemblies of essential equipment, devices are to be provided which in the event of a fault facilitate its recognition.
4. The control shall be so engineered that the installation is protected from damage during the

switching-on and switching-off sequence, dedication alterations and faulty operation.

F. Protective Equipment

1. Power electronics equipment shall be protected against exceeding of their current and voltage limits.

For protective devices, it shall be ensured that upon activating

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

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

3. Special semiconductor fuses are to 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.

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

G. Tests

1. General

Power electronics assemblies are to be individually tested at the maker's works. A Works Test Report is to be provided for the tests carried out. Essential equipment from 50 kW/kVA upwards is to be tested in the presence of the BKI Surveyor.

2. Extent of routine tests

2.1 Voltage test

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

$$U = 2 U_n + 1000 \text{ V, duration 1 minute,}$$

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

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

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

2.2 Insulation resistance test

Following the voltage test, the insulation resistance is to be measured at the same connections as for the

voltage test. The measurement is to be performed at a voltage of at least 500 V DC. Insulation resistance requirements see IEC 60140-1-1 or equivalent.

2.3 Operational test

Correct functioning is to be demonstrated as far as possible.

2.4 Testing of protection and monitoring devices

The response thresholds and the coordinated operation of the protective and monitoring devices are to be demonstrated.

Section 8

Auxiliary Equipment

A. Auxiliary Equipment Installations

1. Fire extinguishing systems

1.1 Fire pumps

1.1.1 The power supply to the fire pump motors and control systems with regard to both the assignment of power sources and the routing of power cables is to be so arranged that a fire in any fire zone does not render all the fire pumps unserviceable.

1.1.2 Automatically started fire pumps shall also be capable of being started by hand from the fire extinguishing control station.

If remote starting is provided for fire pumps, pump controls shall be so designed that in the event of failure of the remote control the local control remains operative. Regarding remote starting of fire pumps on installations/units with unattended engine room see Section 9.

1.2 Sprinkler fire extinguishing systems

1.2.1 For the design of sprinkler systems, see also Volume 4 – Rules for Machinery Installations, Section 10.

1.2.2 For automatic fire extinguishing systems, the pump and compressor drives shall be supplied via one direct power cable each from the main and from the emergency switchboard. Should the main power supply fail, the supply shall be automatically switched to the emergency switchboard.

1.2.3 If the hydraulic pressure in the system drops, the pressure water pump shall be started automatically.

1.2.4 Provision shall be made for supplying the associated fire alarm, fire detection and other systems both from the main generators and from the emergency power source.

The requirements of Section 9 are applicable in analogous manner to the design of the fire alarm system.

1.2.5 The switches on the main and emergency switchboards required for the power supply to all units forming part of the alarm and extinguishing systems shall be clearly marked.

1.2.6 The supply cables to the pumps should not be routed through galleys, engine rooms and other spaces

with an increased fire hazard unless this is essential to connect them to the switchboards.

2. Fans

2.1 Power ventilation of accommodation spaces, service spaces, storerooms, control stations and machinery rooms shall be capable of being stopped from an easily accessible position outside the spaces being served and with maximum security against being cut off in case of fire.

The switches for disconnecting the power ventilation of the machinery spaces shall be separate from the switches for stopping the other fans.

2.2 It is recommended that one of the engine room fans should be supplied from the emergency power source to permit the extraction, should the need arise, of inert gases used for fire extinguishing.

3. Fuel pumps and separators

The drive motors of fuel pumps and fuel and lubricating oil separators shall be stopped from outside the spaces concerned. The control circuits are subject to the requirements of Section 5.

4. Bilge pumps

4.1 Where submersible bilge pumps are electrically driven, their motors and connecting cables shall be suitable for underwater operation. The cables are to be laid in one continuous length from a position above the highest anticipated waterline to the motor and are to enter the bell, if any, from below.

4.2 Bilge spaces shall in every case be equipped with a level alarm.

5. Pumps discharging overboard

The motors of pumps discharging overboard, whose outlets are located in the lifeboat launching area above the waterline, are to be equipped with emergency switches housed in a glass-covered box at the lifeboat or liferaft launching station. Control circuits are subject to the requirements of Section 5, E.

6. Turning gear

6.1 See also Volume 4 – Rules for Machinery Installations, Section 1, D.10.

6.2 The turning gear shall be equipped with a device which prevents the diesel engine from being started as long as the turning gear is engaged.

6.3 The remote control of electrically driven turning gear shall be so designed that the gear motor stops immediately, if the switch or push-button is released.

6.4 A disconnecting switch shall be fitted near the drive unit.

B. Cargo Winches and Cranes

See Volume 2 - Rules for Structure, Section 8 and the Regulations for the Construction and Survey of Lifting Appliances

National Regulations are to be complied with, wherever applicable.

C. Free Fall Lifeboat Launching Equipment

If the lifeboat launching device operates without the force of gravity, stored mechanical energy or manual swinging effort, the device shall be connected to the installation's/unit's main and emergency source of electrical power. See also Volume 6, Section 9 and Volume 7, Section 5.

D. Electrical Heating Equipment and Heaters

1. Space heating

1.1 For the supply to heaters see Section 4; for the construction of heating appliances see Section 15, J.

1.2 Hooks or other devices on which garments can be hung may not be fitted above space heaters.

1.3 Where heaters are installed inside the bulk-head lining, a tray made of incombustible material shall be fitted behind the heater to prevent the accumulation of heat behind the lining.

1.4 Only heaters with IP 44 class enclosure as a minimum requirement may be used in washrooms, bathrooms, other wet rooms and machinery spaces.

1.5 In the case of ceiling-mounted heaters, it is essential to ensure that the heat is radiated downwards. An insulating layer of incombustible material shall be fitted above the heater. The heating elements are to be protected against accidental contact.

2. Oil and water heaters

Oil and water heaters are subject to the requirements of Section 15, J.

Section 9

Control, Monitoring and Safety Systems

A. General Requirements

1. Scope

1.1 This Section contains requirements for the equipment and design of control, monitoring and safety systems necessary for the operation of offshore units and installations.

2. Design Criteria

2.1 The requirements laid down for each component and system depend on their use and the process-technological conditions. These Rules stipulate the minimum requirements for these.

2.2 If special operating conditions call for a particular system design, BKI reserve the right to impose additional requirements, depending on the operational and system-specific considerations.

2.3 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.

2.4 Where appropriate, the following basic requirements shall be observed:

- compatibility with the environmental and operating conditions
- compliance with accuracy requirements
- recognizability and constancy of the parameter settings, limiting and actual values
- compatibility of the measuring, open and closed loop controls and monitoring systems with the process and its special requirements
- immunity of system elements to reactive effects in overall system operation
- non-critical behaviour in the event of power failure and power restoration
- unambiguous operation
- maintainability, traceability of faults and test capability
- reproducibility of values

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

2.6 If danger to persons or to the safety of the installation/unit arising from normal operation or from malfunctions cannot be ruled out, safety devices or safety measures are required.

2.7 If danger to machinery and systems arising from faults or malfunctions in control, monitoring and measuring systems cannot be ruled out, protective measures are required.

2.8 Where mechanical systems or equipment are either completely or partly replaced by electric/ electronic equipment, the requirements relating to mechanical systems and equipment according to Volume 4 - Rules for Machinery Installations, shall be met accordingly.

3. Construction

3.1 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 applies also to measuring facilities.

3.2 For machinery and process systems which are controlled remotely or automatically, control and monitoring facilities shall be provided to permit manual operation.

3.3 After disturbances or shutdowns an automatic reset is prohibited. A local manual reset is required especially for process installations.

3.4 The design of safety devices is to be as simple as possible and shall provide reliable operation. Proven safety devices which are not depending on a power source should be preferred.

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

3.6 Safety devices shall be designed so that potential faults such as loss of power or a broken wire do not create a hazard to human life or to the unit or installation. These faults as well as the tripping of safety devices shall be signalled by an alarm.

3.7 The adjustment facilities for safety devices have to be designed so that the last setting can be traced.

3.8 Where auxiliary energy is needed for the function of safety devices or systems, this has to be monitored and a failure has to be alarmed. An uninterrupted power supply has to be provided.

3.9 Safety systems as well as safety devices shall be independent of other systems of open and closed loop control and alarm systems. Faults in one system shall not affect other systems.

3.10 Safety systems shall be designed fail-safe, where applicable, i.e. the closed circuit principle has to be applied. Fail-safe conditions have to be determined before. In case of not defined fail-safe conditions, the monitored working current principle may be applied instead of the closed circuit principle, e.g. for propulsion systems of self-propelled units or control of fire extinguishing facilities (CO₂).

4. Maintenance

4.1 Access shall be provided to all facilities 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.

4.2 The operational capability of other facilities shall not be impaired as a result of maintenance procedures.

4.3 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.

4.4 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.

5. Tests

5.1 The suitability of systems and equipment is to be demonstrated by tests in the manufacturer's works and on site.

5.2 Factory acceptance test

5.2.1 Manufacturers shall ensure that their products meet the specified requirements and shall carry out and keep records of quality control tests.

5.2.2 In the case of extensive systems, tests are to be carried out in the presence of a BKI Surveyor on the basis of the approved technical documents, i.e. test procedure. These tests will be specified in each case depending on the application and scope of the system.

Exception to this rule may be type-tested equipment as per BKI requirement or another institution acknowledged by BKI.

5.3 On Board / On Site tests

Tests are to be carried out on board / on site on the basis of approved documents in the presence of the Surveyor. Functions are to be checked in a coordinated operation with the peripheral equipment. Test procedures have to be approved by BKI.

B. Communication Systems

1. Internal communications

1.1 An internal communication system is to be provided for exchanging information between all rooms and working places.

1.2 In case of failure of the mains, the power supply to the system shall be automatically switched to the emergency power source.

2. Public address system

2.1 In addition to the general emergency alarm a public address system is required which can be operated from strategically important locations and from the bridge/central control station. The public address system shall be audible throughout the accommodation area, at the crew's normal working places and at the strategically important locations.

2.2 If the public address system is used to transmit the general emergency alarm, the following requirements shall be fulfilled:

- The requirements for the general emergency alarm shall be satisfied.
- At least two amplifiers are to be provided, each of them separately supplied and fused.
- At least two loudspeaker circuits, supplied from separate amplifiers, are to be installed in each fire zone, respectively in its subdivisions.
- The loudspeaker circuits are to be so arranged that transmission at a reduced loudness is maintained in the event of a failure of an amplifier or loudspeaker circuit.
- Where loudspeakers with built-in volume controls are used, the volume controls shall be disabled by the release of the alarm signal.
- It shall be possible to transmit the undistorted and clearly audible alarm signal at all times. Other simultaneous transmissions shall be automatically interrupted.

- It shall be possible to operate all loudspeakers at the same time.
- The loudspeaker system shall be designed under observance of the minimum required sound level.
- Announcement via microphone shall be free of acoustical feedback and other disturbances.

3. Alarm system

3.1 On all units or installations an alarm system shall be provided to alert the crew or to call them to the assembly points. It shall be possible to release the alarm from the central control station and also from strategically important locations.

3.2 The following alarms shall be established:

- general emergency alarm
- fire alarm
- gas alarm
- abandon unit/installation

3.3 The elements of the alarm system have to be designed independently, but shall be connected by a bus system. The use of a common control panel is permitted.

3.4 Means for announcement shall be provided in a sufficient number to ensure that all persons inside the installation/unit and on deck are alerted. In noisy rooms, additional visual means of alarm may be necessary.

3.5 Once released, the alarm shall sound continuously until it is switched off manually or is temporarily interrupted for an announcement through the public address system.

3.6 Cables for general emergency alarm installations and for loudspeaker systems shall be fire-resistant.

3.7 If the main electrical power source fails, the general emergency alarm system shall be fed by the emergency power source.

C. Safety Systems

1. Overall safety and monitoring system

1.1 An integration of the safety systems of a unit/installation described in the following shall be established by an overall safety and monitoring system.

1.2 The integration of the safety systems shall be designed in co-ordination with BKI. The different safety systems shall be connected by a bus system as data link but shall work without repercussion to each other.

1.3 For the design principles of the different safety systems and especially also the emergency shut-down system (ESD) see Volume 4 – Rules for Machinery Installations, Section 17.

1.4 Power supply via UPS may be required for safety systems, e.g. ESD, fire detection, gas detection, depending on the system design.

2. Fire detection and fire alarm system

2.1 Design

2.1.1 The requirements for fire detection and fire alarm systems of mobile offshore units are defined in the Rules for Electrical Installations, Volume IV, Section 9, D.3. For fixed offshore structures the requirements in the following apply.

2.1.2 Central fire control panels and fire detectors which are used shall be approved by BKI.

Manual call points and automatically activated fire detectors are to be used in fire detection and alarm systems. Automatic detectors shall be activated by heat, smoke or other combustion products, flames or any combination of these factors. Detectors activated by other influences may be approved if their sensitivity is not less than that of the approved detectors.

Flame detectors may only be used in addition to the prescribed detectors unless they are installed in areas where other detectors would be ineffective.

2.1.3 The central fire control panel shall be mounted in a permanently manned location.

2.1.4 Additional remote display panels may be necessary at safety stations and other control stations.

2.1.5 Clear information shall be displayed at the central fire control panel and at each display panel, indicating which rooms are monitored and the location of the individual sections.

2.1.6 The fire detectors are to be grouped in sections or detecting loops.

A fire alarm section monitoring a service area or an accommodation area shall not include a machinery space of category A.

2.1.7 The activation of a fire detector shall trigger a visual and audible alarm at the central fire control panel and at the additional remote display panels.

For all operating, service and accommodation areas, this alarm shall normally be passed on to the crew manually using the signalling facilities of the general

alarm system. However, if the fire alarm at the central control panel is not acknowledged within 2 minutes, the fire alarm shall be automatically transmitted to all areas of the unit via the general alarm system or shall be audibly and visually signalled via another system suitable for this purpose.

2.1.8 The audible fire alarm signal shall be clearly distinguishable from all other signals.

2.1.9 Each detecting loop shall not include more than one fire zone or one watertight compartment and, wherever possible, not more than two superimposed decks. Where there are separate facilities for flooding different machinery spaces with gaseous extinguishing agents (e.g. CO₂), separate detecting loops are also to be provided. The number of detectors grouped in each loop within a machinery space should not exceed ten.

2.1.10 Detectors should not be mounted close to ventilation outlets or in positions where the flow of air may affect their operation, or where they are liable to suffer mechanical damage.

Ceiling-mounted detectors shall normally be located at least 0,5 m from bulkheads.

The maximum distance between detectors (and the maximum area monitored) shall not exceed the following figures:

- for heat detectors: 9 m (37 m²)
- for smoke detectors: 11 m (74 m²)

The distance from bulkheads shall not exceed

- for heat detectors : 4,5 m
- for smoke detectors: 5,5 m

2.1.11 The following types of detectors may be used as automatic fire detectors:

- ionization/smoke detectors for all enclosed operating areas, store rooms, stairways, passageways and escapes within accommodation areas
- heat detectors, preferably in galleys, sleeping rooms and day rooms
- differential and flame detectors for operating areas subject to high air speeds and for areas in the open

2.1.12 Manual call points shall be installed in all areas. The distance between manual call points shall not exceed 20 m wherever possible.

The locations of manual call points shall include the exits from day rooms, stairways, control stations, passageways and escapes.

If manual call points are not sufficiently well lit by emergency lighting close-by, they are to be provided with an indicator lamp.

2.1.13 In workshops and rooms where the activation of detectors is liable to be caused by, for example, welding work, the detectors may be rendered tempo-

rarily inoperative. After the expiry of a pre-selected time the detectors shall automatically become operative again.

2.2 Central fire control panel

2.2.1 The installation shall be supplied directly by separate cables from the main and the emergency power supply system. Provision is to be made in the central fire control panel for automatic switch-over to take place should one of the supplies fail. The switch-over shall be signalled visually and audibly.

Cables forming part of the fire detection system are to be so arranged as to avoid galleys, category A machinery spaces and other closed spaces with a high fire risk, except if it is necessary to transmit a fire signal from these spaces, to initiate a fire alarm in these spaces, or to make the connection to the appropriate source of electrical power.

2.2.2 A signal at the central control panel shall indicate that the system is operative.

2.2.3 Each detecting loop is to be provided with its own visual display.

2.2.4 The audible and visual signals shall be maintained until they are acknowledged at the central fire control panel. The acknowledgement shall not suppress further alarms in other detecting loops.

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

2.2.6 The failure or disconnection of a detecting loop shall not affect the operation of another detecting loop.

2.2.7 Detectors responding simultaneously shall not impair the operation of the equipment.

2.2.8 The fire detection system shall be so constructed that any faults which occur, e.g. a supply failure, short circuit or wire breakage in detecting loops, removal of a detector from its socket or an earth fault in detecting loops insulated on all poles, are signalled visually and audibly at the central fire control panel. Fault alarms are to be acknowledgeable and, wherever possible, distinguishable from a fire alarm.

2.2.9 Fire detection systems with a loop-wise indication shall be so designed that

- a loop cannot be damaged at more than one point by a fire
- equipment is available which ensures that a fault in the loop (e.g. wire break, short circuit, earth fault) does not cause failure of the entire loop

- all possible precautions have been taken to allow the function of the system to be restored in the event of a failure (electrical, electronic, affecting data processing)
- the first fire alarm indicated does not prevent the indication of further alarms by other fire detectors

2.2.10 Where the detectors in the alarm mode are not all simultaneously indicated at the central fire alarm panel, the central panel shall have the means of scanning all the detectors which have responded in order to establish clearly whether other detectors are in the alarm mode besides the one indicated.

2.3 Fire detectors

2.3.1 The following types of detectors may be used depending on local conditions:

- ionization detectors and optical smoke detectors which respond to a fire even in the initial phase
- differential detectors which respond as soon as a given temperature rise per unit time is exceeded
- heat detectors which respond when a predetermined limit temperature is exceeded
- flame detectors activated, for example, by the infrared or ultraviolet radiation of naked flames
- manual call points

2.3.2 The sensitivity of automatic detectors, either individually or in groups, shall be adaptable to local conditions.

2.3.3 Unless the central fire control panel shows which detector has been activated, each detector shall itself be provided with a visual indicator. This signal shall be maintained pending acknowledgement at the central control panel.

2.3.4 All fire detectors shall be so constructed that, after the prescribed regular testing, they are once more serviceable without having to change components.

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

3. Fire door closing system

Where fire doors are specified, electric operating devices shall release the catches of open fire doors if the power supply fails, so that the doors can close automatically. The closure of the doors shall be capable of being initiated at a central point, and an individual release shall also be provided at each door. These devices are to be connected to the emergency power supply.

4. Indicator system for fire doors

Indicator lights on the bridge or at the safety station are to indicate when the fire doors are closed. It is permissible for the indicator system to be operated automatically only when a fire alarm is given. This system is to be connected to the emergency source of power.

5. CO₂ alarm systems

5.1 For the general design of CO₂ alarm systems, see Volume 4 – Rules for Machinery Installations, Section 10.

5.2 The CO₂ alarm system shall be supplied from the emergency switchboard.

5.3 An audible alarm combined with a visual signal shall precede for a sufficient long period the opening of the CO₂ flooding valves.

5.4 The alarm shall continue to be given as long as the flooding valves are open.

6. Alternative gas fire extinguishing systems

6.1 A pressure drop in the extinguishing agent container shall be signalled visually and audibly by the alarm system. If the propellant tanks are released electrically, the release station is to be supplied from two power sources, one of which shall be the emergency power supply.

In this case the supply lines to the containers holding the extinguishing agent are to be laid in such a way that they are fireproof (e.g. in metal conduits), or fireproof cables are to be used.

The release device is to be self-monitoring and the release circuits are to be monitored for wire breakage and short circuit. Faults are to be signalled visually and audibly.

6.2 The release of each system shall be signalled visually and audibly outside the entrances to the rooms concerned as well as on the bridge or in the central fire control station.

6.3 Further requirements defined in Volume 4 – Rules for Machinery Installations, Section 10 are to be observed.

7. Watertight door closing system, if applicable

7.1 Where watertight doors are operated by a power drive, an audible signal shall be automatically given close to each door about 5 seconds before the start of closure, and this signal shall remain clearly audible throughout the closing operation.

7.2 The electrical controls and indicators shall be so constructed and fused that no fault of any kind in

the control of one of the doors can interfere with the operation of the other doors. In addition, a single fault in the control of each door shall not cause a closed door to open unintentionally.

7.3 The warning and control systems shall be supplied from the emergency power source.

8. Watertight door indicator system, if applicable

8.1 All control stations from which the watertight doors are not visible shall be fitted with indicators showing whether the doors are open or closed. The equipment is to be connected to the emergency power supply.

8.2 The transmitters for the indicators shall have at least IP X6 type of enclosure.

9. Sprinkler systems

9.1 Installations/units equipped with an automatic sprinkler system are to be additionally provided with a fire detection and alarm system with automatic smoke detectors and manual call points with displays in the control room.

9.2 Where sprinkler systems are installed in the accommodation and day rooms, the alarm devices are to conform to the following requirements:

Automatic devices shall be mounted which give an audible and visual alarm as soon as a sprinkler is activated. Activation shall be indicated in the control room. With regard to the self-monitoring function, the alarm system is to be designed similarly to a fire detection system.

10. Gas detection systems

10.1 Design of gas detection systems

10.1.1 For the general requirements covering gas detection systems, see also Volume 4 – Rules for Machinery Installations, Section 10, G.

10.1.2 Equipment type tested by BKI should preferably be used for the central unit and the gas detectors.

10.1.3 Gas detection systems are used for the early detection of both explosion hazards due to explosive gas-air mixtures and toxic gases such as hydrogen sulphide (H₂S).

The measurement of explosive or toxic atmospheres shall be continuous.

The relevant hazard warning shall be given before the lower hazard limit is reached.

10.1.4 For the measurement of combustible hydrocarbons, the scale of measurement shall extend from 0 % to 100 % of the lower explosion limit. The alarm thresholds are normally set at 20 % and 60 %

of the lower explosion limit.

10.1.5 For the measurement of toxic gases, instruments with a measuring range from 0 ppm to about 300 ppm are used. The limit values for the preliminary and main alarms, e.g. for hydrogen sulphide, are normally set at 10 ppm and about 70 ppm respectively.

10.1.6 The actual alarm limits depend on the properties of the media concerned and are to be decided by agreement with BKI.

10.1.7 The actual gas detection station is to be sited in a permanently manned location, e.g. the control room. It shall be provided with easily intelligible indications showing which detectors have been activated and where these are located.

10.1.8 The appropriate arrangement of gas detectors depends on their purpose and the construction of the area being monitored. Monitoring encompasses both the hazardous areas and areas classified as “safe“, where it shall be assumed that the latter too could be endangered by an operational malfunction.

Gas detectors are therefore in principle to be arranged in such a way that

- accidental gas leaks can be detected as soon as possible. This means that gas detectors shall be placed close to possible gas leaks in the hazardous area
- dangers due to gas infiltrating into safe areas are detected in good time, i.e. the paths along which the gas shall pass to reach the safe areas are to be monitored with gas detectors

The necessary protective measures such as the shutdown of ventilation equipment, the automatic closure of ventilation inlets and vents and, where applicable, the disconnection of non-explosion-protected facilities, etc. are initiated by the gas warning system.

10.1.9 The activation of a gas detector shall trip a visual and audible alarm at the central gas detection station. This alarm shall be passed on to all areas of the unit via the signalling equipment of the general alarm system or via a separate alarm system for the crew. The audible signal of the gas alarm shall be clearly distinguishable from all other alarms.

10.1.10 Safety functions initiated by the gas detectors and carried out automatically, e.g.

- interventions in production processes
- disconnection of possible sources of ignition
- protection of unclassified (safe) areas

are to be designed in accordance with a safety logic tested and approved by BKI. For further details on safety actions see Volume 4 – Rules for Machinery Installations, Section 17.

10.2 Gas detection station

10.2.1 The installation shall be supplied with power via separate cables from the main power supply and an emergency power source. Should one of the power supplies fail, the central gas detection station shall switch automatically to the remaining supply. The completed switch-over shall trip an alarm.

10.2.2 The central station, which shall be located in a permanently attended space, shall be provided with a visual indicator showing that the system is operative.

10.2.3 Each gas detector shall be provided with its own evaluator.

Each evaluator should be equipped as follows:

- two adjustable alarm limit values
- an indicator lamp for the lower limit value
- an indicator lamp for the upper limit value
- an indicator lamp for failures (e.g. wire breakage)
- a pilot light showing that the evaluator is operative
- isolated signal outputs for actuating external alarms and safety circuits
- a reset button

Failure signals shall be acknowledgeable and, as far as possible, distinguishable from a gas alarm.

Wherever possible, evaluators with an integrated indicating device are to be used for toxic gases.

10.2.4 The measured gas concentrations are to be indicated as a percentage of the lower explosion limit (LEL) or in ppm in the case of toxic hazard. The detection system shall initiate an alarm in the control station before the gas concentration reaches dangerous limits.

At a concentration of 20 % of the LEL an audible and visual alarm shall be initiated.

At a concentration of 60 % of the LEL safety functions shall be activated before the concentration of gases reaches the explosion limit, see Volume 4 – Rules for Machinery Installations, Section 17, B.

For toxic gases like hydrogen sulphide an audible and visual alarm shall be initiated for a concentration of 10 ppm.

10.2.5 The central console shall be fitted with a selector switch for the "normal operation" and "test" modes. The indicating device shall function both in the normal operating mode and in the test mode.

10.2.6 The visual and audible signals, including the external alarms, shall be maintained pending acknowledgement at the central unit.

The visual signal at the evaluator and switching commands for safety equipment shall not be acknowledge-

able until the variable concerned has dropped below the alarm limit value.

It shall be possible to identify the detector giving alarm on the control panel.

In systems for measuring toxic gases the external alarms shall be maintained until the variable concerned drops below the alarm limit value. Only then shall it be possible to acknowledge the external alarm.

10.3 Gas detectors

10.3.1 Gas detectors type tested by BKI should be used.

The agreement of BKI is required for the use of non-type-tested measuring heads.

Note

The agreement of BKI for non-type-tested gas detectors is necessary because various measuring techniques may be used, including some which offer only limited practical operation experience.

10.3.2 Only gas detectors with a type of protection suitable for the particular explosive atmosphere may be used.

10.3.3 Gas detectors mounted in the open shall be provided with sufficient protection against water spray and jets.

Where necessary it should also be possible to retrofit them with a wind shield.

10.4 Calibration and testing

10.4.1 Provision shall be made to enable the fixed system to be tested without disruption of the normal routine.

10.4.2 Means shall be provided whereby operational personnel may readily check on the accuracy of gas percentage readings and the response of fire detectors.

In the test mode it shall be possible to test the operation of the individual measuring channels and the calibration of the gas detectors without transmitting control instructions to external equipment.

10.4.3 To introduce test gases to not easily accessible gas detectors, it shall be possible to retrofit gas detectors with a test attachment enabling the test gases to be piped to the measuring head through a measuring line.

A fixed test attachment shall not impair the measurements made in normal operation.

11. Lift alarm

11.1 Lifts with internal controls shall be equipped with an audible emergency calling device which can

be actuated from the lift cage. The alarm is to be transmitted to a permanently manned position.

11.2 The lift cage lighting and the emergency calling system are to be supplied from the emergency power source.

11.3 The relevant national regulations are to be observed.

12. Engine safety systems

12.1 Safety devices

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

12.1.2 The suitability and function of safety devices has to be demonstrated in the given application.

12.1.3 Safety devices shall be designed so that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, unit/installation or machinery.

These faults and also the tripping of safety devices shall be signalled by an alarm.

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

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

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

12.1.7 Safety devices with type approval of BKI should be used. Agreement of BKI is required for the use of non-type tested safety devices.

12.2 System characteristics

12.2.1 Systems shall be independent of open and closed loop control and alarm systems. Faults in one system shall not affect other systems. Deviations from this requirement may be allowed for redundant equipment with the agreement of BKI where this would entail no risk to human life and where installation/unit safety would not be compromised.

12.2.2 Systems shall be assigned to systems which need protection.

12.2.3 Where systems are provided with overriding arrangements, these shall be protected against unintentional operation. The actuation of overriding arrangements shall be indicated and recorded.

12.2.4 The monitored open-circuit principle shall be used for these systems. Alternatively, the closed circuit principle shall be applied where the provisions of national regulations demand it (e.g. boiler and oil-fired systems).

Equivalent monitoring principles are permitted.

Faults and also the tripping of systems shall be indicated by an alarm and recorded.

12.2.5 The systems shall be designed for preference using conventional technology (hard wired). Alternative technical solutions shall be agreed with BKI.

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

12.2.7 Safety devices with type approval of BKI should be used. Agreement of BKI is required for the use of non-type-tested safety devices.

12.3 Open loop control

12.3.1 Essential equipment shall be provided with effective means for the control of its operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems, see also A.2.4, 12.7 to 12.9.

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

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

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

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

- competitive commands shall be prevented by suitable interlocks. The control station in operation shall be recognizable as such;
- taking over of command shall only be possible with the authorization of the user of the control station which is in operation
- precautions shall be taken to prevent changes to desired values due to a change-over in control station
- open loop control for speed and power of internal combustion engines (main and auxiliary engines) and electrical actuators are subject to mandatory type approval

12.4 Closed loop control

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

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

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

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

12.4.5 Closed loop control for speed and power of internal combustion engines and electrical actuators with type approval of BKI should be used. Agreement of BKI is required for the use of non-type-tested control elements.

12.5 Engine alarm systems

12.5.1 Engine alarm systems shall indicate unacceptable deviations from operating figures optically and audibly.

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

12.5.3 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.

12.5.4 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.

11.5.5 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.

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

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

12.6 Operational devices for auxiliary engines

Operational devices required for the engine room control position for:

- speed
- lubricating oil pressure
- control air pressure
- fuel pressure

shall be electrically independent of other systems.

12.7 Speed/output controls of diesel engines

12.7.1 General

12.7.1.1 The governor and the actuator shall be suitable for controlling the engine under the operating conditions laid down in the BKI Rules for Construction and shall be also in line with the requirements specified by the engine manufacturer, see Volume 4 – Rules for Machinery Installations, Section 3, F.

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

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

Faults in the governor system shall cause an alarm.

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

12.7.2 Power supply to the control systems of generator sets

12.7.2.1 Each control system shall be provided with a separate supply from the main source of electrical power with battery back-up for at least 15 minutes.

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

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

The automation battery may be used as a second back-up battery to boost the input voltage.

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

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

12.7.2.6 Batteries shall not be discharged by the control system following an engine shutdown.

12.8 Speed/output controls of gas turbines

The requirements for the speed and output control of gas turbines have to be agreed with BKI.

12.9 Integration of systems for essential equipment

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

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

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

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

D. Computer Systems

1. General

1.1 For mobile self-propelled offshore units the Rules for Electrical Installations, Volume IV, Section 10 apply directly to the propulsion part.

1.2 The requirements defined in the following are valid for the non-propulsion part of mobile offshore units and for fixed offshore installations.

1.3 The safety integrity level of a self related computer system (especially PLC based ESD-Systems) has to be examined based on an international recognised standard, e.g. IEC 61508.

1.4 It has to be proven that the selected computer system fulfils the approval requirements, e.g.:

- a type approval by a recognized organisation
- a listing of measures to fulfil the requirement according to a related standard

1.5 In any case, the documentation necessary to enable BKI to examine the application software of the system has to be submitted for approval.

BKI type approved systems should be used preferably.

1.6 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

1.7 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.

1.8 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.

2. System configuration

2.1 General requirements

2.1.1 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.

2.1.2 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.

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

2.2 Power supply

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

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

2.3 Hardware

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

2.3.2 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.

2.3.3 For integrated systems, it is recommended that sub-systems be electrically isolated from each other.

2.3.4 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.

2.4 Software

2.4.1 The manufacturer shall prove that a systematic procedure is followed during all the phases of software development.

2.4.2 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.

2.4.3 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests shall be retraceable.

2.4.4 The version of the software with the relevant date and release has to be documented and shall be recognizable of the assignment to the particular requirement class.

2.5 Data communication links

2.5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and specified accordingly.

2.5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

2.5.3 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.

2.5.4 When the same data communication link is used for two or more essential functions, this link shall be redundant.

2.5.5 Switching between redundant links shall not disturb data communication or continuous operation of functions.

2.5.6 To ensure that data can be exchanged between various systems, standardised interfaces shall be used.

2.5.7 If approved systems are extended, prove of trouble-free operation of the complete system shall be provided.

2.6 Integration or interaction of systems

2.6.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

2.6.2 A defect in one of the subsystems of the integrated system shall not affect the functions of other subsystems.

2.6.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

2.7 User interface

2.7.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

2.7.2 The status of the computer system shall be recognisable.

2.7.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

2.7.4 For using computer systems, a general comprehensible user guide shall be provided.

2.8 Input devices

2.8.1 The feedback of control commands shall be indicated.

2.8.2 Dedicated function keys should be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognise which of the assigned functions are active.

2.8.3 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices. Measures shall be taken to prevent the execution by a single action only, such as:

- use of a special keyboard lock
- use of two or more keyboards

2.8.4 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

2.8.5 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

2.9 Output devices

2.9.1 The size, colour and density of text, graphic information and alarm signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

2.9.2 Information shall be displayed in a logical priority.

2.9.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

2.10 Graphical user interface

2.10.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

2.10.2 When general purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

2.10.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

3. Testing of computer systems

3.1 For testing of computer systems see also Section 16.

3.2 Evidence, tests and assessments of computer systems have to be carried out in accordance to their importance for the unit/installation.

3.3 By the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

3.4 If other proofs and tests are provided by the manufacturer and are of an equivalent nature, they may be recognized.

3.5 The test schedule of system testing has to be specified and submitted before the hardware and software test will be carried out.

3.6 Modifications after completed tests which have influence on the functionality and/or the safety of the system have to be documented and retested.

3.7 Tests in the manufacturer's work

- function tests
- operating conditions simulation
- fault simulation
- simulation of the application environment

3.8 Tests on board

- complete system tests
- integration tests

E. Emergency Shut-down System

Reference is also made to the requirements for the emergency shut down system in Volume 4, Machinery Installations, Section 17.

1. General design requirements

1.1 The emergency shut down system initiated by the gas/oil production process, drilling process, etc. comprises, in principle, 3 levels of components

- sensors, manual initiators
- a safety related data processing logic (hydraulic, pneumatic or electric)
- actuators (process equipment)

1.2 Where necessary, operating equipment is to be provided in order to limit or prevent the spread of damage or danger in case of fire, aggravated explosion hazard or other hazard situations.

1.3 An emergency shut-down may be designed to function as general or selective shut-down. It may be designed to be tripped manually or automatically.

Both methods of tripping are normally provided in conjunction and fulfil equivalent functions.

1.4 Operating equipment which has to continue in service in hazard situations in order to prevent the danger from spreading shall not be included in a general emergency shut-down system. Wherever necessary, it is to be provided with a separate emergency shut-down system.

1.5 Shut-down systems shall operate on the fail-safe principle wherever possible (e.g. process safety systems). Faults in the safety system shall, however, be indicated.

1.6 Installations requiring emergency remote shut-down include the following:

- drilling system
- processing systems oil/gas production systems
- ventilation systems
- non-essential equipment
- essential electrical equipment
- internal combustion engines for generators
- internal combustion engines for pumps
- battery-powered installations

1.7 Manually operated emergency remote shut-downs (e.g. push buttons) are to be mounted at important operating, control and escape stations, including:

- control station respectively bridge
- safety stations
- drilling plant or processing area
- boat landing stage
- helicopter landing area

1.8 Automatically tripped emergency shut-downs are normally installed as a follow-up to area alarms and early-warning systems such as:

- fire detection system
- gas detection system

Their purpose, after the tripping of the alarm system, is to act in the danger area by disconnecting installations or by the automatic execution of suitable safety measures, as the case may be, in order either to eliminate or at least to limit the danger.

1.9 Systems such as

- emergency shut-down systems
- fire and gas detection systems
- battery-powered lighting of escapes lighting of the helicopter landing deck
- light beacon and associated sonic transmitter
- blow-out preventer control
- telephone connections and loudspeaker systems between important operating, control and safety stations
- general alarm system
- battery-powered emergency radio equipment

should not be disconnected by the tripping of the emergency shut-down.

1.10 The final shut-down configuration has to be agreed with BKI, depending on the safety philosophy, see also Volume 4 – Rules for Machinery Installations, Section 17.

2. Shut-down in case of fire

2.1 Independently of the remote shut-down tripped centrally in accordance with 1.8, power-driven fans for

- accommodation
- service spaces
- store rooms
- control stations
- material spaces, etc.

shall be capable of being disconnected by sections from outside the ventilated areas concerned. The closing mechanisms of the corresponding air intakes and outlets shall be actuated simultaneously, unless these openings are exclusively for manual closure.

2.2 A separate remote shut-down from outside the spaces in which they are mounted is to be provided for the power drives of

- fuel pumps
- fuel separators
- lubricating oil separators
- oil/gas fired equipment
- auxiliary blowers for main engines
- thermal oil pumps

and similar operating equipment.

3. Shut-down in case of explosion hazard

3.1 Where installations with areas subject to an explosion hazard are placed on the unit/installation, an examination shall be carried out to determine whether, as a result of an operating fault, the danger of explosion can spread into the safe areas.

3.2 Further requirements are defined in Section 13, D.

4. Special aspects for automatic shut-down systems

4.1 If the installation of a start-up by-pass is required by process conditions, this has to be clearly indicated at the main control station.

4.2 Shut-down actions as a result of a cascade effect are not acceptable. A direct trip signal has to be provided.

4.3 Shut-down systems are safety related systems in any case and shall be independent from all other systems.

One way links to other systems, e.g. to the process control system, are acceptable for status transfer, if the integrity of the shut-down system is maintained.

4.4 If overrides for input as well as output signals are provided, the solution has to be discussed with BKI in detail.

4.5 For electrical systems an uninterruptible power supply has to be provided for the whole shut-down time, as a minimum for ½ hour.

4.6 The complete emergency shut-down (ESD) chain has to be designed fail-safe. If the data processing logic is a PLC (Programmable Logic Controller) based system, the requirements stated in D. have to be considered.

Section 10

Lighting and Socket Outlets

A. Lighting Equipment

1. General requirements

1.1 The provisions contained in the other Sections of this Volume also apply generally to the lighting equipment. Particular attention is to be given to the following items.

1.2 For lighting in spaces with explosion hazard, see Section 13.

1.3 For minimum degrees of protection against touching and water, see Section 1, K.

1.4 For permissible voltages, see Section 1, H. and F.1.

2. Construction and extent of the lighting system

2.1 Main lighting

2.1.1 There shall be a main lighting system supplied by the main source of electrical power and illuminating all areas normally accessible to and used by personnel.

2.1.2 The arrangement of the main lighting system shall be such that a fire or other casualty in the space or spaces containing the main source of power, including transformers or converters, if any, will not render the emergency lighting system required by 2.2 inoperative.

2.2 Emergency lighting

2.2.1 An emergency lighting system is to be installed, the extent of which shall conform to Section 3, D.2.

2.2.2 The arrangement of the emergency lighting system shall be such that a fire or other casualty in the space or spaces containing the emergency source of power, including transformers or converters, if any, will not render the main lighting system required by 2.1 inoperative.

2.2.3 The emergency lighting system shall be switched on automatically in case of a failure of the main source of electrical power. Local switches are to be provided only where it may be necessary to switch off the emergency lighting.

2.2.4 Emergency lights shall be marked for easy identification.

2.3 Additional emergency lighting, if applicable

2.3.1 Additional emergency lighting may be provided on request of the operator in addition to the emergency lighting according to 2.2. The task of the additional emergency lighting is to provide so much additional lighting that the Operator will be able to start the operation of the unit/installation from "dead ship" condition.

2.3.2 The volume of the additional emergency lighting may be in the range of 30 % of the main lighting according to 2.1.

2.3.3 The additional emergency lighting, if installed, may be used as emergency lighting as per 2.2.

2.4 Transitional emergency lighting

2.4.1 Transitional emergency lighting is understood as the emergency lighting according to 2.2 supplied by the transitional source of emergency power according to Section 3, D.2.2.3.

2.4.2 Where the emergency source of power is a generator not fitted with an automatic starting device and an automatic connection to the emergency switchboard, a transitional source of emergency power is to be installed.

2.4.3 Normally the transitional emergency lighting will be based on an accumulator battery with a capacity for half an hour of illumination.

2.5 Lighting in hazardous areas

2.5.1 Lighting systems in hazardous areas as defined in Volume 4 - Rules for Machinery Installations Section 2 have to be provided with electrical equipment according to Section 13.

2.5.2 Emergency and transitional emergency lighting in non-hazardous areas, but where the danger of explosion can spread into these areas, have to be suitable for a zone 2 location. For installations in enclosed spaces see also Section 9, E.3. Protection classes and performance are defined in Section 13.

2.6 Low level escape direction system

In case of fire, escape routes in living areas have to be visible even in event of thick smoke. A low level

lighting system or self reflecting escape route signs approximately 0,3 m above ground are deemed to be sufficient.

2.7 Main fire zones

Where, in accordance with the Rules, an installation or unit is divided into main fire zones, at least two circuits shall be provided for the lighting of each main fire zone, and each of these shall have its own power supply line. The supply lines shall be routed in such a way, that a fire in one main fire zone does not, if possible, interfere with the lighting of the other zones.

2.8 Machinery and service spaces

Lights in machinery and service spaces, stores, galleys and service passageways shall be provided with unbreakable covers or with additional mechanical protection if that afforded by their positioning is inadequate.

3. Siting of lights

3.1 On self-propelled mobile units, lights on open decks which are to be in use while the unit is travelling are to be located in such a way that they do not interfere with navigation.

3.2 High-intensity lights with housings experiencing a temperature rise of more than 55 K in service are not to be sited within arm's reach.

3.3 The use of low-pressure sodium lamps is not permitted in areas with an explosion hazard.

3.4 For light fittings or switches in bathrooms and shower rooms see C.

3.5 Where lights are fitted in corridors, the clear headroom should be at least 1,80 m.

4. Design of light fittings

See Section 15, I.

5. Power supply to lighting systems

5.1 Lighting systems are to be supplied from the main switchboard, emergency lighting from the emergency switchboard.

5.2 Final circuits

The maximum permissible fused current of final lighting circuits is 16 A.

5.3 Switches shall act simultaneously on all the non-earthed conductors of a circuit. The single-pole disconnection of final lighting circuits in systems insulated on all poles is permitted only in the accommodation area.

5.4 Wherever possible, socket outlets are to be connected to separate circuits.

5.5 In the important rooms listed below the lighting shall be supplied by at least two separate fused circuits:

Machinery and other important service spaces, safety stations and control rooms.

- galleys
- passageways and other escapes
- stairs and passageways leading to the lifeboats
- messes and day rooms for the personnel
- drilling floor
- helicopter landing area

Where an emergency generator set is installed, it is recommended that one of the circuits should be supplied from the emergency switchboard. However, it is not permitted to supply all the lighting circuits exclusively from the emergency switchboard.

The light fittings are to be so arranged that adequate illumination is maintained should any circuit fail.

B. Socket-Outlets

1. General

1.1 The supply for socket-outlets in the accommodation, day rooms and service rooms (250 V) are to be run from lighting distribution panels. The maximum fuse rating for a circuit is 16 A.

1.2 For sockets of distribution systems with different voltages and / or frequencies, non-interchangeable plugs and socket outlets shall be used.

1.3 Plug-in connections shall not be installed below the floor in engine rooms or boiler rooms or in enclosed fuel oil and lubricating oil separator rooms.

1.4 Socket outlets for power circuits over 16 A AC or 10 A DC shall be interlocked in such a way that the plug can be neither inserted nor withdrawn when the socket contacts are live.

Socket outlet for power circuits shall be supplied individually from distribution panels, shall be fused individually and shall be individually disconnectable.

1.5 Where sockets are mounted in different distribution systems with differing voltages and/or frequencies, non-interchangeable sockets and plugs are to be used to ensure that a consumer cannot be connected to a socket of another system.

2. Holds

Sockets in holds shall be installed only in locations with sufficient protection against mechanical damage.

3. Container connections

Several socket outlets may be grouped together for common supply via one power cable, provided that the individual connections are protected at site against overcurrent and short circuit, and the supply cable is rated for the total power demand. For details, see Section 11, C.

C. Electrical installations in shower rooms and bathing rooms

1. In locations containing a bath or shower the electrical equipment shall be installed in accordance with IEC publication 60364-7-701.

2. The minimum degree of protection against foreign bodies and water shall be appropriate to Table 10.1.

Table 10.1 Minimum degree of protection against foreign bodies and water

Zone	Degree of protection of the installed electrical equipment
0	IP x7
1	IP 55
2	IP 34

D. Navigation Lights

For navigation lights of units in transfer respectively during self-propelled travel see Section 12, K.

E. Marking of the Unit or Installation fixed on Site**1. General**

Offshore units and installations fixed at the operation site are to be equipped with nautical facilities con-

forming to the IALA Recommendations for the Marking of Offshore Structures and the requirements for safety of navigation of the coastal state in whose waters the site is located. These include signal lights and sound signalling devices for fog.

2. Signal lights and sound signalling devices for fog which transmit a coded signal for the identification of the offshore structure are to be provided with their own emergency battery. The capacity of this battery, assuming simultaneous operation of all consumers, is to be rated to provide a supply for at least 4 days, unless some other period is specified by national regulations.

3. The coding and range of the visual and sound signalling equipment are governed by the national regulations relating to the site.

4. The switchboard for the signalling equipment is to be sited in a permanently manned room, e.g. the control station.

5. Each signalling device is to be supplied from the switchboard by its own feeder which is to be protected by a fuse or automatic circuit breaker.

6. The failure of a signalling device is to be indicated visually and audibly.

7. The switchboard is to be supplied from the emergency switchboard and the emergency battery mentioned in Section 3, D.2.

In the event of a mains failure, the supply shall switch automatically to the emergency battery.

8. A charger is to be assigned exclusively to meet the needs of the battery. Failure of the charger and switch-over to the battery shall be indicated at the switchboard.

9. Where the signalling devices are switched on and off automatically, e.g. by photo-electric switches and visibility meters, the switchboard is to be provided with a manual/automatic selector switch. The operating mode at any time shall be indicated.

F. Helicopter Landing Area

See Section 14, B.

Section 11

Cable Network

A. Choice of Cables and Wires

1. General provisions

Cables and wires shall generally conform to the provisions of Section 15.

2. Rated voltage

The rated voltage of cables shall be not less than the rated operating voltage of the relevant circuit.

In insulated distribution systems, the voltage between two phases shall be deemed to be the rated voltage of the cable between a conductor and the hull/structure.

3. Temperatures

At places where higher ambient temperatures are expected, only those cables shall be used whose permissible temperature is at least 10 K above the maximum anticipated ambient temperature.

A correction factor shall be applied to the permissible current rating in accordance with Table 11.1.

Cables on locations, where there is danger of excessive heating or even jet fire, shall be so routed that they are protected against inadmissible external heating stress, or cables are to be used which are approved for the maximum arising ambient temperature.

4. Ambient conditions

In accordance with the characteristics specified in Section 15, only those cables may be used whose sheaths are resistant to the ambient conditions at the work site.

5. Mechanical protection

The selection of the cables shall take account of the mechanical loads at the work site concerned (see also D. Installation).

6. Movable connections

6.1 Machines or equipment mounted on (rubber or spring) vibration absorbers are to be connected via cables or wires with sufficient flexibility and compensation loops.

6.2 Mobile equipment shall, in every case, be supplied via flexible cables, e.g. of type HO 7 RN-F, CENELEC HD 22 or equivalent.

For rated voltages above 50 V, the movable connecting cables or wires for equipment without double insulation shall also include an earthing conductor.

The earth conductor shall have continuous green/yellow coloured marking.

6.3 For mobile parts of installations supplied via scissor-type cable supports, suspended loops, festoon systems, etc., the use of suitable, flexible cables is required.

7. Application of cables and wires

Cables and wires shall be used according to the application defined in Table 11.2.

Table 11.1 Corrective factors for rating capacity of conductor cross-sectional areas

Permissible operating temperature		Ambient temperature [°C]										
		35	40	45	50	55	60	65	70	75	80	85
[°C]	Table	Correction factor										
60	11.6	1,29	1,15	1,0	0,82	-	-	-	-	-	-	-
75	11.6	1,15	1,08	1,0	0,91	0,82	0,71	0,58	-	-	-	-
80	11.7	1,13	1,07	1,0	0,93	0,85	0,76	0,65	0,53	-	-	-
85	11.7, 11.8	1,12	1,06	1,0	0,94	0,87	0,79	0,71	0,61	0,50	-	-
90	11.9	1,10	1,05	1,0	0,94	0,88	0,82	0,74	0,67	0,58	0,47	
95	11.9	1,10	1,05	1,0	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 11.2 Application for power, control and communication cables

Application	Recommendation
Within the installation/unit in all areas and on open deck	Cables with shielding and outer sheath
Within the installation/unit in all areas, except where EMC requirements exist and not in hazardous areas	Cables without shielding
Only in crew accommodation / day rooms, for final supply circuits of lighting, sockets and space heating	Cables without shielding, with single wire (solid) conductors up to 4 mm ²
At diesel engines, turbines, boilers and other devices with higher temperatures	Heat-resistance cables (wires)
Other application areas, not specified above	See type test Certificate

B. Determination of Conductor Cross Sections

1. Rating method on the basis of maximum current-carrying capacity

Conductor cross-sections are to be determined on the basis of load with due regard for C.1. - C.3.

The calculated current shall be equal to, or smaller than, the permissible current for the chosen conductor cross-section.

The permissible current-carrying capacities of cables listed in Tables 11.6 and 11.7 apply to an ambient temperature of 45 °C and to the stated permissible operating temperature of the cables or wires.

1.1 The current-carrying capacities listed in Tables 11.6 and 11.7 apply to flat cable configurations containing not more than 6 cables laid side by side, or to groupings of not more than 3 cables or insulated wires, as follows:

Flat arrangement:



Groupings with not more than 3 cables:



The triple groups shall be laid in each direction with a spacing corresponding to at least one outer diameter of the largest cable or largest insulated wire.

1.2 If the specified configurations cannot be adhered to, or the passage of cooling air is not assured, the current-carrying capacity shall be reduced to 85 % of the values given in the tables, and the overcurrent protection shall be modified accordingly.

Exceptions are made for bundles of cables and insulated wires which are not part of the same circuit

and/or which will not be loaded with their rated currents simultaneously.

1.3 For the laying of single-core cables and wires in single-phase and three-phase alternating current systems, see D.7.

1.4 Cables whose maximum permissible conductor temperatures differ from each other by more than 5 K, may be bundled together only, if the permissible current-carrying capacity of the lowest-capacity type is taken as the rating-basis for all cables.

1.5 Parallel cables are permitted only with conductor cross-sections of 10 mm² (AWG 7) and over.

Only cables of the same length and having the same conductor cross-section may be installed as parallel cables. Equal current-distribution shall be ensured.

Parallel cables may be loaded to the sum of their individual current-carrying capacities, and shall be common fused.

2. Rating on the basis of voltage drop

2.1 Under normal service conditions, the voltage drop between the busbars (main/emergency switchboard) and the consumers shall not exceed 6 %, or 10 % in the case of battery-supplied networks of 50 V or less. Navigation lights are subject to the requirements of Section 12, K.

2.2 Where short-term peak loads are possible, for instance due to starting processes, it is to ensure that the voltage drop in the cable does not cause malfunctions.

Table 11.3 Minimum cross-sectional areas

	Nominal cross section			
	External wiring		Internal wiring	
	International	AWG ¹	International	AWG
Power, heating and lighting systems	1,0 mm ²	17	1,0 mm ²	17
Control circuits for power plants	1,0 mm ²	17	1,0 mm ²	17
Control circuits in general, safety system in accordance with Section 9	0,75 mm ²	18	0,5 mm ²	20
Telecommunications equipment in general, automation equipment	0,5 mm ²	20	0,1 mm ²	28
Telephone and bell equipment, not required for the safety of the installation/unit or crew call installations	0,2 mm ²	24	0,1 mm ²	28
Data bus and data cables	0,2 mm ²	24	0,1 mm ²	28

¹ AWG = American wire gauge

Table 11.4 Rating of telecommunication and control cables

Number of core pairs (2 cores each)	Number of cores	Nominal cross section 0,5 mm ² (AWG 20)		Nominal cross section 0,75 mm ² (AWG 18)	
		Permissible load	Rated fuse current	Permissible load	Rated fuse current
		A max.	A	A max.	A
1 × 2	2	–	–	10,5	10
2 × 2	4	5	6	7,5	6
4 × 2	8	4	4	6	6
7 × 2	14	3,5	4	4,5	4
10 × 2	20	3	4	4	4
14 × 2	28	3	2	3,5	4
19 × 2	38	3	2	3,5	4
24 × 2	48	2	2	3	2
48 × 2	96	2	2	–	–

The values in the Table relate to an ambient temperature of 45 °C and a conductor temperature of 85 °C

3. Consideration of current peaks

The cross-section shall be so chosen that the conductor temperatures do not exceed the maximum limits specified below neither under short circuit nor start-up conditions:

for PVC	(60 °C) 150 °C, or
for PVC	(75 °C) 150 °C
for EPR	(85 °C) 200 °C
(EPM or EPDM)	
for XLPE (VPE)	(85 °C) 250 °C
for silicone	(95 °C) according to specification

The figures in brackets are the permissible operating temperatures at the conductor in continuous operation.

4. Minimum cross-sectional areas and their current-carrying capacity

4.1 The conductor cross-sections indicated in Table 11.3 are the minimum cross-sections for external cabling respective for internal wiring, e.g. of switchgear and consoles.

4.2 The maximum current-carrying capacity of conductor cross-sections for external cabling is indi-

cated in Tables 11.6 and 11.7. For cables and wires in telecommunications systems the values listed in Table 11.4 are to be applied.

A maximum permissible current of 1,0 A is applicable to the 0,2 mm² (AWG 24) conductor cross-section regardless of the number of cores.

4.3 In accommodation and day rooms, flexible cables with a conductor cross-section of not less than 0,75 mm² (AWG 18) may also be used for the connection of movable equipment with a current consumption of up to 6 A.

4.4 For hull / main structure return, see Section 1, G.3. and Section 4, H.1.2.

4.5 For earthing conductors, see Section 1, K.

4.6 Neutral conductors in three-phase distribution systems shall be in cross-section equal to at least half the cross-section of the outer conductors. If the outer conductor cross-section is 16 mm² (AWG 5) or less, the cross-section of the neutral conductor shall be the same as that of the outer conductors.

4.7 Exciter equalizer cables for three-phase generators in parallel operation shall be rated for half the nominal exciter current of the largest generator.

C. Current-carrying Capacity, Protection and Installation of Circuits

1. Individual consumers and current-carrying capacity of final subcircuits

1.1 Cables shall be rated according to the expected operating load based on the connected load and mode of operation of the consumers. The values given on the consumer's name plate are valid.

1.2 In calculating the expected load for 250 V AC lighting circuits and socket outlet circuits, the current corresponding to a 60 W lamp is to be counted for each lamp socket and 120 W for each socket outlet.

2. Consideration of the diversity factor to be applied to group supply cables

2.1 If the connected consumers in a part of the system are not in operation simultaneously, a diversity factor may be used for determining the cross section of the group supply cable.

A diversity factor is the ratio of the highest operating load expected under normal operating conditions to the sum of rated loads of all connected consumers.

2.2 The load determined by the application of a diversity factor shall be deemed to be the continuous load for the determination of the cross-section.

2.3 The diversity factors shown in Table 11.5 may be applied to the rating of cables used to supply groups of winches.

The values given in the Table 11.5 shall be related to the rated motor current, or, in the case of motors with several different outputs, to the current corresponding to the highest output.

2.4 Group supply feeders for hydraulic winches shall be rated for the installed power without the application of a diversity factor.

2.5 The cross-section of group supply feeders for cranes shall be determined in the same way as for cargo winches.

2.6 For cranes with one drive motor, the supply cable shall be rated according to the current rating of the maximum load capacity.

2.7 Where cranes have more than one motor, the feeder cable to an individual crane can be rated as follows:

The value of the current used for cross-section determination shall be equal to 100 % of the output of the lifting motors plus 50 % of the output of all the other motors. With this calculated current the cross-section of the cable shall be selected for continuous operation.

2.8 If current diagrams for the various operating conditions of cranes or groups of winches have been ascertained, the average current based on the diagram may be used instead of application of a diversity factor.

3. Cables overload protection

3.1 Cables shall be protected against short circuit and overcurrent.

3.2 Rating and setting of the protection devices shall be in compliance with the requirements in Section 4.

3.3 Cables protected against overcurrent at the consumers side require only short-circuit protection at the supply side.

3.4 Exciter cables for DC motors and DC generators operating in parallel shall not be fused.

Exciter cables for individually connected DC generators and synchronous three-phase alternators shall be fused only if there are special reasons for it, e.g. where the cables are passing through various compartments of the installation/unit.

Table 11.5 Diversity factor during operation with winches

Number of winches	The following values shall be used for determining the cable cross-section	
	Winches with DC motors	Winches with induction motors
2	100 % of the largest motor + 30 % of the second motor, or, with identical motor, 65 % of their combined full current	100 % of the largest motor + 50 % of the second motor, or, with identical motor, 75 % of their combined full current
3	100 % of the largest motor + 25 % of the remaining motors, or, with identical motors 50 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 67 % of their combined full current
4	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors 40 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 62 % of their combined full current
5	100 % of the largest motor + 20 % of the remaining motors, or, with identical motors 36 % of their combined full current	100 % of the largest motor + 50 % of the remaining motors, or, with identical motors 60 % of their combined full current
6 or more	33 % of the combined full load current	58 % of the combined full load current

4. Separation of circuits

4.1 A separate cable is normally to be provided for each circuit having its own over-current and short circuit protection. Deviating from this requirement the following functions may be combined in one cable:

- a main circuit and its control circuits which branch off behind the main circuit protection and can be disconnected by a common switch
- various control circuits all laid separately from the main circuits
- various main circuits and their control circuits belonging to a common system, e.g. for several drives of an air-conditioning system, if all the cores of the cable can be centrally disconnected from the supply

4.2 Separate cables shall be provided for safety (extra-low) voltage circuits.

4.3 Separate cables shall be provided for intrinsically safe circuits. For cables in areas with explosion hazard, see Section 13, F.

5. Cable laying for circuits

5.1 For single-phase and three-phase AC systems, multi-core cables are to be used wherever possible.

5.2 Should it be necessary to lay single-core cables for the carriage of more than 10 A in single-phase or three-phase AC circuits, the special requirements of D.7. shall be fulfilled.

5.3 Main structure / hull return

Main structure / hull return is allowed only exceptionally compare Section 1, G.3. If allowed, the following requirements have to be applied:

5.3.1 In three-phase systems without hull / main structure return, three-core cables shall be used for three-phase connections; four-core cables are required for circuits with loaded neutral point.

5.3.2 In three-phase systems with hull/main structure return the asymmetry of the currents in the three conductors of three-core cables shall not exceed 20 A (see Section 4, H.).

5.3.3 In DC systems without hull/main structure return multi-core cables shall be provided in all cases of smaller cross-sections.

Where single-core cables are used for large cross-sections, the outgoing and return cables shall be laid as close as possible to each other over their entire length to avoid magnetic stray fields.

5.4 The generator cables, all cables run from the main or emergency switchboard or an auxiliary switchboard, and all interconnecting cables for essential equipment, shall be laid as far as possible uninterrupted in length to the distribution panels or to the equipment.

5.5 The cables of intrinsically safe circuits shall be laid at a distance of at least 50 mm separated from the cables of non-intrinsically safe circuits. The laying of intrinsically safe circuits together with non-intrinsically safe circuits in a pipe is not permitted.

Cables of intrinsically safe circuits shall be marked, preferably with light blue colour.

D. Installation

1. Routing of cables

1.1 The routing of cables shall be such that cables are laid as straight as possible and are not exposed to mechanical damage.

1.2 For bends, the minimum bending radius permitted by the manufacturer shall be observed. The radius shall be not smaller than 6 times of the outer diameters of the cables.

1.3 Heat sources such as boilers, hot pipes, etc. shall be by-passed so that the cables are not subjected to additional heating. If this is not possible, the cables are to be shielded from thermal radiation.

1.4 The tensile stress of the cables at long cable runs caused by thermal expansion and/or movement of the structure shall not damage the cables, cable runs or cable penetration systems.

At long and straight cable runs like in passage ways or void spaces, etc. or at positions where unacceptable tensile stresses are liable to occur at the cables and cable trays, precautions shall be taken to distribute the expansion movement uniformly over a cable loop provided for such purpose, so that there is no damaging of the cables, cable runs or cable penetration systems.

The diameter of the cable loop shall be at least 12 times the diameter of the thickest cable. In each division should be provided at least one cable loop.

1.5 Cables shall not to be installed within room isolations.

Exceptions are permitted for lighting, socket outlets and control circuits in accommodation and refrigeration rooms, provided that the maximum loading of the cables does not exceed 70 % of their current-carrying capacity.

1.6 Where, for safety reasons, a system has duplicated supply and/or control cables, the cable routes are to be placed as far apart as possible.

1.7 Supply cables for emergency consumers shall not be run through fire zones containing the main source of electrical power and associated facilities. Exceptions are made for cables supplying emergency consumers located within such areas.

1.8 The electrical cables to the emergency fire pump shall not pass through the machinery spaces containing the main fire pumps and their sources of power and prime movers. They shall be of a fire resistant type, in accordance with IEC 60331.

1.9 Cables for supply of essential equipment and emergency consumers, e.g. lighting and important

communications and signalling systems shall, wherever possible, by-pass galleys, laundries, category A engine rooms and their casings and areas with a high fire risk.

On installations/units whose construction or small size precludes fulfilment of these requirements, measures shall be taken to ensure the effective protection of these cables where they have to be run through the rooms mentioned above, e.g. by the use of fire-resistant cables or by flame-retardant coating, such an installation has to be approved by BKI.

1.10 Cables for high voltage installations shall be run at a distance of at least 50 mm from low-voltage cables.

2. Fastening of cables and wires

2.1 Cable trays and cableways shall be made preferably of metallic materials which are protected against corrosion.

Cables and wires shall be fastened with corrosion-resistant, flameproof clips or bindings. Exceptions are made for cables which are laid in pipes or cable ducts.

Cables and wiring shall be installed and supported in such a manner as to avoid chafing or other damage.

This also applies for the installation of cables and wires in connection boxes of electrical equipment and switchboards.

2.2 Suitable materials shall be placed together when cables are fastened to aluminium walls.

Clips for mineral-insulated cables with copper sheaths have to be made of copper alloy if they are in electrical contact with the latter.

2.3 Single-core cables are to be fastened in such a manner that they are able to withstand the electrodynamic forces occurring in the event of short circuits.

2.4 The distances between the supports for cable racks and the fastenings used shall be selected with due regard to the cable type, cross-section and number of cables concerned.

2.5 Where cables suspended are fastened by the use of plastic clips or straps, metallic cable fixing devices, spaced not more than 2 m apart shall be used additionally in the following areas:

- generally in escape routes and emergency exits, on the open deck, in refrigeration rooms and in boiler rooms
- machinery rooms, control rooms and service rooms, where bunched cables are fastened on riser cable trays or under the cable trays

2.6 Cable trays made from plastics shall be tightened in such a way that they do not obstruct together with the cables the escape routes in case of fire, see 6.2.

The suitability of cable trays shall be proved. Such cable trays are subject to BKI approval. For installation, see also 2.5.

2.7 It is recommended, that cables and cable bunches shall not be painted.

If they still would be painted the following shall be observed:

- the paint shall be compatible with the material of the cables, and
- the flame-retardant property respectively fire resistance of the cables and cable bunches shall be maintained

3. Stress relief

Cables shall be so installed that any tensile stresses which may occur remain within the permitted limits. This shall be particularly observed for cables on vertical runs or in vertical conduits.

4. Protection against mechanical damage

4.1 Cables in storage holds, on open decks and at positions where they are exposed to a particularly high risk of mechanical damage shall be protected by pipes, covers or closed cable ducts.

4.2 Cables passing through decks shall be protected against damage by pipe sockets or casings extending to a height of about 200 mm over deck.

5. Installation of cables and wires in metallic pipes, conduits or closed metal ducts

5.1 If cables are installed in pipes or ducts, attention shall be paid that the heat from the cables can be dissipated into the environment.

5.2 The inside of the pipes or ducts shall be smooth, and their ends shaped in such a way as to avoid damage to the cable sheath.

They shall be effectively protected inside against corrosion. The accumulation of condensation water shall be avoided.

5.3 The clear width and any bends shall be such that the cables can be drawn through without difficulty. The bending radius of the pipe shall be equivalent to at least 9 times of the outer cable diameter.

5.4 Where pipes or ducts passing through areas where panting is expected, suitable means of compensation shall be provided.

5.5 Not more than 40 % of the clear cross-section of pipes and ducts shall be filled with cables. The total cross-section of the cables is deemed to be

the sum of their individual cross-sections based on their outside diameters.

5.6 Pipes and ducts shall be earthed.

5.7 Cables with plastic outer sheaths shall be used in pipes.

5.8 Long cable ducts and pipes shall be provided with a sufficient number of inspection and pull boxes.

6. Installation in non-metallic pipes and ducts

6.1 Non-metallic pipes or cable ducts shall be made of flame-retardant material.

6.2 Cable trays / protective casings made of plastic materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note

When plastic cable trays / protective casings are used on open deck, they are additionally to be protected against UV light.

7. Laying of single-core cables and wires in single-phase and three-phase AC systems

In cases where use of multi-core cables is not possible, single-core cables and wires may be permitted for installation, if the following provisions are made and the requirements of IEC publication 60092-352 are observed:

7.1 The cables shall not be armoured or shrouded with magnetic material.

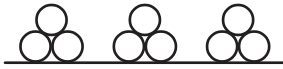
7.2 All conductors belonging to one circuit shall be run together in the same pipe or duct, or clamped by common clamps, unless the clamps are made of non-magnetic materials.

7.3 The cables forming a circuit shall be laid immediately beside of each other and preferably in triangular configuration. If spacing cannot be avoided, the spacing shall not exceed one cable diameter.



7.4 No magnetic material shall be placed between single-core cables passing through steel walls. No magnetic materials shall be between the cables of deck and bulkhead penetrations. Care shall be taken to ensure that the distance between the cables and the steel wall is at least 75 mm, unless the cables belonging to the same AC circuit are installed in trefoil formation, see 7.3.

For the installation of single-core parallel cables between the cable groups these measures are not necessary, if the cable groups are arranged in trefoil formation.



7.5 Single-core parallel cables shall be of the same length and cross-section. Furthermore, to avoid unequal division of the current, the cables of one phase are to be laid, as far as is practicable, alternatively with the cables of the other phases, e.g. in the case of two cables for each phase:

L1, L2, L3, L3, L2, L1 or L1, L2, L3
L3, L2, L1

or L3, L1, L2 or L2, L3, L1
L2, L1, L3 L1, L3, L2

7.6 To balance the impedance of the circuit in single-core cables more than 30 m long and with a cable cross-section of more than 150 mm², the phases are to be alternated at intervals of not more than 15 m.

7.7 For single-core cables, metallic sheaths are to be insulated from each other and from the structure over their entire length. They shall be earthed at one end only, except earthing is required at both ends for technical reasons (e.g. for high voltage cables). In such cases the cables shall be laid over their entire length in triangular configuration.

8. Bulkhead and deck penetrations

8.1 Cable penetrations shall conform to the partition categories laid down by SOLAS, and shall not impair the mechanical strength or watertightness of the bulkhead.

8.2 For testing of bulkhead and deck penetrations reference is made to the Fire Test Procedure (FTP) Code according to IMO resolution MSC.61(67).

8.3 The cables shall not occupy more than 40 % of the cross-section of a penetration.

8.4 Vertical cable ducts shall be so constructed that a fire on one deck cannot spread through the duct to the next higher or lower deck (see also 14.2.2).

9. Cables in the vicinity of radio-communication and navigation equipment

9.1 Except where laid in metallic pipes or ducts, cables and wires with metal sheaths or metal braiding are to be used above the uppermost metallic deck and in positions where the cables and wires are not separated by metallic bulkheads or decks from aerials, aerial downleads, the radio room, direction finder or

other radio navigation or receiving equipment. The metallic sheaths and shields are to be earthed.

9.2 Only cables required in the radio room shall be laid there. If cables without a braid shielding have to be run through a radio room, they shall be installed in a continuous metallic pipe or duct which is earthed at the entrance to and exit from the room.

9.3 Single-core cables are not permitted in the radio room.

9.4 If the radio equipment is installed on the bridge, the requirements stated above are to be complied with as and where applicable.

10. Magnetic compass zone for mobile offshore units

On mobile offshore units all electrical cables, wires, machines and apparatuses shall be laid, installed or magnetically shielded in order to avoid inadmissible interference (deviation < 0,5 degree) with the magnetic compass.

11. Cable installation in refrigeration spaces

11.1 Only cables with outer sheaths, resistant to corrosion and to low temperatures shall be laid in refrigeration rooms.

11.2 Where cables are led through the thermal insulation, 1.5 shall be observed.

11.3 Only cables without hull / main structure return are permitted in refrigerated rooms and in the associated air cooler spaces. The earthing conductors shall be run together with the other cables from the relevant distribution panel.

12. Earthing of braided screens of cable network and accessories

12.1 Metallic cable sheaths, armouring and shields in power installations shall be electrically connected at each end to the installation's/unit's main structure; single-core cables shall be earthed at one end only. For cables and wires for electrical equipment, the manufacturer's recommendation shall be observed, earthing at one end only is recommended. This applies also to intrinsically safe circuits.

12.2 Electrical continuity of all metallic cable covers shall also be maintained inside cable junction and terminal boxes.

12.3 Metallic cable sheaths, armouring and shields shall be earthed, preferably using standardized cable gland fittings designed for that purpose or suitable equivalent clips or earth clamps.

12.4 If the cable armouring is used as earthing conductor the cross-section has to be equivalent to that of a separate earthing conductor.

13. Cable joints and branches

13.1 Cables may be extended only with special approval of BKI. The used material has to be approved by BKI and shall maintain the flame-retardant - and where required - the fire-resistant properties of the cables. (Compare also Section 16, E.2.)

13.2 Junction and distribution boxes shall be accessible and marked for identification.

13.3 Cables for safety low voltage shall not pass a junction or distribution box together with cables for higher voltage systems.

13.4 Terminals for systems of different types of systems, especially such of differently operating voltages, shall be separated.

14. Measures to limit the propagation of fire along cable and wire bundles

14.1 All cables shall be installed so that the original flame-retardant properties of the individual cables are not impaired. This requirement can be considered to be fulfilled if:

- the bundled cable types are individually flame-retardant and have successfully passed bundle fire test in accordance with IEC publication 60332-3, category A/F
- suitable measures have been taken during installation, e.g. the providing of fire stops or the application of flame-proof coatings

14.2 Fire stops

For cable bundles consisting of cables which have not been subjected to a bundle fire test, the following precautions shall be taken to limit the fire propagation:

14.2.1 Fire stops shall be provided:

- at main and emergency switchboards
- at cable entrances into engine control rooms
- at central control panels and consoles for important equipment including the main propulsion plant (at units) and for important auxiliaries

14.2.2 In closed and semi-enclosed rooms, fire stops shall be provided at the following locations:

- at each entry and exit point of cable runs in enclosed metallic installation shafts
- for open vertical cable runs, at least for every second deck, limited to a maximum spacing of 6 m
- every 14 m for open horizontal cable runs

14.3 Exceptions

The fire stops specified in item 1 and item 3 of 14.2.1 can be omitted if the switchboards or consoles are

installed in separate rooms and measures have already been taken at the points of entrance to these rooms. Fire stops shall be provided only for the boundaries of these rooms.

14.4 Version of fire stops

The flame propagation of cables passing through fire stops shall fulfil the **SOLAS** requirements for B-0 partitions.

Fire stops may, for example, be formed by existing partitions or by a steel plate (min. 3 mm in thickness) together with a B-0 penetration.

The steel plate shall be so formed that it extends around the cables as specified below:

- twice the maximum dimension of the cable run with vertically laid cables
- the maximum dimension of the cable run with horizontally laid cables

The steel plates, however, need not to be extended through upper covers, decks, bulkheads or trunk walls.

14.5 Application of flame-proof coatings

Instead of the fire stops specified in 14.4, installed cable bundles may be provided with (BKI type-approved) flameproof coatings as follows:

- for horizontal cable runs for every 14 metres, a length of 1 m
- on vertical cable runs over the entire length

Other distances for the coatings may be approved after special testing.

14.6 Alternative methods

Other methods which have been proved to be equivalent to the measures stated in 14.4 and 14.5 may be accepted.

14.7 Explanatory sketches

Explanatory notes to the installation provisions described above are given in Figs. 11.1 – 11.4.

15. Application of fire-resistant cables

15.1 Scope of installations

15.1.1 Cables for services required to be operable under fire conditions including those for their power supplies are to be of a fire resistant type, complying with Section 15, F.1. where they pass through high fire risk areas, fire zones or decks, other than those which they serve.

15.1.2 Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted provided their functionality can be maintained.

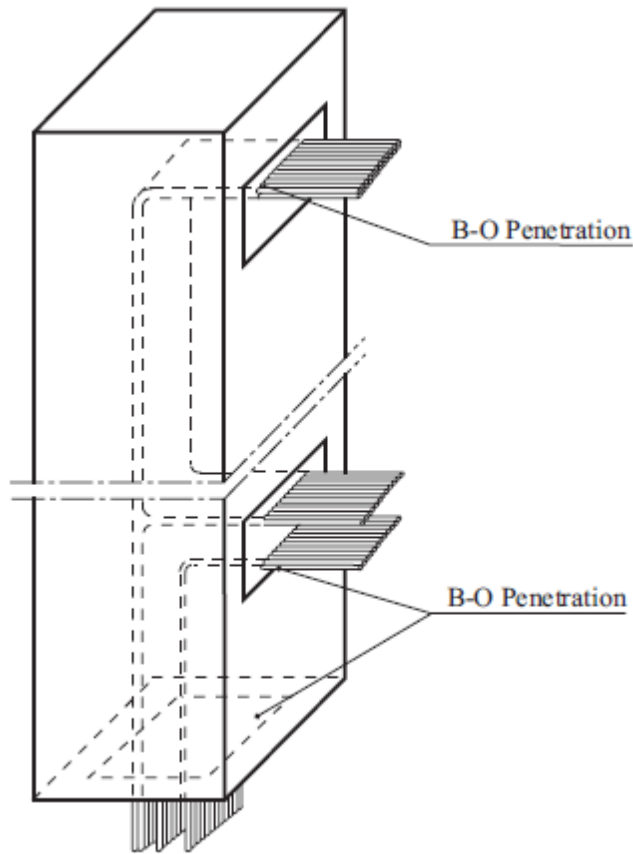


Fig. 11.1 Fire stops, all plates at least 3 mm thick

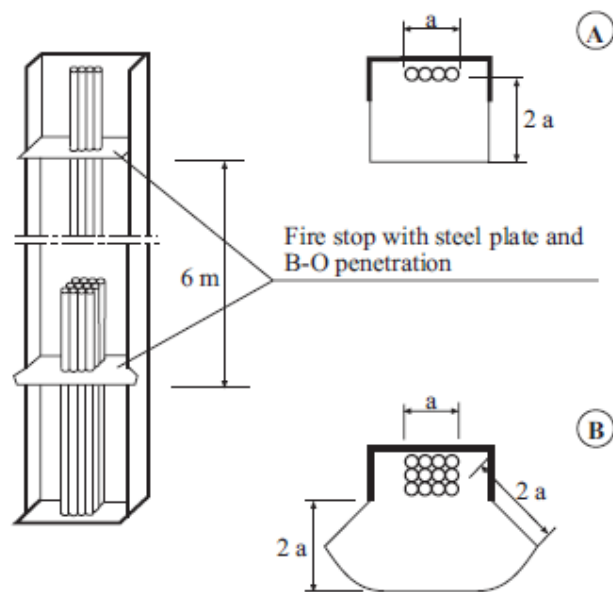


Fig. 11.2 Partly-enclosed ducts - vertical

Notes

- *In case of cables for services required to be operable under fire conditions the fire resistant cables are to extend from the control/monitoring panel to the nearest local distribution panel serving the relevant deck/area.*
- *In case of power supply cables used for services required to be operable under fire conditions, the fire resistant cables are to extend from their distribution point within the space containing the emergency source of electrical power to the nearest local distribution panel serving the relevant deck/area.*

15.1.3 Emergency services required to be operable under fire conditions include:

- fire and general alarm system
- fire extinguishing systems and fire extinguishing medium alarms
- fire detection system
- control and power systems to power operated fire doors and status indication for all fire doors
- control and power systems to power operated watertight doors and their status indication
- emergency lighting
- public address system
- low level lighting
- emergency shut down system

15.2 Installation

For installation of fire-resistant cables the following shall be observed:

- The cables shall be arranged in such a way as to minimise the loss of operational availability as a result of a limited fire in any area.
- The cables shall be installed as straight as possible and with strict observance of special installation requirements, e.g. permitted bending radii.

E. Requirements for Busbar Trunking Systems intended for the Electrical Supply of Distribution Panels and Single Consumers**1. Scope**

The following listed additional requirements are valid for the design and the installation of busbar trunking systems, which are installed outside of switchboards and are intended for the supply of distribution boards or single consumers.

Busbar trunking systems shall not be installed in explosion endangered areas and on the open deck.

2. Components of the busbar trunking system

A busbar trunking system consists of the following components:

- electrical conductors including neutral and protective conductors, their insulation and the encasement of the busbar trunking system
- connecting elements
- separation units
- insulators and fixing elements
- arc barriers
- tap-off units
- bulkhead and deck penetrations
- protection devices

3. Requirements**3.1 Basic requirements**

The safety standard and availability of mains designed to include busbar trunking systems shall be at least equivalent to those of conventionally cables mains, even in case of failure.

Busbar trunking systems shall comply with the requirements of IEC publications 60439-1 and 60439-2.

3.2 Requirements for components**3.2.1 Degree of protection**

The design of the busbar trunking system shall comply with the following minimum degrees of protection:

- dry spaces, e.g. accommodation: IP 54
- wet spaces, e.g. engine rooms: IP 56

The operational readiness of the busbar trunking system shall be not impaired by condensed moisture. Where required, means for automatic draining shall be provided.

Busbar trunking systems shall be protected against mechanical damage.

3.2.2 Bulkhead and deck penetrations, fire protection

The materials used shall be halogen-free and shall be flame-retardant according to IEC publication 60695-2.

The whole busbar trunking system shall meet with regard to the flame-spread the test requirements of IEC publication 60332-3, category A/F.

Bulkhead and deck penetrations for busbar trunking systems shall conform to categories laid down by **SOLAS** and shall not impair the mechanical strength and the watertightness of bulkheads and decks.

The propagation of smoke via the busbar trunking system shall be effectively prevented.

3.3 System requirements

3.3.1 System configuration

The design of busbar trunking systems shall be such that in case of a single failure the supply to redundant essential equipment continues. Redundant essential equipment shall be supplied via separate busbar trunking systems. Common busbar systems for main and emergency supply are not permitted.

Where a busbar trunking system is arranged below the uppermost continuous deck, a unit's manoeuvrability and the operation of all installations necessary for the main purpose of the unit as well as the safety of the crew shall not be impaired in the event of one or more watertight compartments outside the engine room being flooded.

Where busbar trunking systems are led through several watertight sections, means for separation at the supply-side of the transitions shall be provided. The units for separation shall be approachable, marked for identification and secured against unauthorized uncovering.

3.3.2 Protection devices

Busbar trunking systems shall be protected against overload and short circuit.

Switchgear of the busbar trunking system shall be arranged with regard to selectivity.

The propagation of electric arcs along the busbar trunking system shall be prevented by arc barriers or other means. If current limiting circuit breakers are used, those means are not required.

4. Tests

4.1 Aboard tests

On the basis of approved documentation an aboard test of the completed installation shall be made. This includes the functional testing of the busbar trunking system and the check of settings for protection devices.

4.2 Busbar trunking systems are subject to BKI approval.

Table 11.6 Current-carrying capacity of cable, maximum permissible conductor operating temperature of 60 °C and 75 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature of					
		60 °C			75 °C		
		S 1 cont. operation	S 2 - 30 min	S 2 - 60 min	S 1 cont. operation	S 2 - 30 min	S 2 - 60 min
mm ²	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single core cables							
1,0	17	8	8	8	13	14	14
1,5	15	12	13	13	17	18	18
2,5	13	17	18	18	24	25	25
4	11	22	23	23	32	34	34
6	9	29	31	31	41	43	43
10	7	40	42	42	57	60	60
16	5	54	57	57	76	81	81
25	3	71	76	75	100	107	106
35	2	87	94	92	125	135	133
50	0	105	114	111	150	164	159
70	2/0	135	150	143	190	211	201
95	4/0	165	186	177	230	260	246
120	250	190	220	203	270	313	289
150	300	220	260	238	310	366	335
185	400	250	305	273	350	427	382
240	500	290	365	322	415	523	461
300	600	335	439	379	475	622	537
2-core cables							
1,0	17	7	7	7	11	12	12
1,5	15	10	11	11	14	15	15
2,5	13	14	15	15	20	21	21
4	11	19	21	20	27	29	29
6	9	25	27	27	35	38	37
10	7	34	38	36	48	53	51
16	5	46	52	49	65	73	70
25	3	60	71	65	85	101	92
3- or 4-core cables							
1,0	17	6	6	6	9	10	10
1,5	15	8	9	8	12	13	13
2,5	13	12	13	13	17	18	18
4	11	15	16	16	22	24	23
6	9	20	22	21	29	32	31
10	7	28	31	30	40	45	42
16	5	38	43	41	53	60	57
25	3	50	60	55	70	84	76
35	2	61	76	67	87	108	96
50	0	73	95	82	105	137	118
70	2/0	94	129	108	133	182	153
95	4/0	115	165	137	161	232	192
120	250	133	200	162	189	284	231
Multi-core cables							
5 × 1,5	5 × 15	7			10		
7 × 1,5	7 × 15	6			9		
10 × 1,5	10 × 15	6			8		
12 × 1,5	12 × 15	5			7		
14 × 1,5	14 × 15	5			7		
16 × 1,5	16 × 15	5			7		
19 × 1,5	19 × 15	4			6		
24 × 1,5	24 × 15	4			6		
AWG : American Wire Gauge MCM : Mille Circular Mil							

Table 11.7 Current-carrying capacity of cable, maximum permissible conductor operating temperature of 80 °C and 85 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature of					
		80 °C			85 °C		
		S 1 cont. operation	S 2 - 30 min	S 2 - 60 min	S 1 cont. operation	S 2 - 30 min	S 2 - 60 min
mm ²	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single core cables							
1,0	17	15	16	16	16	17	17
1,5	15	19	20	20	20	21	21
2,5	13	26	28	28	28	30	30
4	11	35	37	37	38	40	40
6	9	45	48	43	48	51	51
10	7	63	67	67	67	71	71
16	5	84	89	89	90	95	95
25	3	110	118	117	120	128	127
35	2	140	151	148	145	157	154
50	0	165	180	175	180	196	191
70	2/0	215	239	228	225	250	239
95	4/0	260	294	278	275	311	294
120	250	300	348	321	320	371	342
150	300	340	401	367	365	431	394
185	400	390	476	425	415	506	452
240	500	460	580	511	490	617	544
300	600	530	694	599	560	734	633
2-core cables							
1,0	17	13	13	13	14	14	14
1,5	15	16	17	17	17	18	18
2,5	13	22	24	23	24	26	25
4	11	30	32	32	32	35	34
6	9	38	41	40	41	45	43
10	7	53	59	56	57	63	60
16	5	71	80	76	76	86	81
25	3	93	111	100	102	121	110
3- or 4-core cables							
1,0	17	10	11	11	11	12	12
1,5	15	13	14	14	14	15	15
2,5	13	18	19	19	20	22	21
4	11	24	26	25	27	29	29
6	9	31	34	33	34	37	36
10	7	44	49	47	47	53	50
16	5	59	67	63	63	72	67
25	3	77	92	84	84	101	92
35	2	98	122	108	101	125	111
50	0	115	150	129	126	164	141
70	2/0	150	206	173	157	215	181
95	4/0	182	262	217	192	276	228
120	250	210	315	256	224	336	273
Multi-core cables							
5 × 1,5	5 × 15	11			12		
7 × 1,5	7 × 15	11			10		
10 × 1,5	10 × 15	9			9		
12 × 1,5	12 × 15	8			9		
14 × 1,5	14 × 15	8			8		
16 × 1,5	16 × 15	7			8		
19 × 1,5	19 × 15	7			7		
24 × 1,5	24 × 15	7			7		
AWG : American Wire Gauge MCM : Mille Circular Mil							

Table 11.8 Current-carrying capacity of cables, conductor operating temperature of 85 °C (JIS)

Nominal cross section to JIS ¹ [mm ²]	Current-carrying capacity based on a maximum conductor operating temperature of 85 °C		
	S 1 continuous operating A max.	S 2 - 30 min A max.	S 2 - 60 min A max.
Single-core cables			
1,25	18	19	19
2,0	25	26	26
3,5	35	37	37
5,5	46	49	49
8,0	59	63	63
14,0	83	88	88
22,0	110	117	117
30,0	135	144	143
38,0	155	167	164
50,0	185	202	196
60,0	205	228	217
80,0	245	277	262
100,0	285	331	305
125,0	325	384	351
150,0	365	445	398
200,0	440	554	488
250,0	505	662	571
2-core cables			
1,25	16	17	17
2,0	21	22	22
3,5	30	32	32
5,5	39	42	41
8,0	50	55	53
14,0	71	79	75
22,0	94	106	101
30,0	115	137	124
3-core cables			
1,25	13	14	14
2,0	17	18	18
3,5	25	27	27
5,5	32	35	34
8,0	41	45	43
14,0	58	65	61
22,0	77	88	82
30,0	94	113	102
38,0	110	136	121
50,0	130	169	146
60,0	145	199	167
80,0	175	252	208
100,0	200	300	244
Multi-core cables			
5 × 1,25	11		
7 × 1,25	10		
9 × 1,25	9		
12 × 1,25	8		
16 × 1,25	7		
19 × 1,25	6		
23 × 1,25	6		
27 × 1,25	6		
¹ Japan Industrial Standard			

Table 11.9 Current-carrying capacity of cable, maximum permissible conductor operating temperature of 90 °C and 95 °C

Nominal cross-section		Current-carrying capacity based on a maximum conductor operating temperature of					
		90 °C			95 °C		
		S 1 cont. operation	S 2 - 30 min	S 2 - 60 min	S 1 cont. operation	S 2 - 30 min	S 2 - 60 min
mm ²	AWG/MCM	A max.	A max.	A max.	A max.	A max.	A max.
Single core cables							
1,0	17	18	19	19	20	21	21
1,5	15	23	24	24	24	25	25
2,5	13	40	43	43	32	34	34
4	11	51	54	54	42	45	45
6	9	52	55	55	55	58	58
10	7	72	77	77	75	80	80
16	5	96	102	102	100	106	106
25	3	127	135	134	135	144	143
35	2	157	170	167	165	178	175
50	0	196	214	208	200	218	212
70	2/0	242	269	257	255	283	270
95	4/0	293	331	314	310	350	332
120	250	339	390	362	360	410	385
150	300	389	459	420	410	484	443
185	400	444	541	484	470	573	512
2-core cables							
1,0	17				17	18	18
1,5	15	20	21	21	20	21	21
2,5	13	26	28	28	27	29	29
4	11	34	37	36	36	39	38
6	9	44	48	46	47	51	50
10	7	61	68	65	64	71	68
16	5	82	93	88	85	96	91
25	3	108	128	116	115	137	124
3- or 4-core cables							
1,0	17				14	15	15
1,5	15	16	17	17	17	18	18
2,5	13	21	23	22	22	24	23
4	11	28	30	30	29	32	31
6	9	36	39	38	38	42	40
10	7	50	56	53	52	58	55
16	5	67	77	72	70	80	75
25	3	89	107	97	94	113	102
35	2	110	136	121	115	143	127
50	0	137	178	153	140	182	157
70	2/0	169	232	195	178	244	205
95	4/0	205	295	244	217	312	258
120	250	237	356	289	252	378	307
Multi-core cables							
5 × 1,5	5 × 15				14		
7 × 1,5	7 × 15				13		
10 × 1,5	10 × 15				11		
12 × 1,5	12 × 15				10		
14 × 1,5	14 × 15				10		
16 × 1,5	16 × 15				9		
19 × 1,5	19 × 15				9		
24 × 1,5	24 × 15				8		
AWG : American Wire Gauge MCM : Mille Circular Mil							

Section 12

Additional Requirements for Mobile Offshore Units

A. General

1. Scope

The additional requirements defined in this Section apply, wherever relevant, to following types of mobile offshore units:

- self-propelled units capable to undertake sea voyages under their own power without external assistance
- units with auxiliary propeller drives for dynamic positioning and/or manoeuvring aids when travelling in tow
- mobile units without propeller drives

2. Main propulsion system

2.1 Definition

As main propulsion system of a mobile offshore unit shall be understood from electrical point of view:

- power generation by generators driven by an internal combustion engine, gas turbine or steam turbine
- driving source for main propellers in form of an electric motor
- power transmission
- drive controls
- control of variable pitch propellers
- measuring, indicating and monitoring equipment
- engine telegraph system
- electric drive of steering gear
- rudder control and monitoring system

2.2 References

As the elements of the system described in 2.1 are identical to the systems used on seagoing merchant ships the requirements for their Classification or Certification are not fully defined in these Rules, but are also referred to the Rules of Seagoing Ships. The following references can be given:

- generators, see Section 3
- electric motors according to Section 15, A. and Rules for Electrical Installations, Volume IV, Section 13
- power transmission, see Sections 4 to 6

- drive controls, see Section 7
- engine telegraph system according to Rules for Electrical Installations, Volume IV, Section 13
- control of variable pitch propellers according to Rules for Electrical Installations, Volume IV, Section 7, C.
- measuring, indicating and monitoring equipment according to Rules for Electrical Installations, Volume IV, Section 13, H.
- steering gear according to Rules for Electrical Installations, Volume IV, Section 7, A.
- rudder control and monitoring system according to Rules for Electrical Installations, Volume IV, Section 7, A. and Section 9, C.4.
- testing according to Rules for Electrical Installations, Volume IV, Section 21

3. Ship control systems

3.1 The requirements for control systems of self-propelled offshore units are defined in the Rules for Electrical Installations, Volume IV, Section 9, C.

3.2 Where the remote control of the main engines from the bridge is envisaged, the requirements according to the BKI Rules for Automation, Volume VII shall be observed.

3.3 The Voyage Data Recorder, if required for mobile offshore units by the relevant Authorities, shall be supplied from the main and emergency switchboard. Data or alarms for the recorder have to be free of reactive effects on unit operation.

B. Rudder Propellers

The arrangement and mechanical part of rudder propellers is defined in Volume 4 – Rules for Machinery Installations, Section 6, B.

1. Drives

The electric drives for the different rudder propellers are to be individually supplied from the main switchboard.

2. Control of the direction of thrust

2.1 The requirements for rudder control systems are to be applied as and where relevant. Two mutually independent control systems shall be provided. This

requirement is deemed to be satisfied if two mutually independent rudder propeller drives are installed and each plant has its own complete control system.

2.2 Thrust direction indicators are to be fitted. The requirements stated in the Rules for Electrical Installations, Volume IV, Section 9, C.4. relating to rudder angle indicators are to be observed as and where applicable.

3. Propeller speed control

The propeller speed control shall be independent of the control of direction of thrust.

4. Monitoring and displays

4.1 Signals

The following signals are to be mounted on the bridge and/or in the steering station for monitoring the equipment:

4.1.1 Indicator light showing which propeller unit is in operation at any time.

4.1.2 Indicator light signalling failure of the propeller units.

4.1.3 Indicator light signalling overloading of the electric motor and the loss of a phase in the feeder line to three-phase a. c. equipment,

4.1.4 Indicator light signalling failure of the control system in service at any time. This individual indication may be dispensed with, if the failure of the power supply to the control system is also covered by the monitoring facility specified in 4.1.2 above, e.g. if the control system is permanently assigned to the relevant drive unit.

4.1.5 The faults mentioned in 4.1.2 to 4.1.4 are also to be audibly signalled. Cancellation shall be possible for the audible alarm. The cancellation of an audible alarm shall not prevent the signalling of a fault in the other rudder propeller drive units in operation.

4.2 Suppression of alarms

Display and alarm suppression may be provided on the bridge of the propeller unit not in operation.

4.3 Alarms

For monitoring the equipment, the engine room or engine control room shall be provided with visual and audible alarms for:

4.3.1 The signals/fault indications mentioned in 4.1.1 to 4.1.4 as a combined alarm.

4.3.2 Low level in any of the hydraulic oil tanks.

4.3.3 The alarms mentioned in 4.3.1 and 4.3.2 shall be acknowledgeable in the engine room/engine control room and may be integrated into the general engine alarm system.

4.4 Protective equipment

A short circuit and overload protection has to be provided. For further details see C.3.

5. Testing

5.1 For the testing of electrical machinery, see Section 16.

5.2 Switchgear and control systems for rudder propellers shall in every case be tested and certified in the manufacturer's works in the presence of the BKI Surveyor. Exceptions are possible where the switchgear and control system has undergone a full type test.

The works test normally comprises:

- examination for conformity with the drawings approved by BKI
- inspection of the components used, construction and wiring
- functional testing, wherever possible also with the voltage and frequency variations to be expected on board in accordance with Section 1, F.
- insulation measurement and voltage test in accordance with the requirements for switchboards, see Section 5

5.2 Type tests

For devices subject to mandatory type approval see Section 16, E.

C. Lateral Thrust Units

The arrangement and mechanical part of lateral thrust units is defined in Volume 4 – Rules for Machinery Installations, Section 6, C.

1. Power supply

The power supply shall be provided directly from the main switchboard.

2. Rating

The equipment is to be designed in accordance with the operating conditions of the unit. It is normally to be rated for continuous duty.

3. Protective equipment

3.1 The equipment shall be protected in such a way that in the event of an overcurrent, an audible and visual warning is first given on the bridge, followed by an automatic power reduction or disconnection of

the system if the overload persists. The audible warning shall be acknowledgeable on the bridge. For plants with automatic current limitation the warning is not required.

3.2 If fuses are used for short-circuit protection, a phase-failure supervision is required to prevent the system to be started if one phase fails.

3.3 It shall be ensured that, if a lateral thrust propeller stalls, the main power supply to the drive is disconnected quickly enough to avoid endangering the selectivity of the system with regard to the generator switchgear.

3.4 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.

4. Controls, monitors and indicators

4.1 For lateral thrusters, the main steering station on the bridge shall be provided with the following indicators:

- an indicating light showing that the system is ready for operation
- an indicating light signalling an overload (for systems without power control)
- depending on the type of equipment, indicators showing the power steps and the desired direction of motion of the unit

4.2 Indications and alarms required in the engine room or engine control room:

- Faults which cause failure or endanger the drive shall be signalled optically and audibly as collective alarms.
- An ammeter for the drive motor shall be provided at the main switchboard.

4.3 The direction of movement of the controls of lateral thrust units shall correspond to the desired direction of motion of the unit. Power for the electrical control system shall be taken from the main power supply of the drive.

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

D. Podded Drives

Arrangement and mechanical part of podded drives are described in Volume 4 – Rules for Machinery Installations, Section 6, D.

1. Remote controls

1.1 The design of remote control systems for propeller drives is subject to the Rules for Electrical Installations, Volume IV, Section 13.

For sensor and control systems, including excess temperatures, oil levels, leakage indications, etc. see Rules for Automation, Volume VII.

The following additional requirements are to be observed.

1.2 In all cases each propeller drive shall be capable of being individually controlled. An additional joy-stick control may be approved.

1.3 Subordinate and auxiliary control stands additional to the bridge control stand shall be capable of being disconnected to ensure faultless operation of the bridge control stand in case of failures. It shall be possible to make this disconnection from the bridge control stand.

1.4 Controls and displays shall be illuminated. Provision shall be made for dimming the illumination to the extent that the display remains legible but the personnel on the bridge is not dazzled.

2. Speed/direction of rotation indicator and pitch indicator

The power supply to indicators showing the speed and direction of rotation of propeller shafts, as well as the propeller pitch in the case of variable pitch propellers, shall be independent of the main power supply (e.g. tacho-generators, battery back-up).

E. Dynamic Positioning

The basic principles and the general requirements for dynamic positioning systems are defined in Volume 4 – Rules for Machinery Installations, Section 6, E.

1. Power system

1.1 The power system shall have an adequate response time to power demand changes.

1.2 For Class Notation **DP 1** the power system need not be redundant.

1.3 For Class Notation **DP 2**, the power system shall be divisible into two or more systems such that in the event of failure of one system at least one other system will remain in operation. The power system may be run as one system during operation, but shall be arranged by bus-tie breakers to separate automatically upon failures which could be transferred from one system to another, including overloading and short circuits.

1.4 For Class Notation **DP 3**, the power system shall be divisible into two or more systems such that in the event of failure of one system, at least one other system will remain in operation. The divided power system shall be located in different spaces separated by "A-60" class divisions.

1.5 For Class Notations **DP 2** and **DP 3**, the power available for position keeping shall be sufficient to maintain the vessel in position after a single fault according to Volume 4 – Rules for Machinery Installations, Section 6, E.

1.6 If a power management system is installed, adequate redundancy or reliability shall be demonstrated.

2. Thruster system

The thruster system shall provide adequate thrust in longitudinal and lateral directions and yawing moment for heading control.

3. Control system

3.1 General

3.1.1 In general, the control system shall be arranged in a DP control station from where the operator has a good view of the unit's exterior limits and the surrounding areas.

3.1.2 The DP control station shall display information from the power system, thruster system, and control system. Information necessary to operate the DP system safely shall be always visible. Other information shall be available upon operator request.

3.1.3 For Class Notations **DP 2** and **DP 3**, Operator controls shall be designed so that no single inadvertent action on the operator's panel may lead to a critical condition.

3.2 Computer systems

3.2.1 For Class Notation **DP 1**, the control system need not be redundant.

3.2.2 For Class Notation **DP 2**, the control system shall consist of at least two independent computer systems. Common facilities, such as self-checking routines, data transfer arrangements and interfaces, shall not cause the failure of all systems.

3.2.3 For Class Notation **DP 3**, the control system shall consist of at least two independent computer systems with self-checking and alignment facilities. Common facilities, such as self-checking routines, data transfer arrangements and interfaces, shall not cause failure of all systems. In addition, one back-up control system shall be arranged. An alarm shall be initiated, if any computer fails or is not ready for operation.

3.2.4 An uninterruptable power supply (UPS) shall be provided for each DP computer system to ensure that any power failure will not affect more than one computer. UPS battery capacity shall provide a minimum of 30 minutes operation following a mains supply failure.

3.3 Position reference systems

3.3.1 Position reference systems shall be selected with due consideration to operational requirements, both with regard to the restrictions caused by the manner of deployment and expected performance for the operating conditions.

3.3.2 For Class Notations **DP 2** and **DP 3**, at least three position reference systems shall be installed and simultaneously available to the DP control system during operation.

3.4 Sensor systems

3.4.1 Unit's sensors shall at least measure unit's heading, unit's motions, and wind speed and direction.

3.4.2 If, for a Class Notation **DP 2** or **DP 3**, the control system is fully dependent on correct signals from unit's sensors, these signals shall be based on three systems serving the same purpose (i.e. this will result in at least three gyro compasses being installed).

4. Cable systems

For Class Notation **DP 3**, cables for redundant equipment or systems shall not be routed together through the same compartments. Where this is not practicable, such cables may run together in cable ducts of "A-60" Class including duct ends, which are effectively protected from all fire hazards, except those originating from the cables themselves. Cable connection boxes are not allowed in such ducts.

5. Requirements for essential non-DP systems

For Class Notations **DP 2** and **DP 3**, systems not directly part of the DP system but which in the event of failure could cause failure of the DP system (e.g. common fire suppression systems, engine ventilation systems, shut-down systems, etc.), shall also comply with the relevant requirements of these Rules.

6. Further details

Further details concerning dynamic positioning are defined in the Rules for Dynamic Positioning Systems.

F. Units with Unattended Engine Rooms

1. General

The extent and design of automated equipment are generally required to conform to Rules for Automation, Volume VII.

The following requirements are also to be observed.

2. Generator standby systems

2.1 On units with facilities for unattended engine rooms, the electrical plant is also required to comply with the requirements set out in Volume 4 on the restoration of the power supply following a mains failure.

The automatic connection of a generator and of essential consumers following a blackout shall occur as quickly as possible and in any event within 30 seconds. Where necessary, the load may be connected in steps so that the prime mover is able to deliver the corresponding output.

In the event of continuous drop in frequency of more than 10 %, the non-essential consumer shall be tripped automatically within 5 to 10 s. If this does not restore normal operating conditions, the supply generators shall disconnect themselves from the network so that the standby set can cut in.

2.2 Where provision is made for the automatic load-related connection and disconnection of generators, connection shall be initiated when any generator attains 80 % of its rated current. The connection of a further generator shall also be possible in the event of a persistent drop in frequency of up to 10 %.

2.3 Following a failure of the main power supply system, the restoration of the power supply shall be possible without recourse to the emergency power supply.

3. Consumer standby circuit

3.1 Standby circuits are to ensure the alternating service of units of the same type. A changeover to another unit due to a fault is to be signalled visually and audibly.

3.2 The systems of automatically controlled consumer groups are to be so designed that a fault in one of the systems does not disable the other systems.

3.3 Air compressors providing the starting air for diesel engines shall start and stop automatically in order to maintain the stored starting air.

4. Machinery alarm systems

4.1 Alarms shall also be given on the bridge, in the living quarters and accommodation area of the

technical officers and/or the personnel responsible for the machinery plant, if the engine room is unattended. The watch station of the technical officer or responsible crew member shall be individually selectable and indicated on the bridge.

4.2 If an alarm signal is not acknowledged in the engine room or the engine control room within a pre-set time, the alarm system is to activate the general engineer's alarm in accordance with G.1. in the engineers' living quarters and accommodation area.

4.3 Depending on the degree of urgency involved, the visual failure signals on the bridge are to be arranged in three groups to act as collective alarm signals:

- Group 1:
Alarms due to failures requiring the immediate shut-down of the main engine (red lights).
- Group 2:
Alarms due to failures requiring a reduction in power of the main engine (red light).
- Group 3:
Alarms due to failures which do not require measures as described in groups 1 and 2 (yellow light).

Simultaneously with a collective alarm signal, an acknowledgeable audible alarm is to be given on the navigating bridge. After acknowledgement, this alarm shall at once be available for actuation in the event of another collective alarm signal.

Acknowledgement of the alarm signal in the engine control room is to be indicated on the navigating bridge. A group 3 visual collective alarm signal may then be cancelled. However, group 1 and group 2 visual indications shall remain until the fault has been corrected.

4.4 The audible alarm in the engine room may be switched off for the period of unattended operation, provided that special measures are taken to ensure that the audible signalling device is operative during the remaining time, e. g. by coupling it to a duty-time selector switch.

4.5 The supply to the engine alarm system and its peripheral equipment shall have battery back-up (see Section 4).

4.6 The extent of the monitoring points is to be determined in accordance with Volume 4 – Rules for Machinery Installations, Section 17.

G. Communication Systems

The general internal communications and the public address/alarm systems are defined in Section 9, B.

1. Engineer calling system "Engine room – accommodation area"

1.1 Provision shall be made for alerting the technical officers or the crew members responsible for the machinery installation in their accommodation area from the engine room or engine control room. The calling devices may be located individually in the respective cabins and the mess room within the technical officers' accommodation area.

1.2 With a decentralized arrangement of the calling devices it shall be possible to call the responsible personnel both individually and together.

1.3 The engineer calling system is to be powered from the emergency switchboard or from another permanently available power source.

2. Important intercom systems

2.1 The important intercom systems specified in the following are to be designed to ensure fully satisfactory vocal intercommunication under all operating conditions.

Where several service telephones are located in one room, the called telephone shall be indicated visually.

Intercom links are to be provided between the following stations:

2.2 Engine room – bridge and engine control room - bridge

An intercom link is to be provided between the bridge, the engine room and all control positions from which the main propulsion plant can be operated.

A noise-absorbent hood should be used in engine rooms with high noise levels.

The calling devices in the engine room are to be so designed that they clearly attract attention from any position in the engine room even when the plant is running at full load. Additional visual means may be used to meet this requirement.

2.3 Bridge - radio room

An intercom link is to be provided between the bridge and the Operator's position in the radio room. This intercom link is not required if communication can be made without technical aid.

2.4 Bridge - steering gear compartment

Provision shall be made for fully satisfactory transmission of commands between the bridge and the steering gear control stand (if any) in the steering gear compartment.

2.5 Other intercom links

Intercom links shall also be provided between all other locations at which activities may need to be performed in an emergency.

2.6 Power supply to intercom systems and special instructions

The intercommunication systems specified in 2.2 and 2.3 shall be independent of the main power supply system and any other power source. Wherever possible, they are to be designed as one-to-one links. A one-to-one link between the bridge and engine room or between the bridge and radio room may be dispensed with, if the system consists of not more than 6 sets and steps are taken to ensure that intercommunication between the two points can be established at all times (e.g. by cutting into an engaged line).

2.7 In the event of a failure of the main power supply, the intercom links specified in 1., 2.4 and 2.5 have to be uninterruptibly supplied by a battery whose installation meets the requirements for an emergency battery.

3. Voice communications in an emergency

3.1 An intercommunication system shall be provided which enables commands to be transmitted between strategically important locations, the assembly points, the emergency control stations, the muster stations and launching stations of lifesaving equipment.

3.2 This system may comprise portable or permanently installed equipment, and shall also be operable in the event of a failure of the main power supply.

H. Deck Machinery

1. General

1.1 Deck machinery is to be designed in accordance with the requirements for mooring equipment in Volume 6, Rules for Offshore Unit, Section 8, for windlasses and winches in Volume 4 - Rules for Machinery Installations, Section 8 and for cranes in Volume 2 – Rules for Structure, Section 8.

1.2 Enclosures

The degree of protection for motors and switchgear shall be selected in accordance with Section 1, Table 1.11.

1.3 Emergency stop

Hoisting gear shall be equipped with an emergency switch which allows the motor to be stopped immediately in case of a control device failure.

1.4 Control devices

When released, the levers and hand wheels controlling hoisting gear shall automatically return to the zero position. Exceptions to this requirement may be allowed for special drives.

2. Windlasses and mooring winches

2.1 Motor rating

Motor design and construction are to conform to Section 15, A. Windlasses and mooring winches are to be rated in accordance with the proposed application and shall be capable of delivering twice the rated torque for 2 minutes without dangerous overheating.

2.2 Overload protection

An electrical overload protective device is to be provided to prevent excessive overloading of the motors and, as far as possible, of the windlasses and winches.

2.3 Power supply

Windlass and winch motors and their control systems shall be supplied directly from the switchboard of the main electrical power source.

2.4 Brakes

The electromagnetic operating elements of brakes shall conform to Section 15.

If the power supply to windlasses and winches fails, the brakes shall engage automatically and be capable of holding against 50 % of the total static braking capacity of the windlass.

Their holding power is to be rated in accordance with Volume 4 – Rules for Machinery Installations, Section 8.

2.5 Winch controls

2.5.1 From the winch control stands it shall be possible to observe the operation of each winch, including fairleads, cables and anchor handling vessels.

2.5.2 Individual control shall be provided for each winch. Any failure in the control systems of one winch shall not affect the operation of the controls of other winches.

2.5.3 The respective control stand shall be equipped with at least the following facilities for each winch in addition to the emergency OFF switch mentioned in 1.3:

- wattmeter or ammeter
- device for monitoring and indicating the pull on the anchor chain or cable
- devices showing the length of paid-out chain or cable

The power supply to the above mentioned devices shall be independent of the power supply to the winch

control system. The operative state of the system is to be indicated.

2.5.4 In a permanently manned control station the following data are to be indicated:

- the pull on the chain or cable, and
- the strength and direction of the wind

2.5.5 Local and remote means shall be provided to enable the anchors to be emergency released from the unit after loss of main power.

2.5.6 Circuits shall be arranged for automatic transfer in the event of failure of the normal control power supply, but need not be exclusive to the supply of the anchor operation control power.

Operation of transfer arrangements shall not cause a power supply failure mode to be initiated.

2.5.7 A permanently installed communication system shall be provided to establish communication between all stations from which an anchoring operation can be controlled and supervised.

I. Electric Drives and Controls for the Jacking System

1. General

1.1 References

The basic requirements for self elevating units, where the jacking systems are part of, are already defined in Volume 6 - Rules for Offshore Unit, Section 2.

The general design principles and the machinery installations of jacking systems as well as the documents for approval are defined in Volume 4 – Rules for Machinery Installations, Section 9.

All electrical and electronic requirements for jacking systems are defined in this Section.

1.2 Design principles

1.2.1 The electrical installations and controls of the jacking system are to be designed and constructed with sufficient redundancy so that upon failure of any one component, the system shall be capable of continuing to jack or holding in place.

1.2.2 The system shall be designed so that overloading of the electrical components is avoided during all kinds of operation.

1.2.2.1 The electrical items to be considered for rack and pinion jacking systems in this respect include the following:

- motor controller, if applicable
- drive of central or local hydraulic power stations, if applicable

- characteristic of electric motors
- brake torque
- interlock between electric motors and blocking system (if any)

1.2.2.2 The electrical items to be considered for ram and pin jacking systems are:

- drive of central or local hydraulic power stations
- actuators for pins
- control of operation of the hydraulic rams

1.2.2.3 The electrical items to be considered for rubber block friction systems are:

- drive of the compressor
- drive of the hydraulic power station, if applicable
- control of operation of the pneumatic holding and ram system

2. Electrical jacking motors

2.1 Capacity

2.1.1 The capacity of the electrical jacking motors shall be sufficient for lifting requirements such as the following:

- requirements as defined in Volume 4 – Rules for Machinery Installations, Section 9
- lifting the platform with uneven load (but within approved tolerances) for a specific duration
- lifting in preload, if specified, with a specific duration

The friction between legs and guides, as well as the efficiency of the gear transmissions are to be considered.

2.1.2 At least two motors shall be provided for each transmission or drive unit.

2.1.3 In determining the motor ratings an allowance is to be made for reserve capacity. This is to be determined in such a way that, if individual motors fail, the residual capacity is sufficient for the safe conclusion of the lifting or lowering operation.

2.1.4 The torque characteristics of the electric motors shall be such that the motor is not able to damage any part of the transmission or pinion rack in the case of a mechanically blocked lifting system.

2.2 Design and construction

Design and construction of the motors shall conform to Section 15, A.

2.3 Power supply

2.3.1 The jacking motors may be arranged in drive groups for each platform leg.

2.3.2 Each drive group shall be supplied directly from the main switchboard via a circuit breaker.

2.4 Generating of electric power

When lowering a unit with an electric rack and pinion system, the weight of the unit will tend to overspeed the electric motors causing them to actually generate electric power. This electric power shall be absorbed to avoid damage to the electric power generation and control equipment.

3. Protective devices

3.1 Each drive group at a leg is to be protected against short circuit and overload.

The short-circuit protective device is to be set to a threshold value corresponding to not more than 10 times the rated current of all the motors in a group.

3.2 The overcurrent protective device shall release a visual/audible alarm at the control console.

3.3 Automatic disconnection of the drive in case of overload is to be provided only where excessive load torque can cause damage to the transmission system, the platform leg and the platform structure.

Each drive motor is to be fitted with an overload indicator at the control console so that, for instance, in case of a brake failure selective remedial measures can immediately be taken.

4. Brakes

Electro-magnetically operated brakes shall conform to Section 15, A.

Brakes shall engage automatically, should the power supply fail.

5. Control

5.1 An individual control system is to be provided for each leg drive group.

The control circuits of the individual drive groups shall work independently of each other.

5.2 Means shall be provided for the simultaneous collective control of all the drive groups at the legs.

An emergency push button shall enable the drive groups of all the legs to be shut-off simultaneously.

If not an automatic collective load control is used, the group torque at the electric motors shall be checked and adjusted for the purpose of load equalization between the drive groups, if necessary. This shall be done after the lifting of the platform and after being subject to weather conditions which may have altered the distribution.

5.3 Control of the blocking system is to be provided, if any.

6. Monitoring

6.1 For each leg the following control and monitoring elements are to be provided at least:

- ON/OFF control main switch
- UP/STOP/DOWN control switch
- "Ready" indicator lights
- "Overload" indicator lights
- Wattmeter and/or ammeter for electrical power of all current motors running together
- position of the blocking system, if any

6.1 At the jacking control station the following control and monitoring elements are to be provided at least:

- control system for a collective jacking operation, if any
- an emergency stop push button for all drives simultaneously
- the available generator capacity is to be indicated
- displays for monitoring the inclination angle of the platform structure
- with more than 3 legs, a continuous overload monitor with an alarm system for signalling excessive differences between the leg loads

7. Communications

A permanently installed communication system is to be provided between the central jacking control station and the local leg drive stand of the individual platform legs. This may form part of the telephone network or of the loud-speaker intercom system.

8. Testing

8.1 Tests at manufacturer's works

Shop tests of system elements are to be provided as appropriate. For major components the presence of the BKI Surveyor at the testing is required.

8.2 Dock trials

8.2.1 The electrical installations shall be function tested for at least one complete cycle of all specified conditions and with preload. During these tests all alarms, brake or valve functions and interlocks, if any, shall be checked. The different elements of the trial program are defined in Volume 4 – Rules for Machinery Installations, Section 9, E.2.

8.2.2 For rack and pinion jacking systems, electric motor input torque and speed shall be checked for all loading conditions.

After the lifting test, the brake torques shall be checked and adjusted, if necessary.

J. Ballast Systems for Column-Stabilized Units

1. General

1.1 References

Besides the application at all mobile offshore units, the ballast system has special importance for column-stabilized units. The basic requirements for column-stabilized units are already defined in Volume 6 - Rules for Offshore Unit, Section 3.

The general design principles and the machinery installations of ballast systems as well as the documents for approval are defined in Volume 4 – Rules for Machinery Installations,, Section 13e, I.

All electrical and electronic requirements for ballast systems are defined in this Section.

1.2 Design principles

1.2.1 Units shall be provided with an efficient piping system capable of ballasting and deballasting any ballast tank under normal operation and transit conditions.

1.2.2 The ballast system shall still be capable of operation when the unit is:

- under the inclination expected in the operational condition as stated in Section 1, Table 1.3
- powered from the emergency switchboard, with the unit in the damaged condition specified by BKI or the appropriate Authority

1.2.3 The power supplies and the control equipment for the ballast systems are to be so designed that at least restricted operability is maintained should any system component fail.

1.2.4 Enclosures housing electrical components of the ballast system, the failure of which may cause unsafe operation of the ballast system upon liquid entry into the enclosure, shall have a minimum degree of protection IP 56.

2. Electric motors

2.1 Ballast pump motors

Each pump motor shall be directly supplied both from the appropriate switchboard of the main power supply system and from the emergency power source. The device for switching over to the standby supply shall be located in the vicinity of the pump motor and outside the ballast control station.

2.2 Electric drives for ballast valves

2.2.1 Depending on the design of the ballast system, the power supply to individual valve drives can be arranged in groups. Each group shall be supplied

directly from the appropriate switchboard of the main power supply and from the emergency power source.

2.2.2 The device for switching over to the standby supply shall be located at the group distribution panel. Each valve drive shall as a minimum requirement be protected against short circuit at the group distribution panel.

2.2.3 Each power-operated ballast valve shall fail to the closed position upon loss of control power. Upon the reactivation of control power, each such valve shall remain closed until the ballast control operator assumes control of the reactivated system. BKI may accept ballast valve arrangements that do not fail to the closed position upon loss of power, provided BKI is satisfied that the safety of the unit is not impaired.

3. Controls

3.1 Central control

3.1.1 A central ballast control station shall be provided. It shall be located above the worst damage waterline and adequately protected from weather. From this station the individual remote control of ballast pumps and of ballast valves shall be possible.

3.1.2 In addition to the individual controls, approval may be given for the collective control of functional units, e.g. a combination of certain ballast valve controls which have to be operated simultaneously. In the event of a fault, however, the operability of the individual controls shall be maintained.

3.1.3 The use of computer based ballast control systems is permissible but shall be agreed with BKI.

Computer based systems are in addition to be provided with

- a manual OFF push button, independent of the computer, with which all the controls of the ballast system can be shut down
- a safety system hard-wired and computer-independent, for detecting inadmissible limit values, tripping the associated alarms and, where applicable, initiating safety measures

3.1.4 If the voltage fails,

- control circuits shall assume the OFF condition, and
- ballast valves shall close automatically

Restoration of the voltage shall not automatically reactivate the systems. Reinstatement shall require intervention by the operating personnel.

3.1.5 Provision shall be made at the central ballast control station for the all-pole disconnection of the power supply of the controls of ballast pumps and ballast valves.

3.1.6 The control and display systems shall work independently of each other. A failure in one system shall not affect the operability of the other systems.

3.1.7 The control and display systems shall be provided with a second power supply from an emergency power source.

3.2 Local controls

3.2.1 It shall be possible to control pump motors and valve drives locally and independently of the central control station.

The controls for both systems shall be located in the same room and in the vicinity of the ballast valves and ballast pumps.

3.2.2 It shall be possible to check the position of the ballast valves from the local control stand. The indicators shall rely on movement of the valve spindle.

3.2.3 The availability of the main and emergency power supplies for valve drives and pump motors shall be indicated.

3.2.4 The power for local controls shall be supplied from the appropriate group distribution panel in the case of valve drives and from the associated motor switchgear in the case of ballast pumps. Faults in the remote controls shall not affect the local controls.

4. Monitoring

4.1 At the central ballast control station the following displays shall be provided in so far as they are required by the operating principle of the ballast system and for assessing its current state:

- availability of the main and emergency power supply
- hydraulic/pneumatic pressure in the ballast system, if applicable
- operational status of the ballast pumps
- position (open/closed) of the ballast valves
- liquid level in all ballast tanks and all other tanks liable to affect the stability of the unit
- draught of the unit either at each corner of the unit or at a representative position as required for assessing the draught of the underwater areas concerned
- unit's heeling angle and trim
- type of control (remote/local/automatic) and operative status

4.2 The control and monitoring systems defined in 4.1 shall function independently of one another, or have sufficient redundancy, such that a failure does not jeopardize the operation of any of the other systems.

4.3 Recording level gauges are not to be mounted in the pipes of the ballast system.

4.4 The failure of a control or indicating system shall release a visual and audible alarm.

5. Communications

A permanent installed intercom link, independent of the unit's main source of electrical power, is to be provided between the central ballast control station, any additional safety station, where installed, and the local control stands.

6. Testing

6.1 Shop tests of system elements are to be provided as appropriate.

6.2 The complete ballast system and its electrical installations shall be function tested for all relevant ballast situations under BKI's supervision. During these tests all alarms and interlocks, if any, shall be checked.

K. Navigation Lights and Sound Signalling Equipment

1. General

1.1 When a unit is not stationary, attention is drawn to the IMO Regulation "Convention on the International Regulations for Preventing Collisions at Sea" (COLREG). Attention is drawn in relation to the provision of primary and alternative lanterns for each of the navigation lights.

All units shall be provided with "steaming lights", which comprise masthead, side, stern, anchor, not under command and, if applicable, special purpose lights, etc.

1.2 When the unit is fixed at the operation site the requirements of Section 10, D. have to be applied.

2. Lamps

The construction and installation of navigation lights shall be to the satisfaction of the appropriate Administration.

The lamps, which are to be individually protected by a fuse or mini-circuit-breaker, are each to be supplied by a separate cable from the navigation lights panel.

Main and standby lamps of identical type may be supplied via a single cable with separated conductors provided that it is guaranteed that the lamps can be switched on/off individually.

3. Lights panel

3.1 The navigation lights panel may be extended to provide connections for signal lamps specified in the current "International Regulations for Preventing Collisions at Sea".

Other consumers shall not be connected to this panel.

3.2 For every lamp the panel is to be fitted with a device which indicates or signals the extinction of a lamp.

Where the indicating device is connected in series with the lamp, it shall be ensured that a failure of the device does not cause the navigation light to be extinguished. If an acoustic device is used alone for indicating, it shall be connected to an independent source of supply, for example a battery, and provision shall be made for testing this supply.

Navigation and signal lights have to be fed from the main and emergency power source.

4. Lamp supply

4.1 Where navigation lights are supplied from the main power source, the voltages at the lamp holder shall not be permanently more than 5 % above or below the rated voltages.

If, in case of a mains failure, the navigation lights are supplied from the emergency power source, the voltage at the lamp holder may be temporarily up to 10 % above or below the rated voltage.

4.2 So far as practicable, the arrangements should be such that a fire, a fault or mechanical damage at any one point will not render both systems inoperative. It is, however, accepted that the systems shall come together at some point where the changeover can be effected. This should, preferably, be at or near the light panel.

5. Foghorn

The sound signalling system shall be supplied from the emergency power source if it is only electrically operated or controlled.

Section 13

Explosion Protection in Hazardous Areas

A. General

1. The requirements of this Section apply additionally to offshore units and installations with spaces subject to an explosion hazard due to flammable gas-air mixtures.

2. Where certified equipment has to be used, the Test Certificate has to be issued by an internationally recognized institution accepted by BKI.

3. The explosion protection and the testing of the electrical equipment shall conform to a recognized national or international standard, e.g. IEC Publication 60079.

For further details, reference should be made to the Guidelines for the Explosion Protection of Electrical Equipment.

B. Hazardous Areas

1. Hazardous areas are deemed to be those which in accordance with Volume 4 – Rules for Machinery Installations, Section 2 are assigned to one of the Zones 0, 1 or 2 defined in IEC Publication 60079-10.

2. Areas such as paint stores or battery rooms, which are not covered by a zone classification, and spaces in which tanks, pipes and machines for media with a flash point below 60 °C are operated, are also considered to be dangerous spaces assigned to Zone 1. These areas have also to be considered as Zone 1, if liquids with a flashpoint above 60 °C are heated to a temperature higher than 10 °C below their flashpoint. The explosion protection of the electrical equipment is to be so specified that it at least meets the requirements for the atmosphere which may be formed in the aforementioned spaces, or which may infiltrate into these spaces from the drilling or processing area, e.g. in case of faulty conditions.

C. Electrical Equipment in Zones 0, 1 and 2

1. Electrical equipment and wiring installed in hazardous areas shall be limited to that necessary for operational purposes. Only the cables and types of equipment described in this Section shall be installed.

2. Where in 3. reference is made to certified types of equipment, such equipment shall be certified as suitable for the flammable gas/air mixture which may be encountered (temperature class, etc.).

3. In hazardous areas the following ex protected electrical equipment has to be installed:

3.1 Zone 0

All equipment has to be certified Ex ia, with electrical isolation from the power supply system, including the associated cables of approved type.

3.2 Zone 1

All equipment used in this zone has to be certified and the following types of explosion protection are permitted:

- Ex d, flameproof enclosure
- Ex p, pressurized enclosure
- Ex e, increased safety
- Ex s, special enclosure
- Ex i, intrinsic safety
- Ex o, oil immersion
- Ex m, encapsulation
- Ex q, sand filled

Continuous cables with armouring, braiding or in welded conduits. Flexible cables shall be accepted by BKI.

3.3 Zone 2

- Equipment with all types of ex-protection suitable for zone 1
- Equipment which does not cause sparks in service and whose surfaces exposed to the outside atmosphere do not reach unacceptably high temperatures
- Equipment with vapour-proof enclosure with at least IP 55 type protection, whose components do not reach unacceptably high temperatures
- Equipment with Ex n type protection
- Continuous cables

Notes

- *Closed spaces with direct access to spaces belonging to zones 1 and 2 are to comply with the special requirements stated in Volume 4 – Rules for Machinery Installations, Section 2.*
- *Electrically operated safety equipment which has to remain operative in the event of emergency*

shutdowns shall also be provided with explosion protection in safe spaces and areas.

- *Remarks of the test Certificates of the certified equipment, e.g. t_E time for Ex e components have to be considered. For intrinsically safe circuits a calculation of the circuits has to be carried out and has to be submitted to BKI. Reference is made to IEC 60079-14.*

3.4 For fixed offshore installations the national requirements valid at site have to be met in addition.

D. Emergency Conditions due to Drilling Operations

1. Scope of shutdown

In view of exceptional conditions in which the explosion hazard may extend outside the above mentioned zones, special arrangements shall be provided to facilitate the selective disconnection or shutdown of:

- ventilation systems, except fans necessary for supplying combustion air to prime movers for the production of electrical power
- main generator prime movers, including the ventilation systems for these
- emergency generator prime movers

2. Locations for shutdown

Disconnection or shutdown shall be possible from at least two strategic locations, one of which shall be outside hazardous areas.

3. Shut-down systems

Shut-down systems that are provided to comply with 1. shall be so designed that the risk of unintentional stoppages caused by malfunction in a shut-down system and risk of inadvertent operation of a shut-down are minimized.

4. Facilities operable after shutdown

4.1 Equipment which is located in spaces other than enclosed spaces and which is capable of operation after shut-down as given in 1. shall be suitable for installation in zone 2 locations. Such equipment which is located in enclosed spaces shall be suitable for its intended application to the satisfaction of BKI.

4.2 At least the following facilities shall be operable after an emergency shutdown:

- emergency lighting according to Section 3, D.2. for half an hour
- blow-out preventer control system
- fire and gas detection systems
- general alarm system

- public address system
- battery-supplied radio communication installations

E. Other Hazardous Spaces

1. Scope

1.1 Other hazardous spaces to be considered are:

- paint stores
- battery rooms
- welding gas storage rooms

1.2 The following electrical appliances with approved explosion-protected enclosure may be installed:

- lighting fixtures and the associated switches
- fan motors and the associated switches. Where fan motors are installed in the exhaust air flow of the ventilation system, the cables located in the air flow shall be mechanically protected, e.g. by conduits extending to the terminal box.
- electrical space heaters and the associated switch-gear
- other electrical equipment in individual cases with the agreement of BKI

1.3 The following explosion groups and temperature classes are applicable:

- for battery rooms: IIC, T1
- for paint and oil lamp rooms: IIB, T3
- for storerooms containing welding gas bottles: IIC, T2

2. Pipe tunnels

In pipe tunnels with fuel lines or with adjacent fuel tanks, all equipment and apparatus shall be fixed installed regardless of the flash point of the fuels. Where pipe tunnels are arranged immediately adjacent to tanks containing combustible liquids with a flash point below 60°, or where these tunnels contain pipes carrying liquids with a flash point below 60 °C, all equipment and apparatus shall have explosion-protected enclosures.

3. Areas with ignitable dust atmosphere

Only lighting fixtures having at least IP 65 type protection may be used in spaces in which ignitable dusts may be present.

The surface temperature of horizontal surfaces and surfaces inclined at up to 60° off horizontal shall in continuous service be at least 75 K lower than the glow temperature of a 5 mm thick layer of the dust. Other electrical installations are to be agreed with BKI.

4. Helicopter landing decks

See Section 14.

F. Selection and Routing of Cables

1. All cables liable to be exposed to the medium being conveyed, to oil vapours or gases and/or laid in zones 0 and 1 shall be provided with armouring or shielding and a watertight, oil-resistant outer sheath.

2. The cables of intrinsically-safe circuits are to be laid at a distance of at least 50 mm from the cables on non-intrinsically-safe circuits. Intrinsically-safe and non-intrinsically-safe circuits may not be laid together in one conduit.

Intrinsically-safe cables and wires shall be marked. If the marking is done by colour, the colour has to be light blue.

3. Flexible lines for connecting portable electric appliances may not be run in spaces with an explosion hazard, except for the lines of intrinsically-safe circuits.

G. Aerials in Hazardous Spaces

1. Transmitting aerials and their rigging shall not be placed in hazardous areas.

2. Wherever possible, receiving aerials should be located in non-hazardous areas. If considerations of structure or radio reception necessitate the siting of receiving aerials in hazardous areas, measures are to be taken to ensure that atmospheric static charges can be discharged without risk.

H. Earthing/Equipotential Bonding

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

2. To avoid static charges, tanks, processing plant, piping systems, etc. shall be permanently linked by electrical conductors and/or earthed to the structure, unless they are electrically connected to the structure by welds or bolts.

These connections shall be accessible for inspection and protected against mechanical damage and corrosion.

3. For helicopter earthing see Section 14.

Section 14

Helicopter Facilities

A. General

Reference is made to the definition of helicopter facilities in Volume 2 - Rules for Structure, Section 9.

B. Lighting

1. General

The lighting arrangements for landing areas are to be so designed that they also comply with current national regulations. The following facilities are normally to be provided:

- perimeter lighting of the landing area
- floodlighting of the landing area
- obstruction lights for marking elevated superstructures
- visual warning system

2. Perimeter lighting

2.1 The perimeter lighting depends on the current national regulations, compare Volume 2 - Rules for Structure, Section 9, A.2.

2.2 Normally shall the helicopter deck be fitted with omni-directional lights in order to enable the landing area to be easily identified at night. The colour of the lights shall meet the requirement of the relevant Authority. These lights shall be uniformly positioned along the perimeter of the helicopter deck and not more than 3 m apart.

An intensity of at least 25 candelas is recommended.

2.3 The lights shall not project more than 25 cm above the plane of the landing area. Use of flush fitting lights or electro-luminescent panels in the obstruction free approach sector perimeter would provide adequate illumination whilst affording minimum obstruction to personnel and equipment movement.

3. Floodlighting of the landing area

3.1 The landing area shall also be floodlit, if intended for night use. The arrangements and aiming of floodlights shall be such that the markings are illuminated and the shadows are kept to a minimum. They shall be arranged so as not to dazzle the pilot and, if elevated and located off the landing area, the system shall not present a hazard to helicopters landing or

taking off. Such floodlights shall be capable of being switched on and off at the pilot's request.

The average illumination intensity is recommended to be at least 10 Lux with a uniform ratio (average to minimum) of not more than 8 to 1.

3.2 It may be necessary to enhance the lighting to improve depth perception, possibly by using discrete floodlighting to the main structure or legs of self-elevating units.

3.3 The wind direction indicator is to be illuminated.

3.4 Undirected and therefore unnecessary light from other parts of the installation/unit shall be avoided at the helicopter deck area. Adequate shielding of helicopter deck "polluting" light sources shall already be considered in the early design stage or shall also be minimised on existing installations/units. Temporary working lights which pollute the helicopter deck lighting environment should be switched off for helicopter operations.

It is also important to confine the helicopter deck lighting to the landing area, since any light overspill may cause reflections from the sea.

4. Obstruction lights

4.1 For the guidance of helicopter pilots, obstructions such as elevated superstructures, drilling towers, processing plant, crane booms, tops of legs, etc. are to be marked with red obstruction lights.

Objects which are more than 15 m higher than the landing area shall be fitted with intermediate red lights of the same intensity spaced at 10 metre intervals down to the level of the landing area (except such lights would be obscured by other objects).

4.2 Lights should be used which conform to the recommendations of the International Civil Aviation Organization (ICAO).

4.3 The lights are to be assigned to more than one circuit so that not all the lights are simultaneously extinguished in the event of a fault.

5. Visual warning system

5.1 If a condition can exist on an installation/unit which may be hazardous for the helicopter or its occupants, a visual warning system should be installed according to national regulations.

This system (status lights) may be a flashing red light which is visible to the pilot from any direction of approach and on any landing heading.

5.2 The system shall be automatically initiated at the appropriate hazard level, e.g. gas alarm, crane travel, etc., as well as being capable of manual activation.

6. Feeding and control

6.1 The lighting systems according to 2. to 5. are to be supplied from a common lighting switchboard. Each circuit shall be protected against short circuit and overload. Supplies to the switchboard are to be run from the main switchboard and the emergency switchboard of the installation/unit and are to be fed from an Uninterrupted Power Supply (UPS) system.

6.2 The control of the lighting shall be possible from a central position overlooking the complete helicopter operations. It shall be executed by the officer responsible for flight operations on the installation/unit, who shall be able to report any failures or outages immediately to the helicopter pilot.

C. Protection

1. Electrical appliances located within the open range of the helicopter landing area, like the lights defined in B., shall meet the requirements of IP 55 type protection or better.

2. Electrical equipment, including the aviation fuel handling system according to Volume 2-Rules for Structure, Section 9, E., shall be explosion protected conforming to temperature class T3 and an explosion group II A suitable for installation in explosion Zone 1 as a minimum requirement.

3. All equipment used in refuelling operations shall have earthing to the installation/unit.

4. During the whole refuelling procedure, helicopters shall have earthing to the installation/unit. This is to be done by a flexible cable with a minimum cross-section of 6 mm². The cable shall be connected to an electrically conductive and earthed part of the helicopter deck. The free end of the cable shall be fitted with a suitable device permitting easy and reliable connection to the helicopter.

Section 15

Electrical Equipment

A. Electrical Machinery

1. Generators and motors

Electrical machines shall conform to IEC publication 60034 or an equivalent standard.

For high-voltage machines, see also Section 6.

1.1 Materials

Materials for the construction of electrical machines shall conform to the requirements set out in Section 1, J.

For shaft materials, see 1.4.

1.2 Degree of protection

Protection against electric shock, accidental contacts and the entry of foreign bodies and water shall conform to Section 1, K. The degree of required protection shall be assured when the equipment is installed and in operation.

1.3 Ventilation and cooling

1.3.1 The construction of machines with coolants other than air shall be agreed with BKI considering the operating conditions.

1.3.2 Draught ventilation

The supply air to draught-ventilated machines shall be as far as practicable free of moisture, oil vapours and dust. If required, filters shall be provided.

1.3.3 Enclosed air cooling circuit

Where heat-exchangers are used in the air circuit, they shall be designed and mounted in such a way that condensation or leakage water from the exchanger system is kept away from the machine windings.

Leakage monitoring is required. The water supply lines and recirculating lines of each heat-exchanger shall be fitted with shut-off valves. The air ducts shall be provided with inspection holes for visual observation of the heat-exchanger.

A failure of cooling (air filters, fan flaps, forced ventilation, recooling) shall be alarmed, e.g. by monitoring of the cooling air temperature.

Machines for electric propulsion plants shall be equipped with monitoring devices in accordance with Section 12.

Machines fitted with brushes shall be ventilated in such direction that fines from the brushes does not enter the inside of the machine.

1.3.4 Surface cooling

Surface-cooled machines on the open deck shall have external fans only if they are fully protected against icing.

1.4 Construction of shafts

The materials for the shafts of

- motors of electric propulsion plants
- main generators supplying the motors of electric propulsion plants
- shaft generators or supplementary electrical drives, if their shafts form part of the unit's main shafting

shall conform to Rules for Materials, Volume V.

Proof shall take the form of a BKI acceptance test Certificate, similar as for propeller shafts.

Welds on shafts and rotors shall comply with Rules for Welding, Volume VI.

1.5 Bearings and bearing lubrication

1.5.1 Plain bearings

Bearing shells shall be easily replaceable. Provision shall be made for checking the bearing lubrication. Adequate lubrication shall be assured even in inclined positions in accordance with Section 1, Tables 1.2 - 1.4. No oil shall flow out and penetrate into the machine.

In the case of bearings with forced lubrication, failure of the oil supply and the attainment of excessive bearing temperatures shall cause an alarm.

Two-part bearings shall be fitted with thermometers indicating, wherever possible, the temperature of the lower bearing shell.

Turbogenerators and propulsion motors shall be equipped with devices which, in the event of a failure of the normal lubricating oil supply, provide adequate lubrication until the machine has come to standstill.

1.5.2 Prevention of bearing currents

To avoid damage to bearings, it is essential to ensure that no harmful currents can flow between bearing and shaft.

1.6 Standstill heating system

Generators and main propulsion motors with an output ≥ 500 kW and all transverse-thruster motors shall be equipped with an electric heating designed to maintain the temperature inside the machine at about 3 K above ambient temperature.

An indicator shall show when the standstill heating system is in operation.

1.7 Accessibility for inspection, repairs and maintenance

Components like commutators, sliprings, carbon brushes and regulators for example shall be accessible for inspection, repairs and maintenance.

For larger machines with plain bearings, provision shall be made for the direct or indirect measurement of the air gap.

1.8 Windings

In interaction with the specified protection devices, machines shall be able to withstand the dynamic and thermal stresses likely to result from a short circuit.

Machines shall be designed and rated in such a way that the permissible temperature rises listed in Table 15.3 are not exceeded.

All windings shall be effectively protected against the effects of oil vapours and air laden with moisture or salt.

1.9 Air gaps

Machines with only one internal bearing shall have a minimum air gap of 1,5 mm.

1.10 Brush rocker

The operation position of the brush rocker shall be clearly marked.

1.11 Terminal boxes

Terminal boxes shall be located in accessible positions. Separate terminal boxes are required for terminals with service voltages above 1000 V AC or 1500 V DC.

Terminals shall be clearly marked. The degree of protection of terminal boxes shall correspond to that of the machine, but shall in no case be less than IP 44, see Section 1, K.

1.12 Voltage regulators

Regulators shall withstand the loads expected at the place of installation, see Section 1.

The installation of regulators in terminal boxes is only permitted if the regulator units are mechanically separated so that they cannot be damaged during the mounting of the main cables.

Set point adjusters shall be so designed that shifting of themselves is impossible, and they shall be adjustable from outside by use of a tool only.

1.13 Operation in network with semiconductor converters

Electric machines operating in networks containing semiconductor converters shall be designed for the expected harmonics of the system. A sufficient reserve shall be considered for the temperature rise, compared with a sinusoidal load.

1.14 Rating plate

Machines shall be fitted with durable corrosion-resistant rating plates.

2. Magnetic brakes

The requirements stated in 1. shall be applied correspondingly.

The temperature rise of the windings shall not exceed the permitted values shown in Table 15.3.

Where windings are located in the immediate vicinity of the brake linings, the heat generated during braking shall be considered.

3. Magnetic clutches

The requirements stated in 1. shall be applied correspondingly.

When engaged, the clutch shall take over the drive smoothly and reliably. The clutch shall exert no axial thrust.

4. Testing of electrical machinery

4.1 General

All electric machines shall be tested at the manufacturer's works.

A works test report shall be prepared covering the tests performed.

The tests shall be performed in accordance with the details given in 4.4. BKI reserve the right to stipulate additional tests in the case of new types of machines or where it is required for another particular reason.

4.2 Tests in the presence of the Surveyor

The machines listed below are subject to testing in the manufacturer's works in the presence of the BKI Surveyor:

4.2.1 Generators and motors for essential equipment with outputs of 50 kW or kVA and over.

Table 15.1 Summary of test to be carried out

No.	Tests	AC generators		Motors	
		Type test ¹	Routine test ²	Type test ¹	Routine test ²
1	Technical documentation check, visual inspection	X	X	X	X
2	Winding resistance measurement	X	X	X	X
3	Operational test	X	X	X	X
4	Heat run test	X	–	X	–
5	Load test	X	–	X	–
6	Overload, overcurrent test	X	X	X	X
7	Short circuit test	X	–	–	–
8	Overspeed test	X	X	X	X
9	Winding test (High-voltage test)	X	X	X	X
10	Insulation resistance measurement	X	X	X	X
11	Degree of protection check	X	–	X	–
12	Bearing check	X	X	X	X
13	Test of voltage regulator, see Section 3, C.2. ³	X	X	–	–
¹ test of the first machine of a series ² test of all other machines of the series ³ test together with 5					

4.2.2 Material test for shafts of:

- motors of electric propulsion plants
- main generators supplying the motors of electric propulsion plants

4.3 Works test reports

On request, works test reports shall be presented for machines not tested in the presence of the BKI Surveyor.

4.4 Extent of tests

Regarding scope of tests see Table 15.1.

4.4.1 Check of technical documentation and visual inspection.

4.4.2 Measurement of winding resistance

The winding resistances shall be measured and recorded.

4.4.3 Operational test

The fully assembled machines, including all control and supplementary elements (e.g. winding and bearing temperature sensors, current and voltage transformers), shall undergo operational tests.

Generators shall be tested with their excitation systems.

4.4.4 Heat test

4.4.4.1 A heat test shall be performed until the steady state temperature corresponding to the required mode of operation is reached. The steady-state temperature passes 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 15.3 shall not be exceeded.

4.4.4.2 An extrapolation of the measured values to the disconnection time ($t = 0$) is not necessary if the reading takes place within the periods listed in Table 15.2.

Table 15.2 Time limits for data acquisition

Rated power [kW/kVA]	Time elapsed after disconnection [s]
up to 50	30
over 50 up to 200	90
over 200 up to 5000	120
over 5000	by agreement

4.4.4.3 Heat tests on machines of identical construction made not more than 3 years previously can be recognized.

The referenced temperature rise shall be at least 10 % lower than that listed in Table 15.3

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

4.4.5 Load characteristics

For generators the voltage, and for motors the speed shall be checked as a function of the load.

4.4.6 Overload, overcurrent test

The overload test shall be performed:

- for generators at 1,5 times the rated current for two minutes
- for motors where no particular assessments are made, at 1,6 times the rated torque for 15 seconds. During the tests the motors shall not deviate substantially from their rated speeds. Three phase motors shall not pull-out.
- for anchor windlass motors, at 1,6 times the rated torque for two minutes. Overload tests already performed on motors of identical construction may be recognized. The current of the operating stage corresponding to twice the rated torque shall be measured and indicated on the rating plate.

4.4.7 Short-circuit test

4.4.7.1 On all synchronous generators, the steady short-circuit current shall be determined with the exciter unit in operation.

With a three-phase short circuit between terminals, the steady short-circuit current shall not be less than three times the rated current, and shall not be greater than six times the rated current. The generator and its exciter unit shall be capable of withstanding the steady

short-circuit current for a period of two seconds without suffering damage.

4.4.7.2 A short-circuit withstand test may be demanded

- to determine the reactances
- if there is any concern regarding mechanical and electrical strength.

Synchronous generators which have undergone a short-circuit withstand test shall be thoroughly examined after the test for any damage.

4.4.8 Overspeed test

As proof of mechanical strength, a two-minute overspeed test shall be carried out as follows:

- for generators with their own drive, at 1,2 times the rated speed
- for generators coupled to the main propulsion plant and not arranged in the main shafting, at 1,25 times the rated speed
- for motors with one nominal speed, at 1,2 times the no-load speed
- for variable-speed motors, at 1,2 times the maximum no-load speed
- for motors with series characteristics, at 1,2 times the maximum speed shown on the rating plate, but at least at 1,5 times the rated speed

The overspeed test may be dispensed with in the case of squirrel-cage machines.

4.4.9 Winding test (high-voltage test)

4.4.9.1 The test voltage shall be as shown in Table 15.4. It shall be applied for one minute for each single test.

The voltage test shall be carried out between the windings and the machine housing, the machine housing being connected to the windings not involved in the test. This test shall be performed only on new, fully assembled machines fitted with all their working parts.

The test voltage shall be a practically sinusoidal AC voltage at system frequency.

The maximum anticipated no-load voltage or the maximum system voltage is to be used as reference in determining the test voltage.

4.4.9.2 Any repetition of the voltage test which may be necessary shall be performed at only 80 % of the nominal test voltage specified in Table 15.4.

4.4.9.3 Electrical machines with voltage ratings according to Section 6 shall be subjected to a lightning impulse withstand voltage test according to IEC publication 60034-15. The test shall be carried out for the coils as a random sample test.

Table 15.3 Permitted temperature rises of air cooled machines at an ambient temperature of 45 °C (difference values in K)

No.	Machinery component		Method or measurement ³	Insulation class				
				A	E	B	F ¹	H ¹
1	AC windings of machines		R	55	70	75	100	120
2	Commutator windings		R	55	70	75	100	120
3	Field windings of AC and DC machines with DC excitation, other than those specified under 4		R	55	70	75	100	120
4	a) Filed windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors		R	–	–	85	105	125
	b) Stationary field windings of DC machines having more than one layer		R	55	70	75	100	120
	c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer		R Th	55	70	75	95	115
	d) Single-layer field windings of AC and DC machines with exposed bare or varnished metal surfaces and single-layer compensation windings of DC machines		R Th	60	75	85	105	125
5	Permanently short-circuited, insulated windings		Th	55	70	75	95	115
6	Permanently short-circuited, uninsulated windings		The temperature rises of these parts shall in no case reach such values that there is a risk of injury to any insulation or other material an adjacent parts or to the item itself					
7	Iron cores and other parts not in contact with windings							
8	Iron cores and other parts in contact with windings		Th	55	70	75	95	115
9	Commutators and slip rings, open or enclosed		Th	55	65	75	85	105
10	Plain bearings	measured in the lower bearing shell or in the oil sump after shut-down		45				
11	Roller bearings Roller bearings with special grease	measured in the lubrication nipple bore or near the outer bearing seat		45 75				
12	Surface temperature			Reference 35 ²				
<p>¹ These values may need correction in the case of high-voltage AC windings.</p> <p>² Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidentally touched and there is a risk of burns (> 80 °C), BKI reserve the right to request means of protection such as a handrail to prevent accidental contacts.</p> <p>³ R = resistance method, Th = thermometer method</p>								

4.4.10 Determination of insulation resistance

The insulation resistance measurement shall be carried out at the end of the test sequence, with the machine at operating temperature, if possible.

Minimum values of the measuring voltage and the insulation resistance shall be taken from Table 15.5.

The maximum anticipated no-load voltage or the maximum system voltage shall be taken for the rated voltage.

4.4.11 Test of degree of protection

See Section 1, K.

4.4.12 Bearing check

Plain bearings shall be opened and examined after the test.

4.4.13 Test of voltage regulator

See Section 3, C.2.

B. Transformers and Reactance Coils

1. General

1.1 Transformers and reactance coils shall conform to IEC publication 60076 - Power Transformers or an equivalent standard.

For high voltage machines see Section 6.

1.2 Coolant

Only dry-type transformers may be used on board of mobile units.

For separately cooled transformers the cooling air shall be monitored.

For oil-filled transformers on fixed installations, preferably non-inflammable insulation oil should be used.

1.3 Windings

All transformers shall have separate windings for primary and secondary coils except for starting and ignition transformers, which may be of the auto transformer type.

2. Rating

2.1 Voltage variation during loading

Under resistive load, the voltage variation between no-load and full load may not exceed 5 %.

This requirement does not apply to short-circuit proof transformers.

2.2 Temperature rise

The limit temperature rise of windings may not exceed the values shown in Table 15.6.

Parts of casings with surface temperatures exceeding 80 °C shall be protected against unintentional contact.

2.3 Short circuit resistance

Transformers, in co-operation with their protection devices shall be able to withstand without damage the effect of external short circuits.

3. Rating plate

Transformers shall be fitted with a durable corrosion-resistant rating plate.

4. Tests

4.1 Transformers shall be tested in the manufacturer's works. Transformers rated at more than 100 kVA shall be tested in the presence of the BKI Surveyor. A works test report covering the tests carried out is to be prepared.

The works tests reports shall be presented to BKI on request.

The following tests shall be carried out. The tests according to 4.3 – 4.6 shall be performed at approximately operating temperature.

4.2 Heat test

The test shall be performed to determine the temperature rise, which shall not exceed the maximum permissible values in Table 15.6.

Temperature rise tests on transformers of identical construction manufactured not more than 3 years previously may be recognized. The referenced temperature rise shall be 10 % below the values shown in Table 15.6.

4.3 Induced overvoltage test

The windings shall be tested at twice the rated voltage and at increased frequency to verify that the insulation between turns is satisfactory.

The duration of the test shall be

$$120 \text{ s} \cdot \text{rated frequency} / \text{test frequency}$$

but not less than 15 s.

4.4 Short circuit test

Where required, short circuit proof property in accordance with 2.3 shall be verified.

4.5 Winding test

The test voltage shown in Table 15.7 shall be applied between the winding parts to be tested and all other windings, which are to be connected to the core and frame during the test.

The test voltage shall be applied for one minute.

Table 15.4 Test voltages for the winding test

No.	Machine or machinery component	Test voltage (rms) dependent on rated voltage U of the subject winding
1	Insulated windings of rotating machines of output less than 1 kW (kVA), and of rated voltages less than 100 V with the exception of those in items 4 to 8	2 U + 500 V
2	2 Insulated windings of rotating machines of size less than 10000 kW (kVA), with the exception of those in item 1 and items 4 to 8	2 U + 1000 V, with a minimum of 1500 V
3	Insulated windings of rotating machines of size 10000 kW (kVA) or more with the exception of those in items 4 to 8, and a rated voltage up to 11000 V	2 U + 1000 V
4	Separately excited field windings of DC machines	1000 V + twice the maximum excitation voltage but not less than 1500 V
5	<p>Field windings of synchronous generators, synchronous motors and rotary phase converters</p> <p>a) rated field voltage up to 500 V</p> <p>b) over 500 V</p> <p>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</p> <p>When the machine is intended to be started either with the field winding connected across a resistance of value equal to, or more than, ten times the resistance of the winding, or with the field windings on open-circuit with or without a field dividing switch</p>	<p>10 times rated field voltage with a minimum of 1500 V</p> <p>4000 V + twice rated field voltage</p> <p>10 times the rated field voltage, minimum 1500 V, maximum 3500 V</p> <p>1000 V + twice the maximum value of the rms voltage, which can occur under the specified starting conditions, between the terminals of the field winding, or in the case of a sectionalized field winding between the terminals of any section with a minimum of 1500 V</p>
6	<p>Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheostatic starting)</p> <p>a) for non-reversing motors or motors reversible from standstill only</p> <p>b) for motors to be reversed or braked by reversing the primary supply while the motor is running</p>	<p>1000 V + twice the open-circuit standstill voltage as measured between slip rings or secondary terminals with rated voltage applied to the primary windings</p> <p>1000 V + four times the open-circuit secondary voltage as defined in item 6a)</p>
7	<p>Exciters (exception below)</p> <p>Exception 1: Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting</p> <p>Exception 2: Separately excited field windings of exciters</p>	<p>as for the windings to which they are connected</p> <p>twice rated exciter voltage + 1000 V, with a minimum of 1500 V</p> <p>as under item 4</p>
8	Assembled group of machines and apparatus	A repetition of the test in items 1 to 7 above should be avoided if possible, but if a test on an assembled group of several pieces of new machines, each one of which has previously passed its high-voltage test, is made, the test voltage to be applied to such assembled group shall be 80 % of the lowest test voltage appropriate for any of the group. ¹
<p>¹ Where a number of windings belonging to one or more machines are connected together, the test voltage is dictated by the maximum voltage to earth which can occur.</p>		

Table 15.5 Minimum values for measurement voltage and insulation resistance

Rated voltage [V] ¹	Measurement voltage [V]	Insulation resistance [MΩ]
$U_n \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$1 + U_n/1000$
$7200 < U_n \leq 15000$	5000	$1 + U_n/1000$

¹ The maximum anticipated no-load voltage or the maximum system voltage shall be taken for the rated voltage.

Table 15.6 Permissible temperature rise of transformer and reactance coil windings at an ambient temperature of 45 °C

Insulation class	A	E	B	F	H
Temperature rise [K]	55	70	75	95	120

4.6 Determination of insulation resistance

The measurement of insulation resistance shall be carried out at the end of the test sequence with a DC voltage of at least 500 V.

The insulation resistance shall be at least:

- 5 MΩ between primary and secondary winding
- 2 MΩ for the remaining insulation

C. Capacitors

1. General

The requirements of this Section apply to power capacitors with a reactive power of 0,5 kVA and over.

2. Construction

2.1 Capacitors shall have gastight steel cases.

The metal cases shall have means for the connection of earthing conductors.

The dimensional design of capacitors shall be such that, if the case is damaged, not more than 10 litres of impregnating agent can leak out.

2.2 Internal faults shall be limited by element fuses.

2.3 Discharge resistors shall ensure the discharge of the capacitor to a terminal voltage below 50 V within one minute after disconnection.

3. Testing

A type test report shall be submitted for each capacitor on request.

4. Selection and operation

4.1 The dissipation of heat by convection and radiation shall be ensured. In locations with a high ambient temperature, capacitors of a higher temperature class shall be used.

4.2 The capacitor voltage rating shall be selected in accordance with the operating voltage of the power system, with due regard to a possible voltage increase caused by the capacitor and any inductances in series.

4.3 In systems with high levels of harmonics, capacitors shall be protected against overloading by the use of series inductors and/or by selecting a higher capacitor voltage rating.

4.4 To avoid self-excitation of individually compensated motors, the compensation power shall not exceed 90 % of the no-load reactive power of the motor.

4.5 Reactive power controllers or electrical interlocks are required to avoid overcompensation of the installation's/unit's main.

Table 15.7 Test voltage for transformers and reactance coil windings

Maximum operating voltage [V]	Alternating withstand voltage [V]
≤ 1000	3000
≤ 3600	10000
≤ 7200	20000
≤ 12000	28000
< 17500	38000

D. Storage Batteries and Chargers

1. General

1.1 These requirements apply to stationary storage batteries and chargers.

1.2 Rating of batteries

Storage batteries shall be so rated that they can supply the consumers for the required period, in accordance with the energy balance, when charged to 80 % of their rated capacity.

At the end of the supply period, the voltage at the battery or at the consumers shall conform as a minimum requirement to the values indicated in Section 1, F. and Section 3, D.

1.3 References to other rules

See Section 2, B. and Section 3.

2. Storage batteries

2.1 Permitted are lead-acid storage batteries with dilute sulphuric acid as electrolyte and steel batteries with nickel-cadmium cells and dilute potassium hydroxide as electrolyte.

2.2 Other types of storage batteries such as silver/zinc batteries or sealed lead-acid batteries may be permitted, if their suitability for offshore use is proven.

2.3 In case of mobile units storage batteries shall be so designed that they retain their rated capacity at inclinations of up to 22,5°, and no electrolyte leaks out at inclinations of up to 40°. Cells without covers are not allowed.

2.4 The casing shall be resistant to electrolytes, mineral oils, cleaning agents and corrosion by saline mist. Glass and readily flammable materials shall not be used for battery casings.

2.5 For storage batteries containing liquid electrolyte it shall be possible to check the electrolyte level. The maximum permissible electrolyte level has to be marked.

2.6 The weight of the greatest transportable unit shall not exceed 100 kg.

2.7 The nominal operating data of storage batteries shall be indicated on rating plates.

2.8 Storage batteries shall be maintained and operated in accordance with the manufacturer's instructions.

3. Chargers

3.1 Charging equipment shall be so rated that discharged storage batteries can be charged to 80 % of their rated capacity within a period not greater than 10

hours without exceeding the maximum permissible charging currents.

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

3.2 If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120 % of the rated voltage.

The power demand of the consumers shall be considered for the selection of the chargers.

3.3 Chargers with a charging power above 2 kW shall be tested in presence of the BKI Surveyor.

E. Switchgear and Protective Devices

1. General

1.1 Switchgear and protective devices shall conform to IEC Publications or to another standard recognized by BKI.

1.2 For materials and insulation, see Section 1, J.

1.3 For equipment and components subject to mandatory type approval, see Section 5, H. and Section 16, E.

2. High-voltage switchgear

For details of high voltage switchgear, see Section 6.

3. Low-voltage switchgear

3.1 Circuit breakers

3.1.1 Drives

- Power-driven circuit-breakers shall be equipped with an additional emergency drive for hand-operation.
- Mechanical actuating elements on circuit breakers for generators and essential circuits shall be so connected to the circuit-breakers that they cannot be lost.
- Circuit-breakers with a making capacity exceeding 10 kA shall be equipped with a drive which performs the closing operation independently of the actuating force and speed (by snap action).
- If the conditions for the closing operation are not fulfilled (e.g. undervoltage release not energized), switching-on shall not cause the contact pieces to come into contact.

3.1.2 Making and breaking capacity

The making and breaking capacity shall be tested in accordance with IEC publication 60947-2. Other standards may be recognized.

4. Protection devices

4.1 Short-circuit protection

Short-circuit protection devices shall be independent of energy supplied from other circuits than those to be protected. In the event of a short circuit, the total break-down of the supply voltage shall be expected.

Short-circuit protection devices for generators shall be equipped with reclosing inhibitors, and shall be delayed for selective disconnection.

4.2 Overcurrent protection

The operation of overcurrent relays shall not be influenced by the ambient temperature. Thermal bimetallic relays shall be temperature compensated.

Overcurrent relays for motor protection shall be adjustable and provided with a reclosing inhibitor.

4.3 Undervoltage protection

Undervoltage relays shall cause the circuit-breaker to open if the voltage drops to 70 % - 35 % of the rated voltage. Undervoltage relays of generator circuit-breakers shall have a delay up to 500 ms.

4.4 Shunt trips

Shunt trips shall ensure the disconnection of the circuit-breakers even if the voltage drops to 85 % of the rated voltage.

4.5 Electronic protection devices

Electronic protection devices shall remain operative at their maximum permissible load at an ambient temperature of 55 °C.

4.6 Reverse power protection

The reverse power protection device shall respond to the active power regardless of the power factor, and shall operate only in the event of reverse power.

The response value and pick up time shall be adjustable.

The reverse power protection device shall remain operative despite a voltage drop to 60 % of the rated value.

4.7 Phase failure protection

Protection devices for detection of a single-phase failure in three-phase circuits shall operate instantaneously.

Bimetallic relays with differential release do not constitute phase failure protection devices in the opinion of these Rules.

4.8 Check synchronizers

Check synchronizers for the protection of an alternator against parallel connection at an unacceptable phase angle shall allow parallel switching only up to an

angular deviation (electrical) of 45° and up to a frequency difference of 1 Hz.

The check synchronizer shall ensure that parallel switching is impossible if the supply or measuring voltage fails or in the event of failure of any component.

4.9 Insulation monitoring equipment

Devices for insulation monitoring of unit's / installation's mains shall continuously monitor the insulation resistance of the network, and shall release an alarm should the insulation resistance of the system fall below 50 Ohms per volt of the operating voltage.

The measuring current shall not exceed 30 mA in the event of a dead short circuit to earth.

F. Cables and Insulated Wires

1. General

1.1 Cables and wires shall be flame-retardant and self extinguishing as per IEC 60332.

1.2 If cable- and wire types have passed a bundle fire test according to IEC publication 60332-3, category A/F or IEEE 45.-18.13.5, the installation of fire stops is dispensed with when laying in bundles (see also Section 11, D.14 and SOLAS, Chapter II-1, Part D, Rule 45.5.2).

1.3 Where fire-resistant cables shall be used, it is permitted to use cables with retention of insulating capability in accordance with IEC publication 60331 (see also Section 11, D.15).

1.4 Cables manufactured in accordance with the relevant recommendations of IEC publication 60092-350, 60092-351, 60092-352, 60092-353, 60092-354, 60092-359, 60092-373, 60092-374, 60092-375 and 60092-376 will be accepted by BKI provided that they are tested to its satisfaction.

Cables manufactured and tested to standards other than those specified like above-mentioned will be accepted provided they are in accordance with an acceptable and relevant international or national standard.

2. Conductor material and structure

2.1 Electrolytic copper with a resistivity not exceeding 17,241 Ohm mm²/km at 20 °C is to be used as the material for the conductors of cables and wires.

2.2 If the insulation consists of natural or synthetic rubber vulcanized with sulphur, the individual conductor wires shall be tinned.

2.3 The conductors of movable wires shall be fine-stranded.

The conductors of permanently laid cables and wires shall be made of stranded copper conductors (class 2) or flexible stranded copper conductors (class 5).

Unifilar (solid) conductors up to 4 mm² in cross-section are permitted for the final sub-circuits of room lighting and space heating systems in the accommodation.

Solid conductors up to 4 mm² in cross-section are permitted for final subcircuits of room lighting and space heating systems in the accommodation and for special cables of TV and multimedia applications.

3. Material and wall thickness of insulating covers

The materials used for insulation shall be of standardized types for which the maximum permissible temperatures at the conductors during undisturbed operation are specified.

4. Protective coverings, sheaths and braids

4.1 Single-core cables shall have a suitable separating layer of filler material or foil over the core insulation.

4.2 Multi-core cables shall have a common core covering made of filler material or shall have a wrapping and sheath.

4.3 Only materials of a standardized type may be used for non-metallic sheaths. In all cases the thermal stability of the compounds used shall correspond to that of the insulating material.

4.4 Braids shall be made of corrosion-resistant material such as copper or copper alloy or of material treated to prevent corrosion, e.g. galvanized steel.

4.5 Outer metallic wire braids shall have a coating of protective paint, which shall be lead-free and flame-retardant. The paint shall be of sufficiently low viscosity when applied to enable it to penetrate readily into the wire braid. When dry, it shall not flake off when the cable is bent around a mandrel with a diameter 15 times that of the cable.

5. Identification

5.1 Each cable shall be marked for type and for name of manufacturer.

5.2 The cores of multi-core cables and wires shall have a permanent marking. In multi-core cables and wires where the cores are arranged in a number of concentric layers, two adjacent cores in each layer shall be coloured differently from each other and from all other cores, unless the individual cores are otherwise unambiguously identified, e.g. by printed numbers.

5.3 Protective earth conductors shall have green/yellow colour coding.

5.4 Cables for intrinsically safe circuits shall to be easily identifiable. If the colour of the cable sheath is used as identification, light blue sheath shall be used.

5.5 High-voltage cables shall have a red outer sheath.

6. Approvals

6.1 Cables and wires are subject to mandatory type approval by BKI.

6.2 Proof is required by the manufacturer by issue of workshop test reports stating that the continuous production is made in conformity to relevant standards and is verified by individual and sample tests for each production length of cables. These reports shall record any deviations from the standards.

6.3 The application of cables and wires without type test is subject to an agreement with BKI in every case. Individual and sample tests performed at the manufacturer's works on each lengths delivered are required for these cables, see 7.3.

7. Tests

7.1 For type tests see Section 16, E.

7.2 If not specified in the standards, the following tests shall be performed as an additional requirement:

Ozone tests on cable sheaths whose basic material consists of natural or synthetic rubber. Test conditions shall be:

- Ozone concentration: 250 - 300 ppm
- Temperature: (25 ± 2) °C
- Duration: 24 h

The test shall be carried out in accordance with IEC publication 60811-2-1.

Other equivalent test methods may be agreed with BKI.

The test is passed satisfactory if no cracks will be discovered visible to the naked eye.

7.3 Individual tests on non-type-tested cables and wires shall be performed in the manufacturer's works in the presence of the BKI Surveyor.

The scope of the tests shall be agreed with BKI in advance.

The following tests shall be carried out at least:

- conductor resistance
- dielectric strength
- insulation resistance
- dimensions and construction of samples
- mechanical strength characteristics of samples

G. Cable Penetrations and Fire Stops

1. Bulkhead and deck penetrations

1.1 For sealing compounds and packing systems see Section 16, E.

1.2 The requirements for bulkhead and deck penetrations are stated in Section 11, D.8.

1.3 Type tests shall be performed in the manufacturer's works or in acknowledged independent institutions according to the Regulations for the Performance of Type Tests, Part 4 : Test Requirements for Sealing Systems of Bulkhead and Deck Penetrations.

2. Fire stops

2.1 The requirements for fire stops using steel plates or coatings are stated in Section 11, D.14.

2.2 The construction of fire stops using coatings shall undergo a type test in the presence of the Surveyor from BKI Head Office in the manufacturer's works or in independent institutes.

The test requirements shall be agreed with BKI.

H. Installation Material

1. General

1.1 The installation material shall conform to IEC Publications. Other standards may be recognized by BKI.

1.2 It is necessary to ensure that terminals are suitable for the connection of stranded conductors. Exceptions are permitted for systems with solid conductors (e.g. lighting, socket-outlets and heating appliances in the accommodation area).

The method of connection shall be compatible with the terminals used.

1.3 For materials, see Section 1, J.

2. Plug-and-socket connections

2.1 Depending on their application, the design of plug-and-socket connections shall conform to the following regulations:

- in the accommodation area, day rooms and service rooms (up to 16 A, 250 V AC) - IEC publication 60083 or 60320
- power circuits (up to 250 A, 690 V AC) - IEC publication 60309-1 and 60309-2
- electronic switchgear - IEC publications, e.g. 60130 and 60603

I. Lighting Fixtures

1. General

Luminaries, floodlights and searchlights are to conform to IEC Publications 60598 and 60092-306. Other standards may be recognized by BKI.

The requirements stated in H.1. shall be observed.

2. Design

2.1 The surface temperature of easily touchable parts of light fittings shall normally not exceed 60 °C.

2.2 High-power lights with higher surface temperatures are to be protected against unintentional contact by additional means.

2.3 The terminals and spaces for the connection of cables shall not reach a higher temperature permissible for the insulation of the wires or cables used. The temperature rise in the terminal box shall not exceed 40 K.

2.4 All the metal parts of a light fitting shall be conductively connected to each other and shall be provided with a suitable terminal for earthing.

2.5 Wiring inside lighting fixtures shall have a minimum cross section of 0,75 mm². A cross section of at least 1,5 mm² is to be used for through wiring.

Heat-resistant wires are to be used for internal wiring.

2.6 Each luminaire shall be durably marked with the following details:

- maximum permitted lamp wattage
- minimum mounting distance

2.7 Supports of live parts in lamp holders shall be at least of flame retardant material for fluorescent lamps and at least of incombustible material for incandescent lamps.

2.8 Searchlights and arc lamps

2.8.1 All parts of searchlights or arc lamps to be handled for their operation or adjustment while in use shall be so arranged that there is no risk of shock to the operator.

2.8.2 Disconnection of every searchlight or arc lamp shall be by a multi-pole (all poles) disconnecting switch.

If a series resistor is used with an arc lamp, the disconnecting switch shall be so placed in the supply circuit that both the series resistor and arc lamp are disconnected when the switch is in the off position.

2.9 Portable luminaires

2.9.1 Portable luminaires shall be so constructed and arranged that there is no risk of shock to the Operator, in accordance with one of the methods given in the following:

- supply from an isolating transformer supplying one luminaire only
- supply at extra low voltage
- double or reinforced insulation
- earthing by means of an earth continuity conductor

2.9.2 Portable luminaires intended to be used on decks, in holds, engine rooms and other similar spaces shall be provided with a hook or ring by which the luminaire can be suspended to avoid stress on the supply cable.

J. Electrical Heating Equipment

1. General

1.1 Electrical heating equipment and boilers shall conform to IEC Publications, e. g. 60335, with particular attention to IEC 60092-307. The general provisions set out in H.1. shall be observed.

1.2 The connections of power supply cables shall be so arranged that temperatures higher than permitted for terminals and supply cables do not arise.

1.3 Controls in operation such as switch knobs and handles shall not attain temperatures higher than

- 55 °C for metal parts, or
- 65 °C for parts made of porcelain, glass, moulded plastics or wood

A temperature 5 °C higher is permissible for parts operated by finger tipping only.

1.4 Only heating elements with shrouded or ceramic- embedded heating coils shall be used. Infrared radiators are permitted.

2. Design

2.1 Space heaters

2.1.1 The casing or enclosure of each heater shall be so designed that no objects can be placed on it and air may circulate freely around the heating elements.

2.1.2 Electrical space heaters shall be so designed that, based on an ambient temperature of 20 °C, the temperature of the casing, enclosure or cover and of the air flow from the heater does not exceed 95 °C under defined test conditions.

2.1.3 To prevent unacceptable temperature rises due to heat accumulation, each heater shall be fitted with a safety temperature limiter. Automatic reconnection is not permitted.

The safety temperature limiter may be dispensed with for watertight heaters in rooms without substantial fire hazard, e. g. in bathrooms and washing rooms.

The operating switches shall disconnect all live conductors. The switch positions shall be clearly marked at the switches.

2.2 Passage heaters and boilers

Passage heaters and boilers are to be equipped with two mutually independent temperature protection devices; one of them shall be a permanently set safety temperature limiter, while the other may be a thermostatic controller.

Automatic reconnection of the safety temperature limiter is not permitted.

2.3 Electric ranges and cooking facilities

2.3.1 Only enclosed-type hot plates shall be used. It shall not be possible for liquids to penetrate into the electrical equipment.

2.3.2 The switches for the individual plates and heating elements shall disconnect all live conductors. The switch steps shall be clearly marked.

2.3.3 Internal connections shall be made by heat proof terminals and wires and shall be corrosion-resistant.

2.4 Deep-fat cooking equipment

Deep-fat cooking equipment shall be fitted with the following arrangements:

- an automatic or manual fire-extinguishing system tested to an international standard ¹
- a primary and backup thermostat with an alarm to alert the Operator in the event of failure of either thermostat
- arrangements for automatically shutting off the electrical power upon activation of the fire extinguishing system
- an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed
- controls for manual operation of the fire extinguishing system which are clearly labelled for ready use by the crew

¹ Reference is made to standard ISO 15371:2000 "Fire extinguishing systems for protection of galley deep-fat cooking equipment"

3. Non-sparking fans

3.1 A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

3.2 The air gap between the impeller and the casing shall not be less than 0,1 of the shaft diameter in way of the impeller bearing, but not less than 2 mm. It need not be more than 13 mm.

3.3 Protection screens of not more than 13 mm square mesh are to be fitted in the inlet and outlet of ventilation ducts to prevent the entrance of objects into the fan housing.

3.4 The impeller and the housing in way of the impeller are to be made of alloys which are recognised as spark proof by appropriate test.

Electrostatic charges both in the rotating body and the casing are to be prevented by use of antistatic materials.

Furthermore, the installation of the ventilation units is to be such as to ensure the safe bonding to the hull/structure of the units themselves.

3.5 Tests may not be required for fans having the following material combinations:

- impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
- impellers and housings of non-ferrous materials
- impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness on non-ferrous materials is fitted in way of the impeller
- any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip clearance

3.6 The following impellers and housings are considered as sparking and are not permitted:

- impellers of an aluminium alloy or magnesium alloy and a ferrous housing, regardless of tip clearance
- housing made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
- any combination of ferrous impeller and housing with less than 13 mm design tip clearance

Section 16

Surveys and Tests

A. General

1. The following Rules apply to the testing of electrical and electronic installations, equipment and components.

2. Within the framework of their general quality assurance programme, manufacturers shall ensure that the products they manufacture conform to the specified requirements.

Records shall be made, containing quality-assurance measures and tests and shall be handed over to BKI on request.

3. For certain installations, equipment and components, testing is required in the presence of the BKI Surveyor according to these Rules, see C., D. and E.

The tests and items for testing specified below constitute minimum requirements.

BKI reserve the right to demand that tests also be performed on other items, either on the unit/installation or in the manufacturer's works.

4. For appliances of a new type or for equipment which is being used for the first time on units/installations with BKI Class, additional tests and trials are to be agreed between the manufacturer and BKI, if the circumstances this require.

5. It is the aim of the tests to verify conformity with the requirements covered by the Rules for Construction, and to prove the suitability of equipment for its particular application.

6. Tests are divided into:

- examinations of the technical documentation, see B.
- tests in the manufacturer's works, see C.
- tests on units/installations, see D.
- tests for type approvals, see E.

B. Examinations of Technical Documentation

1. The list of documents subject to approval is specified in Section 1, C.

2. The documents which have been examined and approved shall be presented to the BKI Surveyor on request.

C. Tests in the Manufacturer's Works

1. Tests in the presence of the BKI Surveyor

1.1 The tests shall be carried out on the basis of the Rules for Construction and the approved documents. They shall be performed in accordance with a recognized standard.

1.2 Machines, appliances and systems subject to testing in accordance with 2. are to be tested in the presence of the BKI Surveyor unless the preconditions for tests under the own responsibility of the manufacturer are fulfilled, see 3.

2. Machines, appliances and installations subject to testing

2.1 Electrical machines

For scope of tests see Section 15, A.

- a) Generators and motors for offshore units.
- b) Generators and motors for essential equipment, $P \geq 50$ kW/ kVA.
- c) Motors for jack-up systems.
- d) Transformers $P \geq 100$ kVA.
- e) Autotransformers $P \geq 100$ kVA.

2.2 Power electronics

For scope of tests see Section 7, G.

- a) For electric propulsion plants see Section 12, A.
- b) Essential equipment $P \geq 50$ kW/ kVA.
- c) Battery charging $P \geq 2$ kW.

2.3 Switchboards

For scope of tests see Section 5, H. and Section 6, E.3. and Form "Check List for Switchboards"

:

- a) Main switchboards including switchboards for jack-up systems, if applicable.
- b) Emergency switchboards.
- c) Switchboards for electric propulsion plants of offshore units.
- d) Distribution switchboards with connected power ≥ 500 kW.
- e) Starters for motors in accordance with 2.1 b).

2.4 Boiler and thermal oil plants

For scope of tests see Section 5, H.

2.5 Electrical propulsion plants

For scope of tests see Section 12, A.

2.6 Computer systems

For scope of tests see Section 9, D.

3. Tests under the own responsibility of the manufacturer

3.1 The products under 2.1 b), c); 2.2 b), c) and 2.3 d), e) may be tested on the manufacturer's own responsibility if the following preconditions are fulfilled:

- a QM system recognized by BKI is available
- BKI has carried out type tests of the products
- the tests under own responsibility have been agreed with BKI

3.2 Reference is made to Guidelines for the Inspection of Mechanical and Electrotechnical Products.

D. Tests on Units/Installations

1. General

The tests are divided into

- tests during construction
- tests at the building yard
- tests during sea trials for units or at operational location for installations

2. Tests during construction

2.1 During the period of construction of the unit/installation, the systems shall be checked for conformity with the documents approved by BKI and with the Rules for Construction.

2.2 Test Certificates for tests which have already been performed shall be presented to the BKI Surveyor on request.

2.3 Protective measures

Protective measures shall be checked:

- a) protection against foreign bodies and water
- b) protection against electric shock, such as protective earthing, protective separation or other measures as listed in Section 1, K.

c) measures of explosion protection. The design shall conform to the details on Form "Details about the construction of electrical equipment in hazardous areas" or on equivalent documents, submitted by the building yard for approval; see Section 1, D.

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
 - the reliable supply of emergency consumers.
- b) Selection and fixation of cables.
- c) Construction of watertight and fireproof bulkhead and deck penetrations.
- d) Insulation resistance measurement.
- e) For high-voltage installations, see Section 6.

3. Tests at the building yard

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, if applicable, as well as of all the other systems specified in the Rules for Construction.

Unless already required in the Rules for Construction, the tests to be performed shall be agreed with the BKI Surveyor in accordance with the specific characteristics of the subject equipment.

3.2 Generators

3.2.1 A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on Form "Test Report Shipboard Tests of the Electrical Power Supply" or equivalent.

3.2.2 For units, where electrical power is necessary to restore propulsion, it shall be proven that after black-out and dead ship condition (see Section 1, B.14.) the propulsion to the unit in conjunction with required machinery can be restored within 30 min. after black-out. The same conditions apply to the jack-up system.

3.3 Storage batteries

The following shall be tested:

- a) Installation of storage batteries.
- b) Ventilation of battery rooms and boxes, and cross-sections of ventilation ducts.
- c) Storage-battery charging equipment.
- d) Required caution labels and information plates.

3.4 Switchgear

The following items shall be tested under observance of Form "Check List for Switchboards" and on Form "Test Report Shipboard Tests of the Electrical Power Supply"

- 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) Independence 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 reserve the right to demand the proof of selective arrangement of the power 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) The emergency remote stops (see also Section 9, E.) of equipment such as
 - engine room fans
 - fuel pumps
 - separators
 - boiler blowers, etc.

3.7 Control, monitoring and safety systems

For these systems operational tests shall be performed, see Section 9. Further details for testing are to be agreed with BKI.

3.8 Electrical propulsion plants

Regarding scope of tests see Section 12, A.

3.9 Computer systems

Regarding scope of tests see Section 9, D.

3.10 Explosion protection

A check is to be made that equipment in hazardous areas has been designed and installed in accordance

with the relevant requirements defined in Section 13. Design and installation of electrical equipment installed in hazardous areas shall conform to the listing prepared by the building yard, which is subject to approval by BKI, see Section 1, C.1. See also 2.3 c).

3.11 Emergency shut-down system

Tests have to be carried out to simulate all cases for shut-down requirements which are defined in Section 9, E.

4. Overall trials

These trials for the fully completed unit/installation will take place at the following locations:

- for self-propelled units the overall tests will be done at a sea trial
- for non-self-propelled units the overall tests will be done at the building yard, as far as possible
- for fixed installations, which are only completely erected on site, the overall tests will be done at the operational location
- for jack-up systems at a suitable, protected location: details to be agreed with BKI

4.1 Rating of the main- and emergency electrical power supplies

During these trials it shall be proven that the main and emergency electrical power supplies are adequately rated and conform to Section 3 and all control and monitoring devices are functioning according to their assignments.

4.2 Operating reliability during navigation of units

4.2.1 Tests shall be carried out to determine whether all the machines, equipment, etc. constituting the electrical installation are operating satisfactorily at all revolutions of the main engine, particularly during engine and steering gear manoeuvres.

4.2.2 Tests shall be carried out on the restoration of the main and emergency electrical power supplies following a black-out during navigation.

4.2.3 Tests shall be made of network quality in distribution systems supplied by semiconductor converters and in distribution systems with prevailing load by converters.

4.2.4 Electrical propulsion plants of units

Regarding scope of tests see Section 12, A.

4.3 Checks are to be carried out to determine whether all machines, apparatus, systems, etc. constituting the electrical system operate satisfactorily at all operational conditions.

E. Type Approvals

1. General

1.1 The installations, equipment and assemblies mentioned in 2. are subject to mandatory type approval for mobile units.

1.2 For fixed installations type approval is also recommended, but if this is not suitable, components may be approved by BKI case by case.

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

1.4 Type tests are carried out according to Regulations for the Performance of Type Approvals and defined standards.

1.5 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.

1.6 BKI Head Office will decide case by case if tests carried out by other recognized institutions may be considered as equivalent to BKI type tests.

2. Installations, apparatuses and assemblies subject to type testing

2.1 Electrical installations

2.1.1 For cables and accessories see Section 15, F. and G.

- cables and insulated wires
- sealing compounds and packing systems for bulkhead- and deck penetrations
- connecting systems for cable repairs
- busbar trunking systems for the installation

2.1.1 For switchgear see Section 5, H.

- circuit-breakers, load switches, disconnect switches and fuses for direct connection to the main busbars or unfused distribution busbars of main, emergency and propulsion switchboards
- standardized switchgear units manufactured in series with reduced clearance- and creepage distances, see Section 5, F.3

2.1.2 For generator protection devices, see Section 4, A.

- short-circuit protection
- overcurrent protection
- reverse-power protection
- check synchronizer

- underfrequency protection
- over- and undervoltage protection
- differential protection
- earth fault monitoring

2.2 Steering gears and rudder propeller systems

For steering gear and rudder-propeller systems see Section 12, A. and B.

2.2.1 Input devices such as

- phase failure relays
- level sensors

2.2.2 Steering gear control systems with all components important for the function, e.g.

- steering mode selector switch
- follow up/ non follow up control devices

2.3 Machinery control

For machinery control systems, see Section 9.

- open and closed loop control for speed and power of internal combustion engines (main and auxiliary engines) and electrical actuators, see also Section 9, C.11.
- safety devices
- safety systems

2.4 Safety systems

For safety systems, see Section 9, C.

- fire detection and alarm systems
- gas detection system

2.5 Escape direction system

For low level escape direction systems which are electrically supplied see Section 10, A.

2.6 Computer systems

For computer systems, see Section 9, D. These tests apply only to the propulsion part of self-propelled mobile units.

2.7 Propulsion control with automation

For self propelled units with automated and/or remotely controlled propulsion system see Section 12, A.3.

3. Exceptions

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

Section 17

Spare Parts

1. In order to be able to restore machinery operation of offshore installations and units in case of a failure or of wear and tear, spare parts for the essential equipment including the tools necessary for mounting shall be available on board.

For mobile offshore units in addition the manoeuvring capability in the event of damage at sea shall be main-

tained. Therefore spare parts for the main propulsion plant and the essential equipment shall be available aboard of each unit together with the necessary tools.

2. The amount of spare parts shall be documented and a corresponding list shall be carried aboard.