OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

MARCH 2001

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV Offshore Codes consist of a three level hierarchy of documents:

— *Offshore Service Specifications.* Provide principles and procedures of DNV classification, certification, verification and consultancy services.
— *Offshore Standards.* Provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore services.
— *Recommended Practices.* Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

DNV Offshore Codes are offered within the following areas:

A) Qualification, Quality and Safety Methodology

B) Materials Technology

C) Structures

D) Systems

E) Special Facilities

F) Pipelines and Risers

G) Asset Operation

Amendments April 2002

This Code has been amended, but not reprinted in April 2002. The changes are incorporated in the Web, CD and printable (pdf) versions. The amendments are shown in red colour in the Web and CD versions.

All changes affecting DNV Offshore Codes that have not been reprinted, are published separately in the current *Amendments and Corrections*, issued as a printable (pdf) file.

Comments may be sent by e-mail to *rules@dnv.com*
For subscription orders or information about subscription terms, please use *distribution@dnv.com*
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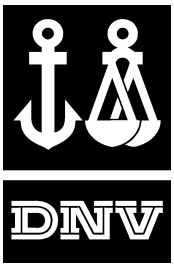
CONTENTS



OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATONS

CHAPTER 1

INTRODUCTION

CONTENTS PAGE

DET NORSKE VERITAS

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SECTION 1
GENERAL

A. Introduction

A 100 Objectives

101 This offshore standard provides principles, technical requirements and guidance for design, manufacturing and installation of electrical installations on mobile offshore units and floating offshore installations.

102 The requirements of this standard are in compliance with relevant parts of SOLAS Ch.II-1 and the IMO MODU Code.

103 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions by this standard depending on the size, type, location and intended service of the offshore unit/installation.

104 The objectives of this standard are to:

— provide an internationally acceptable standard of safety by defining minimum requirements for offshore electrical installations
— serve as a contractual reference document between suppliers and purchasers
— serve as a guideline for designers, suppliers, purchasers and regulators
— specify procedures and requirements for offshore units or installations subject to DNV Certification and Classification.

B. Normative References

B 100 Standards

101 The requirements in this standard are generally based on applicable standards for ships and offshore units as issued by the International Electrotechnical Commission (IEC).

Guidance note:

This implies primarily the 60092 series for ships, and 61892 (1 to 7) for offshore units.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 The publications listed in Table B1 and Table B2 include provisions which, through reference in the text, constitute provisions of this offshore standard. The latest issue of the references shall be used unless otherwise agreed.

103 Other recognised standards may be used provided it can be demonstrated that these meet or exceed the requirements of the publications listed in Table B1 and Table B2.

104 Any deviations, exceptions and modifications to the design codes and standards shall be documented and agreed between the supplier, purchaser and verifier, as applicable.

B 200 Reference documents

201 Applicable DNV publications are given in Table B1.

Table B1 DNV Rules, Standards and Recommended Practices

No.	*Title*
	Rules for Classification of Ships
DNV-OS-D202	Instrumentation and Telecommunication Systems
DNV-RP-A201	Standard Documentation Types
DNV-RP-A202	Documentation of Offshore Projects

202 Other reference documents are given in Table B2.

Table B2 Normative references

No.	*Title*
IEC 60092	Electrical installations in ships
IEC 61892	Mobile and fixed offshore units - Electrical installations
IEC	Other IEC standards as referenced in the text
IMO MODU Code 1989	International Maritime Organisation - Offshore; Code for Construction and Equipment of Mobile Offshore Drilling Units
SOLAS 1974	International Convention for the Safety of Life at Sea

C. Informative References

C 100 General

101 Informative references are not considered mandatory in the application of the offshore standard, but may be applied or used for background information.

102 Informative references are given in Table C1.

Table C1 Informative references

No.	*Title*
DNV-OS-E101	Drilling Plant
DNV-OS-E201	Hydrocarbon Production Plant

D. Definitions

D 100 Verbal forms

101 *Shall:* Indicates requirements strictly to be followed in order to conform to this standard and from which no deviation is permitted.

102 *Should:* Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to agreement.

103 *May:* Verbal form used to indicate a course of action permissible within the limits of the standard.

D 200 Offshore units

201 *Column-stabilised unit:* A unit with the main deck connected to the underwater hull or footings by columns.

202 *Floating offshore installation:* A buoyant construction engaged in offshore operations including drilling, production, storage or support functions, and which is designed and built for installation at a particular offshore location.

203 *Mobile offshore unit:* A buoyant construction engaged in offshore operations including drilling, production, storage or support functions, not intended for service at one particular offshore site and which can be relocated without major dismantling or modification.

204 *Offshore installation:* A collective term to cover any construction, buoyant or non-buoyant, designed and built for installation at a particular offshore location.

205 *Self-elevating unit:* A unit with movable legs capable of raising its hull above the surface of the sea.

206 *Ship-shaped unit:* A unit with a ship- or barge-type displacement hull of single or multiple hull construction intended for operation in the floating condition.

E. Abbreviations and Symbols

E 100 Abbreviations

101 Abbreviations used are given in Table E1.

Table E1 Abbreviations

Abbreviation	*Full text*
A.C.	Alternating current
ACB	Air circuit breaker
AVR	Automatic voltage regulator
CIBS	Classification information breakdown structure
DB	Distribution switchboard
D.C.	Direct current
DYNPOS	Dynamic positioning (DNV class notation)
EDB	Emergency distribution board
EMC	Electromagnetic compatibility
EN	European norm
EPR	Ethylene propylene rubber
ESB	Emergency switchboard
ETD	Temperature measurement by the embedded temperature detector method
HSLC	High speed light craft
IEC	International Electrotechnical Commission
IMO	International Maritime Organisation
IP	Ingress protection
IR	Infrared
IS	Intrinsically safe
MCB	Miniature circuit breaker
MCT	Multi cable transit
MOU	Mobile offshore unit
MSB	Main switchboard
NC	Normally closed
NEMA	National Electrical Manufacturers Association
NO	Normally open
P	Rated output
PE	Protective earth
PVC	Polyvinyl chloride
R	Temperature measurement by the resistance method
RMS, rms	Root mean square
RP/RPS	Redundant propulsion/redundant propulsion separate (DNV class notations)
RT	Routine test
S1	Continuos duty
SCR	Silicone controlled rectifier
T	Temperature measurement by the thermometer method
TT	Type test
UPS	Uninterruptible power supply
XLPE	Cross-linked polyethylene

F. Documentation

F 100 General

101 The types of documentation that are normally produced to document aspects covered by this standard are defined in DNV-RP-A201, mainly under:

— E – Electrical
— Z – Multidiscipline

102 For documentation requirements related to certification and classification, see Ch.3.

OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

CHAPTER 2

TECHNICAL PROVISIONS

CONTENTS PAGE

DET NORSKE VERITAS

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SECTION 1
GENERAL

A. Introduction

A 100 References

101 Sec.2 to Sec.13 are identical to the corresponding sections of the Rules for Classification of Ships / High Speed, Light Craft and Naval Surface Craft, Pt.4 Ch.8. These sections constitute the technical part of this standard.

102 References in Sec.2 to Sec.13 to the International Code of Safety for High Speed Craft (IMO HSC Code) are not applicable in the context of this standard.

A 200 Application

201 The requirements of this standard have been specifically aimed at mobile offshore units and floating offshore installations of the ship-shaped, self-elevating and column-stabilised design types, but may also be applied to other types of floating constructions.

202 The requirements of this standard may also be applied to fixed offshore installations.

203 When the terms 'ship' or 'vessel' are used, it shall be interpreted as 'offshore unit' or 'offshore installation'.

204 The requirements in this standard apply to:

— all electrical installations with respect to safety for personnel and fire hazard
— all electrical installations serving essential or important services with respect to availability.

205 With respect to the definition of 'essential services' in Sec.13, the inclusion of propulsion and steering is only applicable for units dependent on manoeuvrability.

206 The terms 'accepted', 'acceptable' and similar shall be understood as:

— agreed between the supplier, purchaser and verifier, as applicable, when the standard is used as a technical reference
— accepted by DNV when the standard is used as basis for assigning DNV class.

207 The term 'additional class notation' and similar shall be understood as a reference to the unit's service, e.g. drilling unit or production unit, or to special equipment or systems installed, e.g. dynamic positioning.

SECTION 2
SYSTEM DESIGN

A. Power Supply Systems

A 100 General

101 *General requirements*

a) Electrical installations shall be such that the safety of passengers, crew and ship, from electrical hazards, is ensured.

b) There shall be two mutually independent and self contained electric power supply systems on board:

— main electric power supply system
— emergency electric power supply system, except as required in e) and C101.

c) Fire, flood or other damage condition, in a space containing a source of electric power shall not render more than this source, associated main switchboards and transformers, out of operation.

d) Fire, flood or other damage condition, in any other space not covered by c) shall not render any source of electric power or associated main switchboards out of operation (remote operation may be impaired). Nor shall more than one lighting system be rendered inoperative (main or emergency lighting system).

e) Vessels without a dedicated emergency electric power supply system are accepted upon compliance with requirements in C104.

Guidance note:

For requirements concerning the location of the emergency source of power and emergency switchboard, see C101.

Additional class notations may have an impact on the power supply arrangement.

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102 *Environmental conditions*

a) The electrical installations shall normally be suitable for operation in those environmental conditions given in Sec.3 B, and have an ingress protection rating as given in Sec.10 B200.

b) If means are arranged to control the environmental conditions, the installation may be designed for other conditions than those required by a) as long as the means arranged have the same redundancy as the installation in the area served.

c) Electrical installations in gas hazardous areas shall comply with the requirements in Sec.11, and any special requirements set forth in the relevant rule chapters.

Guidance note:

For the requirements for ventilation and air conditioning, see I101.

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103 *System earthing*

a) If the system neutral is connected to earth, means of disconnection shall be fitted so that the system earthing may be disconnected for maintenance or insulation resistance measurement. Such means shall be for manual operation only.

b) In systems with earthed neutral, equalising currents in the neutral earthing exceeding 20% of the rated current of connected generators or transformers is not acceptable.

c) In any four wire distribution system the system neutral shall be connected to earth at all times without the use of contactors.

d) System earthing shall be effected by means independent of any earthing arrangements of the non-current-carrying parts.

e) Transformer neutrals on the primary side shall not be earthed on systems where a generator neutral is earthed.

104 *Types of distribution systems*

a) A.C. power: The following distribution systems can be used (for exemptions see 105 and 106):

— three-phase three-wire with high-resistance earthed neutral
— three-phase three-wire with low-resistance earthed neutral
— three-phase three-wire with directly earthed neutral
— three-phase three-wire with insulated neutral.

b) In addition for all voltages up to and including 500 V A.C.:

— three-phase four-wire with neutral earthed, but without hull return (TN-S-system). Combined PE (protective earth) and N (system earth) is allowed between transformer and N-bus bar in first switchboard where the transformer secondary side is terminated i.e. TN-C-S-system
— single-phase two-wire with insulated neutral
— single-phase two-wire with one phase earthed at the power source, but without hull return.

c) D.C. power: The following distribution systems can be used (for exemptions see 105 and 106):

— two-wire insulated
— two-wire with one pole earthed at the power source (without hull return)
— single-wire with hull return as accepted in 105.

105 *Hull return systems*

a) The hull return system of distribution shall not be used for any purpose in a tanker, or for power, heating, or lighting in any other ship.

b) Provided that any possible resulting current does not flow directly through any gas hazardous spaces, the requirements of 105 does not preclude the use of:

— impressed current cathodic protective systems
— limited and locally earthed systems
— insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

c) Where the hull return system is used, all final sub-circuits, i.e. all circuits fitted after the last protective device, shall be two-wire and special precautions shall be taken.

106 *System on tankers*

a) Normally, earthed distribution systems shall not be used in tankers. The requirement of 106 does not preclude the use of earthed intrinsically safe circuits.

b) Under conditions approved by the national authorities of the flag state, the use of one of the following earthed systems may be used:

— power supplied, control circuits and instrumentation circuits where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions
— limited and locally earthed systems, provided that any possible resulting current does not flow directly through any of the dangerous spaces
— A. C. power networks of 1000 V root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

107 *Special requirements for non-metallic craft*

a) All metal parts of a non-metallic craft should be bonded together, in so far as possible in consideration of galvanic corrosion between dissimilar metals, to form a continuous electrical system, suitable for the earth return of electrical equipment and to connect the craft to the water when water-born. The bonding of isolated components inside the structure is not generally necessary, except in fuel tanks.

b) Each pressure refuelling point should be provided with a means of bonding the fuelling equipment to the craft.

c) Metallic pipes capable of generating electrostatic discharges, due to the flow of liquids and gases shall be bonded so they are electrically continuous throughout their length and shall be adequately earthed.

d) Secondary conductors provided for the equalisation of static discharges, bonding of equipment, etc., but not for carrying lightning discharges shall have a minimum cross section of 5 mm^2 copper or equivalent surge current carrying capacity in aluminium.

e) The electrical resistance between bonded objects and the basic structure shall not exceed 0.05 Ohm except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding path shall have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

f) A main earth bar shall be defined and fitted at a convenient place on board. This earth bar shall be connected to a copper plate with a minimum area of 0.2 m^2 attached to the hull and so located that it is immersed under all conditions of heel.

A 200 System voltages and frequency

201 *General*

a) Electric distribution systems shall operate within the voltage and frequencies given in 202 to 207. This also applies to distribution systems where one or more generator prime movers are driving other equipment. When the main propulsion engine is used as a generator prime mover, variations caused by the wave motion or sudden manoeuvres including crash stop, shall not exceed the given limitations.

b) Voltage variations deviating from the above are accepted in systems or part of systems if these are intentionally designed for the actual variations.

c) All voltages mentioned are root mean square values unless otherwise stated.

202 *Maximum system voltages*

a) Except as stated in b) the following maximum voltages in distribution systems apply:

— connected by permanent wiring: 15000 V
— for portable appliances, which are not hand-held during operation, and with connection by flexible cable and socket outlet: 1000 V
— supply for lighting (including signal lamps), space heaters in accommodation spaces, socket outlets, and hand-held portable appliances and for control, communication and instrumentation equipment: 250 V.

b) For High Speed, Light Craft and Naval Surface Craft, the maximum distribution voltage is limited to 500 V, except for electric propulsion systems, where higher voltages are accepted.

203 *Maximum control voltages*

For control equipment being a part of power and heating installations (e.g. pressure or temperature switches for start and stop of motors), the maximum voltage is 1000 V. However, control voltage to external equipment is not to exceed 500 V.

204 *Supply voltage variations*

a) Electric distribution systems shall be designed and installed so that the voltage variations on main switchboards are maintained within these limits:

Steady state

— ±2.5% of nominal A.C. system voltage
— ±12% of nominal D.C. system voltage on battery installations.

Transient state

— from –15% to +20% of nominal A.C. voltage
— ±25% of nominal D.C. battery voltage.

b) The requirement for maximum transient voltage shall also be complied with due to load shedding or tripping of consumers and under fault conditions.

c) After a transient condition has been initiated, the voltage in a main distribution A.C. system shall not differ from nominal system voltage by more than ±3% within 1.5 s. In an emergency distribution system the voltage shall not differ from nominal system voltage by more than ±4% within 5 s.

205 *Voltage drop in the distribution system*

a) An A.C. distribution system shall be designed and installed so that the stationary voltage drop in supply to individual consumers, measured from the main switchboard to the consumer terminals, does not exceed 6% of system nominal voltage.

b) A D.C. distribution system shall be designed and installed so that the stationary voltage drop in supply to individual consumers, measured from the battery distribution to the consumer terminals, does not exceed 10% of system nominal voltage.

c) Requirements for transient voltages on consumer terminals during start or stop are not given. However, the system shall be designed so that all consumers function satisfactorily.

206 *System frequency*

a) The frequency variations on A.C. installations with fixed nominal frequency shall be kept within the following limits:

— 95 to 105% of rated frequency under steady load conditions
— 90 to 110% of rated frequency under transient load conditions.

b) For A.C. installations designed for variable system frequency, all equipment and its protection subject to the variable frequency, shall be rated to operate within the design limits throughout the frequency range.

Guidance note:

See the Rules for Classification of Ships, Pt.4 Ch.3 regarding the prime movers' speed governor characteristics. For instrumentation equipment, see DNV-OS-D202.

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207 *Harmonic distortion*

a) Equipment producing transient voltage, frequency and current variations is not to cause malfunction of other equipment on board, neither by conduction, induction or radiation.

b) In distribution systems the total harmonic distortion in voltage waveform shall not exceed 5%, nor shall any single order harmonics exceed 3%.

c) The total harmonic distortion may exceed the values given in b) under the condition that all consumers and distribution equipment subjected to the increased distortion level shall be documented to withstand the actual levels.

d) When filters are used for limitation of harmonic distortion, special precautions shall be taken so that load shedding or tripping of consumers, or phase back of converters, do not cause transient voltages in the system in excess of the requirements in 204. The generators shall operate within their design limits also with capacitive loading. The distribution system shall operate within its design limits, also when parts of the filters are tripped, or when the configuration of the system changes.

Guidance note:

The documentation required in c) may consider the following effects:

— additional heat losses in machines, transformers, coils of switchgear and controlgear
— additional heat losses in capacitors for example in compensated fluorescent lighting
— resonance effects in the network
— functioning of instruments and control systems subjected to the distortion
— distortion of the accuracy of measuring instruments and protective gear (relays)
— interference of electronic equipment of all kinds, for example regulators, communication and control systems, position- finding systems, radar and navigation systems.

A declaration or guarantee from system responsible may be an acceptable level of documentation.

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B. Main Electric Power Supply System

B 100 General

101 *Capacity*

a) The main power supply system shall have the capacity to supply power to all services necessary for maintaining the ship in normal operation without recourse to the emergency source of power.

b) There shall be component redundancy for main sources of power, transformers and power converters in the main power supply system so that with any source, transformer or power converter out of operation, the power supply system shall be capable of supplying power to the following services:

— those services necessary to provide normal operational conditions for propulsion and safety
— starting the largest essential or important electric motor on board, except thrusters, without the transient voltage and frequency variations exceeding the limits specified in A200
— ensuring minimum comfortable conditions of habitability which shall include at least adequate services for cooking, heating, domestic refrigeration (except refrigerators for air conditioning), mechanical ventilation, sanitary and fresh water
— for a duplicated essential or important auxiliary, one being supplied non-electrically and the other electrically (e.g. lubricating oil pump No. 1 driven by the main engine, No. 2 by electric motor), it is not expected that the electrically driven auxiliary is used when one generator is out of service
— in addition, the generating sets shall be such as to ensure that with any one generator, transformer or power converter out of service, the remaining generating sets or transformers shall be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by C103, except fire pumps and steering gear, if any.

Guidance note:

Those services necessary to provide normal operational conditions of propulsion and safety do not normally include services such as:

— thrusters not forming part of the main propulsion or steering
— windlass
— mooring
— cargo handling gear
— refrigerators for air conditioning.

However, additional services required by a class notation will be added to the list of important services.

In regard to non-important load, the capacity of all generators can be taken into consideration.

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102 *System redundancy*

a) The failure of any single circuit or bus bar section shall not endanger the services necessary for the vessel's manoeuvrability. The failure of any single circuit shall not cause important services to be out of action for long periods. Any single failure shall not render duplicated consumers serving essential or important services inoperable.

b) If the secondary distribution is arranged as two separate systems each fed from one transformer or converter, possible duplicated essential or important consumers shall be divided between the two systems.

c) Each transformer required according to 101 shall be installed as a separate unit, with a separate enclosure.

Guidance note:

Single failure means failure in any single circuit, feeder, transformer or part of switchboard within one bus tie section.

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103 *Three single core transformers*

a) Three single core transformers may substitute a three-phase transformer.

b) The installation of three single core transformers is considered equivalent to two three-phase transformers upon the following: The three single core transformers shall each be installed in a separate enclosure, shall have separate switchgear and protection and separate cabling. The ca-

pacity of two of the three single core transformers shall be in accordance with 101.

Guidance note:

Three single core transformers installed in the same outer enclosure, but provided with flame retardant partition walls between each phase or core are accepted.

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104 *Control of distribution system*

a) The control systems for the electric distribution system shall be so arranged that neither single circuit nor component failures will render more than the controlled part out of operation.

b) The arrangement shall be such that any single failure will not endanger the duplicated essential services necessary for the vessel's manoeuvrability and will not cause duplicated important services to be out of action for long periods.

c) When the distribution system is equipped for remote operation, local means for operation of breakers shall be fitted. The local operation shall function independently of the remote system.

d) See F104 for power supply requirements for control systems.

Guidance note:

a) implies that a failure in a control system for one part of the distribution system shall not render other parts of the distribution system inoperable, for example failure in the control of one generator breaker shall not render other generator breakers inoperable, likewise for feeders to duplicated transformers etc.

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105 *Restoration of power*

Where the source of electrical power is necessary for propulsion and steering of the ship, the system shall be so arranged that the electrical supply to equipment necessary for propulsion and steering, and to ensure safety of the vessel, will be maintained or immediately restored in case of loss of any one of the generators in service. This means:

— where more than one generating set is necessary to cover normal loads at sea, the power supply system shall be provided with suitable means for tripping or load reduction of consumers, and with provisions for automatic starting and connection to the main switchboard of the stand-by generator. If necessary, important consumers may be tripped in order to permit propulsion and steering and to ensure safety. If the remaining on line generators are not able to permit propulsion and steering and to ensure safety, provision shall be made for automatic starting and connection to the main switchboard of the stand-by generator with automatic restarting of the essential auxiliaries. Connection of the stand-by generator to the main switchboard shall be completed within 30s after loss of power
— where one generator normally supplies the electrical power, provision shall be made, upon loss of power, for automatic starting and connection to the main switchboard of the stand-by generator with automatic restarting of the essential auxiliaries. Connection of the stand-by generator to the main switchboard shall be completed within 30s after loss of power
— it shall be ensured that the total starting current of motors having automatic restart will not cause excessive voltage drop or overcurrent on the installation.

Guidance note:

See also G101 for overload protection and load shedding.

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C. Emergency Power Supply System

C 100 Emergency power and distribution

101 *Independent emergency power*

a) The emergency electric power supply system shall be located above the uppermost continuous deck and be readily accessible from open deck. It shall not be located forward of the collision bulkhead.

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

c) The emergency source of power shall be automatically connected to the emergency switchboard in case of failure of the main source of electric power, and within 45 s automatically supply at least the services required to be supplied by transitional power as listed in Table C1.

d) The emergency source of power shall not be used for supplying power during normal operation of the vessel. Exceptionally, and for short periods, the emergency source of power may be used for blackout situations, starting from dead ship, short term parallel operation with the main source of electrical power for the purpose of load transfer and for routine testing of the emergency source of power.

e) In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power shall be available automatically to the emergency circuits.

f) If the emergency source of power is not in accordance with c), a transitional source of emergency electrical power, suitably located for use in an emergency, with sufficient capacity of supplying the consumers listed in Table C1, may be accepted.

g) Requirements for uninterrupted power for instrumentation and automation, see DNV-OS-D202.

h) For the requirements for battery powered systems, see D100.

Exception for mobile offshore units and high speed light craft

For mobile offshore units applying the IMO MODU Code, or craft applying the HSC Code, location of emergency supply system below uppermost continuous deck may be accepted provided easy access from a normally manned area. However, the emergency source of power shall always be located above worst damage waterline.

Independent of this requirement, MOUs shall be equipped with transitional source supplying consumers as listed in Table C1.

Exception for ships

The requirement for emergency source of power applies to all cargo vessels with the following exemptions:

— ships with one of the service restrictions notations **R2**, **R3** and **R4**
— ships of less than 500 gross tonnage
— fishing vessels.

Guidance note:

For the requirements for an emergency generator, see 300.

For the requirements for a transitional source of emergency electrical power, see 200.

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102 *Capacity*

a) The electrical power available shall be sufficient to supply all services essential for safety in an emergency, due regard being paid to simultaneous operation of all services,

also taking into account starting currents and transitory nature of certain loads.

b) Where the emergency source of electrical power is an accumulator battery it shall be capable of carrying the emergency electrical load without recharging while maintaining the voltage of the battery as required by A200.

c) When non-emergency consumers are supplied by the emergency source of power, it shall either be possible to supply all consumers simultaneously, or automatic disconnection of non-emergency consumers upon start of the generator shall be arranged. The system shall be so arranged that the largest consumer connected to the emergency power supply system can be started at all times without overloading the generator unless automatically disconnected upon start of the emergency generator.

d) Starting air compressors, preheaters and lubrication oil pumps for the main engine or auxiliary engines may be equipped for automatic disconnection from the emergency switchboard. Such consumers necessary for starting from dead ship, if supplied from the emergency source of power, shall be possible to connect manually at the emergency switchboard also when the emergency generator is running. If they may cause overloading of the emergency generator, warning signs shall be fitted also stating the load of the consumers.

103 *Services to be supplied*

a) For High Speed, Light Craft and Naval Surface Craft see the Rules for Classification of HS, LC and NSC Pt.5 Ch.1 Sec.5 A204 and D205.

b) For additional class notations, additional requirements may apply.

c) For main class ships and main class MOUs the list of services in Table C1 shall be supplied by an emergency source of power and by a transitional source of power, if any, for the period listed.

d) In a ship engaged regularly in voyages of short duration, a lesser period than the 18 hour period specified in Table C1 is accepted, but not less than 12 hours.

e) The emergency source of electrical power shall be capable of supplying simultaneously at least the services listed in Table C1 for the periods specified, if they depend upon an electrical source for their operation.

Table C1 Services to be supplied by an emergency source and by a transitional source, including required duration for main class

Service	*Emergency power consumers in ships and MOUs*	*Duration of emergency power, ships (h)*	*Duration of transitional power, ships (h)*	*Duration of emergency power, MOU (h)*	*Duration of transitional power, MOU (h)*
Emergency lighting	At every muster and embarkation station, for survival craft and their launching appliances, and at the area of water into which it is to be launched.	3	0.5[2)]	18	1
	In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks.	18	0.5[2)]	18	1
	In the machinery spaces and main generating stations including their control positions.	18	0.5[2)]	18	1
	In all control stations, machinery control rooms, steering gear and at each main and emergency switchboard.	18	0.5[2)]	18	1
	In all spaces from which control of the drilling process is performed and where controls of machinery essential for the performance of this process, or devices for the emergency switching-off of the power plant are located.			18	1
	At all stowage positions for firemen's outfits.	18	0.5[2)]	18	1
	At the fire pump referred to in this table and its starting position.	18	0.5[2)]	18	1
	At the sprinkler pump and its starting position, if any.	18	0.5[2)]	18	1
	At the emergency bilge pump and its starting position, if any.	18	0.5[2)]	18	
	On helicopter landing decks.			18	1
Escape lights	Emergency lights required for escape from the vessel, with integral batteries.				1
COLREG lights	The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force.	18	0.5[2)]	18	1
Structure marking	Any signalling lights or sound signals that may be required for marking of offshore structures.			96	
Fire pumps	One of the fire pumps required by SOLAS Reg. II-2/4.3.1 and 4.3.3 (the Rules for Classification of Ships, Pt.4 Ch.10 Sec.2 B200) if dependent upon the emergency generator for its source of power. (SOLAS Reg. II-1/43.2.5)	18		18	
Steering gear	The steering gear if required to be so supplied by the Rules for Classification of Ships, Pt.3 Ch.3 Sec.2 J900. (SOLAS Reg. II-1/43.2.6.1) (For a ship of less than 10000 gross tonnage the duration shall only be at least 10 minutes.)	0.5			

Table C1 Services to be supplied by an emergency source and by a transitional source, including required duration for main class (Continued)

Service	*Emergency power consumers in ships and MOUs*	*Duration of emergency power, ships (h)*	*Duration of transitional power, ships (h)*	*Duration of emergency power, MOU (h)*	*Duration of transitional power, MOU (h)*
Ballast valves	Ballast control and indicating system.			18	
Ballast pumps	Any of the ballast pumps required powered by the emergency source of power. Only one of the connected pumps need be considered to be in operation at any time.			18	
Watertight doors and hatches	The remote control system for watertight doors and hatches.			0,5	
Diving equipment	Permanently installed diving equipment, if dependent upon the unit's electrical power.			18	
Stabilisers (if any)	Means to bring the stabiliser wings inboard and indicators on the navigating bridge to show the position of the stabiliser wings if there is a danger of the survival craft being damaged by the ship's stabiliser wings (as required by the Rules for Classification of Ships, Pt.3 Ch.6 Sec.2 J100)	-	-	-	-
Communication [4]	The VHF radio installation required by SOLAS regulation IV/7.1.1 and IV/7.1.2.	18			
	If applicable: the MF radio installation required by SOLAS regulations IV/9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3 the ship earth station required by regulation IV/10.1.1 the MF/HF radio installation required by regulations IV/10.2.1, IV/10.2.2, IV/10.1.2 and IV/11.1.	18			
	All internal communication equipment, as required, in an emergency; shall include: means of communication between the navigating bridge and the steering gear compartment means of communication between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled means of communication between the bridge and the radio telegraph or radio telephone stations.	18[1]	0.5[3]	18	1
	Intermittent operation of the daylight signalling lamp, the ship's whistle, the manually operated call points, and all internal signals that are required in an emergency.	18[1]	0.5[3]		
Navigation	The shipborne navigational equipment as required by SOLAS regulation V/12 (Rules for Classification of Ships, Pt.4 Ch.11 Sec.3 A200), where such provision is unreasonable or impracticable the Society may waive this requirement for ships of less than 5000 gross tonnage.	18[1]			
Alarm systems	The fire and gas detection and their alarm systems.	18[1]	0.5[3]	18	1[3]
	The general alarm system.	18	0.5[3]	18	1[3]
	The fire detection and alarm system, unless these systems are supplied by separate batteries.			18	
	Intermittent operation of the manual fire alarms and all internal signals that are required in an emergency			18	1
	The capability to close the blow-out preventer and of disconnecting the unit from the well head arrangement, if electrically controlled.			18	1

1) Unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency.

2) For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps.

3) Unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

4) Means of communication according to the Rules for Classification of Ships, Pt.4 Ch.12 Sec.1 B.

104 *Independent installation of power sources*

The requirements for a separate emergency source of power in 101 and 102 may be omitted if the following conditions are met:

— applicable regulations are either IMO MODU Code or IMO HSC Code. Alternatively an arrangement approved by the authorities of the flag state is accepted

— the main source of electrical power is arranged so that it complies with the requirements for emergency installations
— electrical power is ensured to be available with fire or flooding in any one space or division
— at least two sources of main power are to comply with the requirements for emergency power generation. Each of these is to be located in a space separated from the other, as required for the separation of main and emergency sources of power. Both of these sources are to be treated as emergency sources of power.

Guidance note:

Observe the requirement in 101: The requirement for starting and loading within 45 s stated in 101 may be overruled by B105, i.e. 30 s. Observe requirements for class notation **E0** in the Rules for Classification of Ships, Pt.6 Ch.3. The required time for starting and connecting a main generator is 30 s.

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105 *Emergency switchboard*

a) The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

b) Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

c) In normal operation, the emergency switchboard shall be supplied from the main switchboard by an interconnecting feeder. This feeder shall be protected against overload and short circuit at the main switchboard, and shall be disconnected automatically at the emergency switchboard upon failure of the supply from the main source of electrical power.

d) Where the emergency switchboard is arranged for the supply of power back to the main distribution system, the interconnecting cable shall, at the emergency switchboard end, be equipped with switchgear suitable for at least short circuit protection.

e) The emergency switchboard and emergency distribution boards shall be as defined in Sec.1 and not be considered as part of the main distribution system, even though supplied from such during normal operation.

f) Technical requirements for functionality and construction for main switchboards, apply to emergency switchboards.

g) Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements.

h) No accumulator battery, except the starting battery for the emergency generator prime mover, shall be installed in the same space as the emergency switchboard.

C 200 Transitional source

201 *Transitional source of emergency electrical power*

a) The transitional source of electrical power, where required by the relevant rule chapters shall consist of an accumulator battery suitably located for use in an emergency. The battery source shall be able to operate, without recharging, while maintaining the voltage of the battery throughout the discharge period as required by A200. The battery capacity shall be sufficient to supply automatically, in case of failure of either the main or the emergency source of electrical power, for the duration specified, at least the following services, if they depend upon an electrical source for their operation:
   — the lighting and other services required by Table C1. See notes to Table C1.

b) A transitional source of emergency electrical power shall be located as required for emergency power in 101, unless it supplies power to consumers within the same space as the transitional source itself.

c) For requirements for battery powered systems, see D100.

C 300 Emergency generators

301 *Prime mover for emergency generator*

a) Where the emergency source of electrical power is a generator, it shall be driven by a suitable prime mover having independent auxiliary systems as for example fuel, ventilation, lubrication, cooling etc. The fuel shall have a flashpoint of not less than 43°C.

b) The prime mover shall be started automatically upon failure of the main source of electrical power supply.

c) Whenever the emergency source of power is not ready for immediate starting, an indication shall be given in the engine room or at a manned control station.

302 *Protective functions of emergency generating sets*

a) The protective shutdown functions associated with emergency generating sets shall be limited to those necessary to prevent immediate machinery breakdowns.

b) Other protective functions such as overcurrent, differential protection, high temperature etc. shall, if installed, give alarm only, when the generator is started as an emergency source of power. The alarm shall be given in a normally manned location.

c) For use as a harbour generator, or in test mode, protection as for normal generator shall be fitted. See G301.

303 *Starting arrangements for emergency generating sets*

a) An emergency generating set shall be capable of being readily started in its cold condition at a temperature of 0ºC. If this is impracticable, or the vessel is intended for operation at lower ambient temperatures, provisions shall be made for heating arrangements to ensure ready starting of the generating sets.

b) Emergency generating set shall be equipped with starting devices with a stored energy capability of at least three consecutive starts. A second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

c) Stored energy for starting shall be maintained at all times, and shall be powered from the emergency switchboard. All starting, charging and energy storing devices shall be located in the emergency generator space. Compressed air starting systems may however be maintained by the main or auxiliary compressed air system through a suitable non-return valve fitted in the emergency generator space.

d) If accumulator batteries are used for starting of the emergency generator prime mover, every such prime mover shall have separate batteries that are not used for any purpose other than the operation of the emergency generating set.

e) If the emergency generator is equipped with an electronic governor, electronic AVR, priming pumps or other auxiliaries dependent upon electric power supply for a successful start, power supply to this equipment shall be in accordance with the requirements for energy for starting.

Guidance note:

If the emergency generating set is arranged so as not to be automatically started, then manual starting may be permissible, such

as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, where it can be demonstrated as being effective within 30 minutes.

When manual starting is not practicable, each emergency generating set may be equipped with starting devices with a stored energy capability of at least three consecutive starts. A second source of energy may be provided for three additional starts within 30 minutes.

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304 *Emergency generator used in port*

a) The emergency source of power may be used during time in port for the supply of the ship mains, provided the requirements for available emergency power is adhered to at all times.

b) To prevent the generator or its prime mover from becoming overloaded when used in port, arrangements shall be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

c) The prime mover shall be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation and for unattended operation.

d) The fuel oil supply tank to the prime mover shall be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the required period.

e) Fire detectors shall be installed in the location where the emergency generator set and emergency switchboard are installed.

f) Means shall be provided to readily change over to emergency operation.

g) Control, monitoring and supply circuits, for the purpose of the use of the emergency generator in port shall be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services. When necessary for safe operation, the emergency switchboard shall be fitted with switches to isolate the circuits.

h) Instructions shall be provided on board to ensure that when the vessel is under way all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard. These instructions are also to contain information on required fuel oil tank level, position of harbour or sea mode switch if fitted, ventilation openings etc.

D. Battery Installation

D 100 General

101 *Capacity of accumulator batteries*

Batteries that shall be used for power supply required by these rules shall be dimensioned for the time required for the intended function at an ambient temperature of 0°C, unless heating is provided.

102 *Battery powered systems*

a) Continuous insulation monitoring with alarm, according to G102, shall be installed for all insulated distribution systems. For battery systems not extending their circuits outside a single panel, this requirement is waived. Insulation monitoring for battery systems for non-important systems below 50 V and for other systems serving one function only, test lamps or similar without continuous monitoring is accepted.

b) Each battery powered system is to have a separate charging device, suitable for the actual service. This may alternatively be:

- — a charging device supplied from the vessel's primary or secondary electric distribution. Such charging devices are considered as important consumers
- — a charging dynamo driven by one of the engines which the battery normally supplies, except that this is not allowed for auxiliary engines for emergency generator and emergency fire pump.

c) Each starting battery required by these rules shall have an independent charging device.

d) Each charging device is, at least, to have sufficient rating for recharging to the required capacity within 6 hours, while the system has normal load.

e) A battery charger shall have automatically regulated charging and operate on floating service with the battery and give trickle charging when the battery is fully charged, or with change-over arrangement for full-(quick-)charging and automatic trickle charging.

f) Charging devices shall be provided with suitable switchgear and fusegear for protection against faults such as short circuits, overloads and connection failures (e.g. harmful overvoltage is not to occur, if the connection with the battery is broken). The arrangement shall further be such that the charging devices can be disconnected for maintenance purpose, without breaking the supply to consumers fed by the battery.

g) Provisions shall be made for preventing reverse current from the battery through the charging device.

Guidance note:

When the charging dynamo is an A.C. generator (alternator), particular attention should be paid to ensure that no damage would occur if the connection with the battery is broken.

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103 *Battery monitoring*

An alarm shall be given at a manned control station if the charging of a battery fails, the ventilation fails or if the battery is being discharged.

E. Generator Prime Movers

E 100 General

101 *General*

a) Each generator required according to B101 shall normally be driven by a separate prime mover. Each generator shall be driven by one engine, and one engine shall only drive one generator.

b) If a prime mover for a generator is also used for driving other auxiliary machinery in such a way that it is physically possible to overload the engine, an interlock or other effective means for preventing such overloading shall be arranged. The availability of the generator shall be at least as for separately driven generators.

c) When generators driven by reciprocating steam engines or steam turbines are used, and the operation of the boiler(s) depends on electric power supply, there shall be at least one generator driven by an auxiliary diesel engine or gas turbine on board, enabling the boiler plant to be started.

d) A generator driven by a main propulsion unit (shaft generator) which is intended to operate at constant speed, e.g. a system where vessel speed and direction are controlled only by varying propeller pitch, may be one of the required

generators according to B101. There shall be at least one generator driven by a separate prime mover. The capacity of separately driven generators shall be sufficient to supply all essential and important services that can be expected to be simultaneously in use, regardless of the operational mode of the vessel. This shall be possible without utilising any emergency power source.

102 *Governor characteristics*

Generator prime movers shall comply with the requirements in the Rules for Classification of Ships, Pt.4 Ch.2 Sec.6.

Guidance note:

Governors on prime-movers shall be such that they will automatically maintain the speed within a transient variation of 10% and a steady-state variation not exceeding 5% when rated load is suddenly thrown off and when 50% load is suddenly thrown on, followed after a short instant by the remaining 50% load, unless other load changes are specified.

Emergency generator sets shall satisfy the above governor condition even when their total consumer load is applied suddenly.

Consideration may be given to the throwing on of loads in portions of with the values differ from those stated above in order to reach 100% rated load condition.

However, application of the load in more than two steps shall permitted only if the condition within the ship's mains permit the use of such prime-movers, which can be loaded in more than two load steps only and provided that this has already been allowed for at the design stage.

Each prime-mover shall be fitted with an emergency overspeed device which will operate at a speed of not more than 15% above the rated speed and has provision for tripping by hand.

Where the driven generators shall operate in parallel, the governor characteristics of the prime movers shall be such that within the limits of 20% and 100% total load, the load on any generating set does not differ from its proportional share of the total load by more than 15% of the rated load of the largest machine or 25% of the rating of the individual machine in question.

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103 *Starting arrangements for main engines*

a) For main engines there shall be at least two separately installed batteries, connected by separate electric circuits arranged such that parallel connection is not possible. Each battery shall be capable of starting the main engine when in cold and ready to start condition.

b) When two batteries are serving a single main engine, a change-over switch or link arrangement for alternative connection of the starter motor with its auxiliary circuits to the two batteries shall be provided.

c) Starting arrangements for two or more main engines shall be divided between the two batteries and connected by separate circuits. Arrangements for alternative connection of one battery to both (or all) engines can be made, if desired.

d) The batteries shall be installed in separate boxes or lockers or in a common battery room with separate shelves (not above each other).

e) Each battery shall have sufficient capacity for at least the following start attempts of the engines being normally supplied:

— 12 starts for each reversible engine
— 6 starts for each non-reversible engine connected to a reversible propeller or other devices enabling the engine to be started with no opposing torque.

The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

f) For multi-engine propulsion plants the capacity of the starting batteries is to be sufficient for 3 starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

104 *Starting arrangement for auxiliary engines*

a) Electric starting arrangement for a single auxiliary engine not for emergency use, shall have a separate battery, or it shall be possible to connect it by a separate circuit to one of the main engine batteries, when such are used according to 103.

b) Each auxiliary engine for an emergency fire pump is to have a separate battery.

c) When the starting arrangement serves two or more auxiliary engines, there shall at least be two separate batteries, as specified for main engines in 103. The main engine batteries, when such are used, can also be used for this purpose.

d) Each starting battery shall have sufficient capacity for at least three start attempts of each of the engines being normally supplied. The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

e) Power supply to electronic governors, AVRs and other necessary auxiliaries for auxiliary engines shall, if dependent on external power, be arranged as required for starting arrangement in c).

F. Electric Power Distribution

F 100 Distribution in general

101 *General*

a) All switchboards and consumers shall be fed via switchgear so that isolation for maintenance is possible. Contactors are not accepted as isolating devices.

b) Each essential or important consumer shall be connected to a main switchboard or distribution board by a separate circuit.

c) Two or more units, supplied from the main generators and serving the same essential or important purpose shall be divided between at least two distribution switchboards when such are used, each having a separate supply circuit from different sections of the main switchboard(s).

102 *Generator circuits*

a) Each generator shall be connected by a separate circuit to the corresponding switchboard.

b) When a generator is used for direct supply to single consumers, more than one generator breaker is acceptable. In such cases, the generator shall be de-exited and all the generator's breakers opened, in case of short circuit between the generator neutral point and the generator breakers.

103 *Division of main bus bars*

a) The main bus bars shall be divided into at least two parts by use of at least a switch disconnector or other approved means. The generating sets and other duplicated equipment shall be divided between the parts.

b) If the vessel is not dependent of electric power for the propulsion, the division of the main bus bar is not required for low voltage installations.

c) Bus tie breakers with co-ordinated protective functions will be required where main generators serve as emergen-

cy sources of power. Special requirements for bus tie breakers may apply for additional class notations.

104 *Power supply to control circuits*

a) Power for control circuits shall generally be branched off from the main circuit of a consumer, with exceptions as specified in b).

b) Power for control circuits may be supplied by a control distribution system with the following conditions:

— the power supply to control circuits for two or more units serving the same essential or important purpose shall be divided between at least two different distribution systems, with the supply complying with B102
— the power supply to each such distribution system shall be from the same main switchboard and bus bar section as the main circuits involved. Power supply can also be taken from battery installations constructed in accordance with the same requirements for redundancy
— the power supply for the control circuit of each essential or important consumer is to have individual short circuit protection.

F 200 Lighting

201 *Lighting redundancy*

a) A main electric lighting system shall provide illumination throughout those parts of the ship normally accessible to, and used by, passengers or crew, and shall be supplied from the main source of electrical power.

b) The arrangement of the main electric lighting system shall be such that fire, flood or other casualty, in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, will not render the emergency electric lighting system inoperative.

c) The arrangement of the emergency electric lighting system shall be such that fire, flood or other casualty, in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard, will not render the main electric lighting system inoperative.

d) If the main lighting is arranged as two separate secondary systems, each fed from a separate transformer or converter, then the main lighting shall be divided between the two systems so that with one system out of operation, there remains sufficient lighting to carry out all functions necessary for the safe operation of the vessel.

e) Redundancy requirement for generators and transformers supplying the main lighting system is given in B101.

f) For vessels where emergency source of power not is required, b) does not apply. However, the following lighting shall be divided between at least two circuits from different parts of the main switchboard:

— engine room lighting
— switchboard room lighting
— lighting in control room and of control positions
— lighting in alleyways, stairways leading up to the boat deck and in saloons.

Exception

For mobile offshore units covered by the MODU Code, the redundancy requirement in d) may be replaced by a lighting installation divided between two systems, built with redundancy in technical design and physical arrangement, i.e. with one system out of operation, the remaining system shall be sufficient for carrying out all the functions necessary for the safe operation of the vessel. The emergency switchboard may be used as one of the secondary distribution systems.

The following lighting is divided between at least two circuits, one from the main and one from the emergency switchboard:

— lighting in the engine room and all control stations
— lighting in saloons, alleyways, stairways leading up to the life boat stations and helicopter deck.

202 *Navigation lights switchboard*

The main navigation lights shall be connected to a dedicated distribution switchboard, placed on the bridge or in the chart room. This distribution switchboard shall not be used for other purposes, except that special signal lights such as anchor lights and signal lights required by canal authorities can be supplied.

Guidance note:

Special national requirements may apply.

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203 *Power supply to navigation lighting*

a) The navigation light switchboard (controller) shall be supplied by two alternative circuits, one from the main source of power and one from the emergency source of power. A changeover switch shall be arranged for the two supply circuits.

b) For any cargo ship without automatic starting of the emergency generator and for all passenger ships, the emergency power to the navigation light shall be supplied by the transitional source of power until the emergency generator is supplying power.

c) For vessels without emergency power the navigation lighting shall have battery backed up supply.

204 *Navigation light circuits*

a) A separate circuit shall be arranged for each light connected to this switchboard with a multipole circuit breaker, multipole fused circuit breaker or with a multipole switch and fuses in each phase.

b) The overload and short circuit protection for each of these circuits shall be correlated with the supply circuit to ensure discriminative action of the protection devices.

c) Each light circuit shall be provided with an automatic monitoring device, giving visual indication in the event of failure of the light, and in the event of a short circuit, when the light circuit is switched on.

F 300 Shore connections

301 *General*

a) When supply from shore is used, the connection of the supply cable from shore shall generally be carried out by suitable terminals placed in a switchboard or in a shore-connection box with a permanent cable connection to a switchboard.

b) In the switchboard, the circuit shall, at least, be provided with a switch. In the shore-connection box, switchgear and protection as required for feeder circuits shall be installed, except that overcurrent protection can be omitted if such protection is installed in the main switchboard.

c) If the shore connection is supplying power via the emergency switchboard, C105 d) shall be complied with. Further, the shore connection breaker shall be fitted with an interlock (e.g. undervoltage release sensing the voltage on the shore side of the breaker), so that the shore connection is disconnected before the emergency generator or transitional source of power is connected.

d) For A.C. systems with earthed neutral, terminals for connection between the shore and ship's neutrals shall be provided.

e) For circuits rated maximum 63 A, connection by socket outlet can be used instead of shore-connection box. The circuit is then to have overcurrent protection on the main switchboard.

f) Normally, high voltage shore connection circuits shall not be used.

Guidance note:
National authorities may require changeover or interlocking system, so arranged that the connection to shore cannot be fed from the vessel's generators.

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G. Protection

G 100 System protection

101 *Overload protection*

a) Load shedding or other equivalent arrangements shall be provided to protect the generators, required by these rules, against sustained overload.

b) In power distribution systems that might operate in different system configurations, the load shedding shall be such arranged that necessary system protection is functioning in all system configurations.

Guidance note:
Overload protection may be arranged as load reduction or as the tripping of non-important consumers. Where more than one generator is necessary to cover normal load at sea, then important consumers may be tripped, if necessary.

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102 *Insulation fault*

a) Each insulated, or high resistance earthed primary or secondary distribution system shall have a device or devices to continuously monitor the values of electrical insulation to earth and to give an audible or visual indication in case of abnormally low insulation values. However, audible or visual indication can be omitted provided automatic disconnection is arranged. The circulation current generated by each device for insulation monitoring is not to exceed 30 mA under the most unfavourable conditions.

b) The requirements in a) shall be applied on all galvanic separated systems on board. Except for:

— dedicated systems for single consumers
— galvanic separated local systems kept within one enclosure.

c) On high voltage systems automatic disconnection shall be arranged for operation at 1/3 or less of the minimum earth fault current. However, for systems with high-resistance earthed neutral or isolated neutral, this disconnection can be replaced with an alarm when the distribution system and equipment are dimensioned for continuous operation with earth fault. For the requirements for voltage class of high voltage cables dependent of system behaviour with earth fault, see J103.

d) On low voltage systems with low-resistance or directly earthed neutral automatic disconnection of circuits having insulation faults shall be arranged. This earth fault protection shall be selective against the feeding network. For low resistance earthed neutral systems the disconnection shall operate at less than 20% of minimum earth fault current.

Guidance note:
Circuits for heating cables, tapes, pads, etc. should be equipped with earth fault breakers. See Sec.8 A400. For propulsion circuits, see Sec.12.

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103 *Battery circuits*

a) Circuits connected to batteries above 12 V or above 1 Ah capacity shall have short circuit and overcurrent protection. Protection may also be required for smaller batteries capable of creating a fire risk. Short circuit protection shall be located as close as is practical to the batteries, but not inside battery rooms, lockers, boxes or close to ventilation holes. The connection between the battery and the charger is also to have short circuit protection.

b) Connections between cells and from poles to first short circuit protection shall be short circuit proof.

c) The main circuit from a battery to a starter motor may be carried out without protection. In such cases, the circuit shall be installed short circuit proof. Auxiliary circuits, which are branched off from the starter motor circuit, shall be protected as required in a).

104 *Overvoltage protection*

Overvoltage protection shall be arranged for lower-voltage systems supplied through transformers from high-voltage systems.

Guidance note:
Direct earthing of the lower voltage system, or the use of voltage limitation devices, are considered as adequate protection. Alternatively, an earthed screen between the primary and secondary windings may be used. See Sec.3 D400 regarding current and voltage transformers.

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G 200 Circuit protection

201 *General*

a) Each separate circuit shall be protected against overcurrent and short circuit.

b) All circuits serving essential or important functions shall be separately protected.

c) Loss of protective functions shall either trip the corresponding equipment or give an alarm on a manned control position, unless other specific requirements apply.

d) Non-important motors rated less than 1 kW, and other non-important consumers, rated less than 16A, do not need separate protection.

e) Each final circuit supplying multiple socket outlets, multiple lighting fittings or other multiple non-important consumers shall be rated maximum 16 A in 230 V systems, 30 A in 110 V systems.

f) The protective devices shall provide complete and co-ordinated protection to ensure:

— continuity of services under fault conditions through discriminative action of the protective devices
— elimination of the fault to reduce damage to the system and hazard of fire.

g) For non-important circuits, circuit breakers with insufficient breaking capacity can be used, provided that they are co-ordinated by upstream fuses, or by a common upstream circuit breaker or fuses of sufficient breaking capacity protecting the circuit breaker and connected equipment from damage.

h) No fuse, single pole switch or single pole circuit breaker shall be inserted in an earthed conductor including earthed neutral.

i) All consumers other than motors shall be controlled by, at least, multi-pole switchgear, except that single pole switches can be used for luminaires or space heaters in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material.

j) See Note 9) to Table B1 in Sec.10 for special requirements for protection in different locations.

Exception

For special requirements for protection of steering gear circuits, see 502.

202 *Capacity*

a) The breaking capacity of every protective device shall be not less than the maximum prospective short circuit at the point where the protective device is installed.

b) The making capacity of every circuit breaker or switch intended to be capable of being closed, if necessary, on short circuit, shall not be less than the maximum value of the prospective short circuit current at the point of installation.

c) Circuit breakers in main switchboards are generally to be selected according to their rated service short circuit breaking capacity. (I_{CS} according to IEC 60947-2 Clause 4)

d) If the main switchboard is divided by a switch disconnector or a circuit breaker according to F103a) the feeder breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. (I_{CU} according to IEC 60947-2 Clause 4)

e) Provided that the main switchboard is divided by a bus tie circuit breaker according to F103 a) and that total discrimination (total selectivity) of generator circuit breaker and bus tie breaker are obtained, all circuit breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. (I_{CU} according to IEC 60947-2 Clause 4)

f) Generator circuit breakers and other circuit breakers with intentional short-time delay for short circuit release shall have a rated short-time withstand current capacity not less that the prospective short circuit current. (I_{CW} according to IEC 60947-2 Clause 4)

g) Every protective device or contactor not intended for short circuit interruption shall be co-ordinated with the upstream protection device.

h) When a switchboard has two incoming feeders, necessary interlocks shall be provided against simultaneously closing of both feeders when the parallel connected short circuit power exceeds the switchboards' short circuit strength. A short time parallel feeding as a "make before break" arrangement is accepted when arranged with automatic disconnection of one of the parallel feeders within 30 s.

203 *Fuses*

a) Fuses above 320 A rating shall not be used as overload protection, but may be used for short circuit protection if otherwise acceptable according to these rules.

b) Fuses for overcurrent protection shall not be rated higher than the cable's current-carrying capacity, or the consumers nominal current, whichever is less.

c) Used for short circuit protection, fuses can be rated higher than the full-load current, but not higher than expected minimum short circuit current.

d) In high voltage equipment, fuses shall not be used for overcurrent protection of power feeder circuits. Fuses may be used for short circuit protection provided they can be isolated and replaced without any danger of touching live parts.

204 *Short circuit protection*

The general requirements for circuit protection in 201, 202 and 203 apply with the following exceptions:

— separate short circuit protection may be omitted for motors serving different functions of the same non-important equipment for example the engine room crane may include hoisting, slewing and luffing motors. Each motor should have separate overload protection and controlgear
— separate short circuit protection may be omitted at the battery or generator end of short circuit proof installed cables.

205 *Overcurrent protection*

a) Overcurrent protection shall not be rated higher or adjusted higher (if adjustable) than the cable's current-carrying capacity, or the consumers nominal current, whichever is less.

b) The general requirements for circuit protection in 201, 202 and 203 apply with the following exceptions:

overcurrent protection may be omitted for circuits supplying consumers having overcurrent protection in their controlgear

this also applies to a circuit supplying a distribution switchboard with consumers having overcurrent protection in their controlgear, provided that the sum of the rated currents of the controlgears does not exceed 100% of the supply cable's rating.

206 *Control circuit protection*

The general requirements for circuit protection in 201, 202 and 203 apply with the following exceptions:

— protection may be omitted for monitoring circuits of automatic voltage regulators
— secondary side of current transformers shall not be protected
— the secondary side of single phase voltage transformers may be protected in one pole (phase) only
— separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 16 A
— separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 25 A and when the control circuit consists of adequately sized internal wiring only.

Guidance note:

Adequately sized wiring means that the wiring shall withstand normal load and short circuit without reaching extreme temperatures.

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G 300 Generator protection

301 *Generator protection*

a) Generators shall be fitted with overcurrent protection; set so that the generator breaker trips at 110 to 125% of nominal current, with a time delay of 20 to 120 s.

b) The short circuit trip shall be set at a lower value than the generator’s steady state short circuit current and with a time delay as short as possible, taking discrimination into account. Maximum 1 s.

c) Other forms for generator overload protection, for example winding over-temperature combined with power re-

lays (wattmetric relays), may substitute overcurrent protection provided the generator cables are sufficiently protected.

d) Generators having a capacity of 1500 kVA or above, and all high voltage generators, shall be equipped with suitable protection, which in the case of short circuit in the generator or in the supply cable between the generator and its circuit breaker will de-excite the generator and open the circuit breaker. Emergency generators are exempted.

e) Each generator arranged for parallel operation shall be provided with a reverse-power relay with a time delay between 3 s and 10 s, tripping the generator circuit breaker at:

— maximum 15% of the rated power for generators driven by piston engines
— maximum 6% of the rated power for generators driven by turbines.

The release power is not to depart from the set-point by more than 50% at voltage variations down to 60% of the rated voltage, and on A.C. installations at any power factor variation.

f) Generator circuit breakers shall be provided with undervoltage release allowing the breaker to be closed when the voltage and frequency are 85 to 110% of the nominal value. The undervoltage release shall release within the range 70 to 35% of it's rated voltage.

g) The arrangement of short circuit-, overcurrent- and reverse power relays shall be such that it is possible to reconnect the circuit breaker within 30 s after a release, provided the voltage is within the range 85 to 110% of the rated voltage.

h) See Sec.5 A301 for requirements for temperature detectors in windings.

i) Where start and stop and load sharing between generators, is controlled by an automation system, it shall be arranged that the following alarms are routed to a permanently manned position, or to the main alarm system, in the case of unattended operation:

— power failure to the control system
— starting failure of prime mover
— high and low frequency
— high and low voltage.

Excessive percentage difference in loads (kVA or alternatively both kW and kVAr) taken by the generators, with the necessary time delay, when in symmetrical load sharing mode.

In addition compliance with other relevant requirements in the Rules for Classification of Ships, Pt.6 Ch.3 may be required.

j) For emergency generators special requirements apply. See C302.

G 400 Transformer protection

401 *Transformer protection*

a) Transformers shall be fitted with circuit protection as required by 200.

b) If the primary side of transformers is protected for short circuit only, overcurrent protection shall be arranged on the secondary side.

c) The protection system is to include an overcurrent alarm if a load diversity factor has been used when deciding the rating. The overcurrent alarm is to be initiated without any time delay. Or alternatively co-ordinated with the overload protection relay to enable manual load shedding. The requirement is only applicable to distribution transformers.

Guidance note:

When choosing the characteristics of protection devices for power transformer circuits it may be necessary to take current surge into consideration.

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G 500 Motor protection

501 *Motor protection*

a) The general requirements for circuit protection in 200 apply.

b) Overcurrent protection for motors may be disabled during a starting period.

c) Overcurrent relays shall normally be interlocked, so that they must be manually reset after a release.

d) Short circuit and overload protection shall be provided in each insulated phase (pole) with the following exemptions:

— for D.C. motors, overcurrent relay in one pole can be used, but this cannot then substitute overcurrent release at the switchboard
— for A.C. motors supplied by three-phase electric power with insulated neutral, overload protection in any two of the three phases is sufficient
— overcurrent release may be omitted for essential or important motors, if desired, when the motors are provided with overload alarm (for steering gear motors, see 502)
— overcurrent release in the controlgear may be omitted when the circuit is provided with a switch-board circuit breaker with overcurrent protection.

Overcurrent protection may be omitted for motors fitted with temperature detectors and being disconnected upon over temperature, provided the feeding cable is sufficiently protected.

e) See Sec.5 A301 for requirements for temperature detectors in windings.

502 *Steering gear protection*

a) Steering gear circuits shall be disconnected upon short circuit only.

b) Overcurrent and single phase operation (if three phase equipment) shall activate alarm in a manned control position.

c) Trip due to time-delayed overcurrent relays with release current at least 200% of the full load current is accepted.

d) Fuses used for short circuit protection of steering gear circuits shall be rated 200 - 300% of the full load current.

H. Control

H 100 System control

101 *Emergency stop*

a) Emergency stops of at least the following pumps and fans shall be arranged from an easily accessible position outside the space being served. These positions should not be readily cut off in the event of a fire in the spaces served:

— fuel oil transfer pumps
— fuel oil booster pumps
— other similar fuel pumps
— nozzles cooling pumps when fuel oil is used as coolant
— fuel oil purifiers
— pumps for oil-burning installations

— fans for forced draught to boilers
— all ventilation fans.

b) The means provided for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces.

c) Emergency stop of thrusters and propulsion motors shall be arranged from all control stations.

d) Emergency stops shall be independent of any remote control system.

e) Requirements for emergency stop of other equipment are given in other parts of the rules.

102 *Arrangement of emergency stop circuits*

a) The arrangement of the emergency stop system shall be such that no single failure will cause loss of duplicated essential or important equipment.

b) Computer based emergency stop systems shall have facilities to detect failures that will set the system inoperable, and give alarm to a manned position. See DNV-OS-D202, Ch.2 Sec.1 C.

c) Alarm for loss of power will be required for normally open emergency stop circuits.

Guidance note:

Emergency stop systems may be based on both normally open (NO) and normally closed (NC) circuits, depending on the arrangement and the function of the system to be stopped. Systems, which can be stopped without any hazard, should be based on NC circuits, emergency stop of propulsion motors and thruster should be based on NO circuits.

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103 *Main and emergency switchboard control*

a) Power supply for control circuits for generators breakers and generator protection shall generally be branched off from the main circuit (i.e. line side of the generator breaker.). For exception, see 104.

b) The interlocking circuit and protection relays shall be arranged so that the generator circuit breaker is not dependent of external power sources except for external power supplies mentioned in 104.

c) Switchboards designed and constructed entirely for remote operation, i.e. without or partly without local instrumentation and control devices on the switchboard, will be accepted. The remote control system shall comply with DNV-OS-D202.

d) Where the main switchboard is arranged for remote operation from a position outside the space containing the main switchboard, the main switchboard shall in addition be arranged for operation from a position within the space containing the main switchboard. This arrangement shall be independent of the remote control outside the space containing the main switchboard. Measuring devices and instrumentation positioned in the generators circuit breaker compartment do not need to be duplicated.

e) One single, common control station for several generators can be accepted provided that necessary precaution is taken with respect to separation of each of the generators control cabling, instrumentation and control circuits. The control station cabinet should not be used for any other purposes. Where the rules require the main bus bar divided, the control for each part of the main switchboard shall be separated with flame retardant partitions, unless each generator has it's own control system.

f) Any casualty within one compartment containing a generator circuit breaker should not render any of the other generators circuit breakers, nor their instrumentation and signals, inoperative.

g) Automatic connection of a generator after blackout shall only be possible when auxiliary contacts on all generator circuit breakers show directly that all generators are disconnected from the main switchboard.

h) For emergency generators, a trip of a control circuit protection shall not lead to uncontrolled closing of the generator breaker against a live bus.

104 *Control power distribution systems*

a) The control power can be supplied from a battery installation arranged as required for starting batteries when the switchboard's main bus bars can be divided in two or more sections by circuit breakers or on-load switches.

b) An independent control power supply system shall be arranged for each of the switchboard sections and be arranged with change over possibilities.

c) The control power circuit for each generator breaker shall have separate short circuit protection.

d) Each auxiliary control power supply system is to have sufficient stored energy for at least two operations of all the components connected to its section of the switchboard. For switching off circuit breakers this applies for all circuit breakers simultaneously, and without excessive voltage drop in the auxiliary circuits, or excessive pressure drop in pneumatic systems.

105 *Generator instrumentation*

a) At any control position for operation of a generator breaker the following information and control signals shall be easily and simultaneously observed by the operator:

— control signals for breaker open and breaker close
— generator power (kw), if the generator is for parallel operation
— generator current. Three separate simultaneous readings or alternatively one reading with a changeover switch for connection to all phases. if changeover switch is used, the current reading shall be supplied by separate current transformers, not used for protection
— generator voltage
— generator frequency
— bus bar voltage
— bus bar frequency
— adjustment device for speed of generator prime mover.

b) It shall be possible to synchronise each generator intended for parallel operation with two different devices. Each such generator shall be able to be synchronised to its bus bar by a synchronising device independent of any other sections of the switchboard.

Exception:

The speed set-point of any main engine driving a generator does not need to be accessible at the control position for the generator breaker.

106 *Main source of power and main switchboard in different locations*

For generators installed in a space that does not have direct access to the space where the generator breaker is installed, the generator cable shall have short circuit protection at both ends. The generator and generator driver shall be equipped with remote control and alarms as required by class notation **E0**.

107 *Sectioning of bus bars*

a) Switchgear for sectioning of bus bars shall have sufficient making and breaking capacity for the service for which it

is intended. If wrong operation may cause damage, then instructions for correct operation shall be given by signboard on the switchboard. It shall be clearly indicated whether such switchgear is open or closed.

b) Undervoltage release of sectioning switchgear is not accepted unless the switchgear has sufficient capacity for breaking the prospective fault current at the point of installation.

108 *Parallel incoming feeders*

a) Switchboards that are arranged for supply by two (or more) alternative circuits shall be provided with interlock or instructions for correct operation by signboard on the switchboard. Positive indication of which of the circuits is feeding the switchboard shall be provided.

b) When a secondary distribution switchboard is supplied by two or more transformers or rectifiers, the circuit from each of these shall be provided with multipole switchgear.

c) Switchboards supplied from power transformers shall be arranged with interlock or signboard as in a) unless the power transformers are designed for parallel operation.

d) Interlocking arrangements shall be such that a fault in this interlocking system cannot put more than one circuit out of operation.

e) In the case where a secondary distribution system is supplied by parallel operated power transformers, supplied by different sections of main bus bars, necessary interlocks shall be arranged to preclude parallel operation of the transformers when the main distribution bus ties are open or being opened.

f) Transformers shall not be energised from the secondary side, unless accepted by the manufacturer. For high voltage transformers, secondary side switchgear shall generally be interlocked with the switchgear on the primary side. This so that the transformer will not be energised from the secondary side when the primary switchgear is opened. If backfeeding through transformers is arranged, special warning signs shall be fitted on the primary side switchgear. Different generators shall not feed the different sides of transformers simultaneously (not locking generators in synchronism via a transformer).

Guidance note:

Temporary back-feeding as part of a black-start procedure may be accepted.

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H 200 Motor control

201 *Controlgear for motors*

a) Each motor shall normally be provided with at least the following controlgear, functioning independent of controlgear for other motors:

- each motor rated 1 kW or above: a multipole circuit breaker, fused circuit breaker or contactor, with overcurrent release according to G500, if necessary combined with a controller for limiting the starting current
- each motor rated 1 kW or above: control circuits with undervoltage release so that the motor does not restart after a blackout situation
- each motor rated less than 1 kW: a multipole switch.

For exemptions and additions regarding steering gear motors, see G502.

b) Undervoltage release shall not inhibit intended automatic restart of motor upon restoration of voltage after a blackout.

c) Common starting arrangements for a group of motors (e.g. a group of circulating fans for refrigerated cargo holds) are subject to consideration in each case.

d) Controlgear for motors shall be designed for the frequency of making and breaking operations necessary for the respective motor.

e) Switchgear for feeder circuits shall not be used as motor controlgear unless:

- the switchgear is designed for the frequency of making and breaking operations necessary for the respective motor
- the requirements for motor controlgear otherwise are complied with
- the switchgear shall be of the withdrawable type if low voltage.

202 *Power for motor starting*

a) If the starting of a large motor requires that two or more generators are run in parallel, an interlock shall be provided, ensuring that this circuit can only be switched on when a sufficient number of generators are connected.

b) The interlock may, however, be omitted for motors that can only be started from the room where the generator breakers are located, provided signboards with the necessary instructions are fitted at the starters.

I. Vessel Arrangement

I 100 General

101 *Ventilation*

a) All rooms where electrical equipment is located shall be sufficiently ventilated in order to keep the environmental conditions within the limits given in Sec.3 B300.

b) The heat generated by the electrical equipment itself, by other machinery and equipment, and the heat caused by sun radiation on bulkheads and decks should not lead to operating ambient temperatures in excess of the limits listed in Sec.3 Table B1.

c) The air supply for internal cooling of electrical equipment (i.e. "ventilated equipment") shall be as clean and dry as practicable. Cooling air shall not be drawn from below the floor plates in engine and boiler rooms.

d) If forced ventilation or cooling is required, the same redundancy requirement applies to such equipment and its power supply as to the electrical equipment installed in the ventilated or cooled area.

e) If the actual ambient air temperatures will clearly exceed the limits listed in Sec.3 Table B1, then the equipment shall be designed for the actual operating ambient temperatures concerned.

102 *Arrangement of power generation and distribution systems*

a) The integrity of the main electrical supply shall not be affected by fire, flood or other damage conditions, in one space only. The main switchboard shall be located as close as is practicable to the main generating station.

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

c) The integrity of the emergency electrical supply and the transitional source of power shall not be affected by fire, flood or other casualty in the main electrical supply, or in any machinery space of category A. The emergency switchboard shall be located in the same space as the emergency generating station.

d) Normally, the space containing the emergency source of power and associated electrical distribution shall not be continuous to the boundaries of machinery space of category A or those spaces containing the main source of electrical power and associated electrical distribution.

e) All charging and energy storing devices for necessary control and instrumentation shall be located in the same space as the system being under control. UPSs or battery systems for operation of the main power distribution shall not be located together with equipment necessary for operation of the emergency power generation or distribution, or vice versa.

Guidance note:

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

The requirements in a) do not preclude the installation of supply systems in separate machinery spaces, with full redundancy in technical design and physical arrangement.

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103 *Installation of switchboards*

a) Switchboards shall be placed in easily accessible and well-ventilated locations, well clear of substantial heat sources such as boilers, heated oil tanks, and steam exhaust or other heated pipes. The ventilation shall be so arranged that possible water or condensation from the ventilator outlets can not reach any switchboard parts.

b) Normally, pipes shall not be installed above, or immediately below, in front of or behind switchboards. If this is unavoidable, additional screening of pipes and fittings will be required in order to protect the switchboard against splash, or spray, by leakage. Such screening shall be provided with drains, if necessary.

c) Switchboards shall not be located immediately above spaces where high humidity or high concentrations of oil vapours can occur (e.g. bilge spaces), unless the switchboard has a tight bottom plate with tight cable penetrations.

d) The arrangement and installation of switchboards shall be such that operation and maintenance can be carried out in a safe and efficient way. When switchgear is located close to bulkheads or other obstructions, it shall be possible to perform all maintenance from the front.

e) Switchboards more than 7 m long shall not form dead end corridors. Two escape routes shall be available as required by the Rules for Classification of Ships, Pt.4 Ch.10 Sec.15 B401.5 (SOLAS Reg. II-2/45.1).

f) Type tested assemblies or partially type tested assemblies with smaller clearance or creepage distances than given in Sec.3 D600 (i.e. as accepted by Sec.4 A110), are not accepted installed in machinery space category "A".

g) If the installation prohibited in b) is unavoidable, then additional screening of pipes and fittings is required in order to protect the electrical equipment against splash by leakage. Such screening shall be provided with drains, if necessary.

h) For water-cooled electrical equipment seawater pipes shall be routed away from the equipment, so that any leakage in flanges do not damage the equipment.

104 *Arrangement for high voltage switchboard rooms*

The space where high voltage switchboards are installed shall be so arranged that hot gases escaping from the switchboard in case of an internal arc are led away from an operator in front of the switchboard.

105 *Passage ways for main and emergency switchboards*

a) Passages in front of main switchboards shall have a height of minimum 2 m. The same applies to passages behind switchboards having parts that require operation from the rear.

b) The width of the front passage shall be at least 0.8 m for low voltage, and 1 m for high voltage switchboards. When doors in high voltage cubicles are open there shall be at least 0.5 m free passage left. The width of the passage behind a switchboard where access for operation is necessary, shall be at least 0.6 m, except at frames where it can be reduced to 0.5 m. Doors in open position, or switchgear drawn out in position for service, shall not obstruct the passage, i.e. there shall be at least 0.4 m free passage left. (For high voltage there shall be 0.5 m left.).

c) Where switchgear needs passage behind for installation and maintenance work the free passage behind the switchgear shall not be less than 0.6 m, except at frames where it can be reduced to 0.5 m. For voltages above 500 V up to and including 1000 V these figures for passage behind a switchboard shall be increased to at least 0.8 and 0.6 m, respectively.

d) The free passageway in front of, or behind the switchboard, shall give unobstructed access to a door for easy escape in case of an emergency situation occurring in the switchgear room.

106 *Distribution switchboards*

a) Distribution switchboards shall be placed in accessible spaces with enclosures as specified in Sec.10.

b) Alternatively switchboards may be placed in cupboards made of or lined with material that is at least flame-retardant, and with door, cable entrances and other openings (e.g. for ventilation) arranged so that the cupboard in itself complies with the protection required in Sec.10.

c) The front of the switchboard, inside such a cupboard, is to comply with enclosure type IP 20 with exemption for fuses as specified in Sec.4 A104.

107 *Controlgear for equipment in bunker and cargo spaces*

All lighting and power circuits terminating in a bunker or cargo space shall be provided with a multiple pole switch outside the space for disconnecting such circuits.

108 *Hazardous areas*

For installations in hazardous areas, as for example battery rooms, paint stores, gas bottle stores or areas that may be hazardous due to the cargo or processes onboard, the requirements in Sec.11 shall be complied with.

I 200 Rotating machines, general

a) Generating sets with horizontal shaft shall generally be installed with the shaft in the fore-and-aft direction of the vessel.

b) Where a large machine is installed athwartships, it should be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in the Rules for Classification of Ships, Pt.4 Ch.1 Sec.3 B. The manufacturer should be informed when a machine for installation athwartships is ordered.

I 300 Battery installations

301 *Application*

These requirements are applicable for rechargeable batteries of both "vented" and "dry" type batteries.

Guidance note:

The term "vented" batteries is used for rechargeable batteries with wet electrolyte without devices for reduced emission of gas.

The term "dry" batteries is used for rechargeable batteries with reduced emission of gas, such as valve regulated, sealed, gel type or dry type batteries. Variants characterised as “sealed” or “hermetically sealed” should be regarded similar to the dry types unless other properties are confirmed.

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302 *Hazardous area*

a) No electrical equipment, except that necessary for operation and being certified safe for zone 1, hydrogen atmosphere (gas group IIC), shall be installed inside battery rooms, lockers or boxes.

b) Motors mounted inside extract ventilation ducts for lockers and battery rooms, shall be certified safe as for a). The fan itself shall be of non-sparking type.

c) Battery rooms and lockers or boxes shall be regarded as zone 2 hazardous areas with respect to access doors and possible interference with other rooms.

303 *Arrangement*

a) Requirements for the location of batteries depends upon their capacity as shown in 304 Table I1.

b) Accumulator batteries shall be suitably housed, and compartments shall be properly constructed and efficiently ventilated.

- the batteries shall be so located that the their ambient temperature remains within the manufacturer’s specification at all times. Normally, a location at open deck exposed to sun and frost will not be accepted
- battery cells shall be placed so that they are accessible for maintenance and replacement
- in battery boxes, the cells shall be placed at one height only. There shall be minimum 300 mm space above each cell when the top cover is open
- in battery rooms and lockers and boxes with side cover, there shall be a minimum of 300 mm space above each cell
- normally, accumulator batteries shall not be located in sleeping quarters
- only batteries for starting of the emergency generator, if any, shall be installed in the same space as the emergency switchboard.

304 *Ventilation of battery rooms*

a) Ventilation shall be arranged for all battery rooms, lockers and boxes. The air intake shall be in the lower part and can be taken from an adjacent room being readily accessible from the battery installation (e.g. ventilation from the engine room, for batteries with access from this room). The air outlet shall be arranged in the upper part so that gas pockets cannot accumulate.

Table I1 Battery location and ventilation

Battery capacity, (KVAh)		*Minimum requirements for location and ventilation*
Vented type	Dry type	
> 20	> 40	*Location*: Dedicated battery room. *Ventilation*: Separate mechanical ventilation with suction fan, for minimum 30 changes of air per hour. The ventilation fan shall be started automatically when full (quick) charging is commenced, and shall be running until at least 30 minutes after the charger unit has been de-energised. The ventilation fan shall be interlocked with the charger unit in such a manner that the charger unit is de-energised if the ventilation fails.
> 5 and < 20	N/A	*Location*: Dedicated battery room or locker. *Ventilation*: Mechanical ventilation as described above or natural ventilation to free air. Natural ventilation shall be through an unobstructed duct not inclined more than 45° from the vertical. The natural escape of air shall not be reduced by the room ventilation system; i.e. the room is to have positive air pressure. Lockers may be located in engine rooms and similar spaces.
< 5	< 40	*Location*: Dedicated battery box. *Ventilation*: Natural ventilation directly to the room by ventilation holes at top and bottom. The room is to have an extract ventilation duct at ceiling level. The area of the room (m^2), shall be at least 0.3 times battery kVAh. Ventilation rate of the room shall be at least 6 air changes per hour.
N/A	< 0.2	In ventilated electrical assemblies.

Guidance note:

As an alternative to the above ventilation rates, the following may be applied:

Ventilation rate, (m^3/hour), for battery rooms and rooms containing battery boxes:

- for vented batteries, 10 x sum of battery kVAh.
- for dry batteries, 2 x sum of battery kVAh.

For vented batteries, a two step ventilation system applying reduced ventilation rate at trickle charging may be applied if the actual charging current is monitored. The monitoring circuit shall automatically switch to high ventilation rate when the value of the charging current in amperes, rises above 2% of the battery ampere hours value. Switching to low ventilation rate shall be by manual operation. The low ventilation rate, (m^3/hour) shall be at least 0.002 x sum of battery VAh.

In case of natural ventilation by openings to the room or by extract duct to free air, the following is given for cross section (cm^2) of openings and duct. Except for boxes, the inlet shall be of same size as the outlet.

- for dry batteries, 20 x battery kVAh.
- for vented batteries, 50 x battery kVAh.
- for dry batteries located in electrical panels, 500 x battery kVAh.

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305 *Charging station for battery powered fork lift*

a) A charging station is defined as a separate room, only used for this purpose, or a part of a large room, for example a cargo hold, based on the area occupied by the fork lift plus 1 m on all sides.

b) Socket outlets for the charging cables, mechanically or electrically interlocked with switchgear, can be placed in the charging station. Such socket outlets shall have at least enclosure IP 44 or IP 56, depending upon the location (see Sec.10 Table B1). In general no other electrical equipment, except explosion protected equipment (according to Sec.12) as specified for battery rooms may be installed.

c) Charging stations shall generally be mechanically ventilated with at least 30 changes of air per hour. An arrangement as specified for battery rooms with battery capacity in accordance with the actual battery capacity, but not less than 20 kVAh shall be used, see 304. For charging stations in cargo holds having mechanical overpressure ventilation, an alternative arrangement shall provide a natural ventilation outlet duct of sufficient capacity from the upper part of the charging station to free air.

I 400 Cable routing

401 *General*

a) Cable runs shall be installed well clear of substantial heat sources such as boilers, heated oil tanks, steam, exhaust or other heated pipes, unless it is ensured that the insulation type and current rating is adapted to the actual temperatures at such spaces.

b) Cables and wiring serving essential, important or emergency installations shall be routed clear of galleys, machinery spaces and their casings and other high fire risk areas, except for supplying equipment in those spaces. They shall not be run such that heating through fire divisions may jeopardise the function of the cable. Special attention shall be given to the protection and routing of main cable runs for essential installations, for example between machinery spaces and the navigation bridge area, taking into account the fire risk existing in accommodation spaces.

c) For installations in connection with hazardous areas, requirements for selection of cables, cable routing and fixing, see Sec.11.

d) Other requirements for cable routing and installation are located in Sec.10.

e) The cable routing shall be such that in case of a local fire in the engine room it is not likely that the cables to both duplicated consumers will be damaged.

f) In areas where it is impossible to separate the cable runs, they shall be protected against direct exposure to fire (e.g. screens or ducts or fire-protecting coating).

g) Cables may exceptionally be routed through high fire risk area, but shall then have additional fire protection, e.g. by using cable tested in accordance with IEC 60331.

Guidance note:
Main cable runs are for example:

— cable runs from generators and propulsion motors to main and emergency switchboards
— cable runs directly above or below main and emergency switchboards, centralised motor starter panels, section boards and centralised control panels for propulsion and essential auxiliaries.

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402 *Separation of cables for emergency services, essential and important equipment*

a) Where it is required to divide a ship into fire zones cable runs shall be arranged so that fire in any main vertical fire zone will not interfere with essential services in any other such zone.

b) The cables for duplicated steering gear motors are to be separated throughout their length as widely as is practicable. This also applies to control circuits for the steering gears motor starters, and to cables for remote control of the rudder from the bridge.

c) Special attention shall be given to the protection and routing of main cable runs for essential installations, for example between machinery spaces and the navigation bridge area, taking into account the fire risk existing in accommodation spaces.

403 *Separation of main generators or main power converters cabling*

Cables for generators, transformers and converters required according to Sec.2, shall be divided between two or more cable runs. These cable runs shall be routed as far away from each other as practicable and away from machinery having an increased fire risk.

a) The cable routing shall be such that in case of a local fire in the engine room it should not be likely that two or more such cable runs will be damaged. In areas where it is impossible to separate the cable runs, they shall be protected against direct exposure to fire (e.g. screens or ducts or fire protecting coating).

I 500 Lightning protection

501 *General*

a) All vessels with masts or topmasts made of non-conductive material shall be provided with lightning protection.

b) A lighting conductor shall be fitted on all non-metal masts on craft with a non-metal hull.

c) Primary conductors provided for lightning discharge currents shall have a minimum cross section of 50 mm^2 in copper or equivalent surge carrying capacity in aluminium.

d) The conductor shall be fastened to a copper spike of minimum diameter 13 mm reaching a minimum of 150 mm above the mast. The conductor shall terminate to a copper plate with a minimum area of 0.2 mm^2 attached to the hull and so located that it is immersed under all conditions of heel.

e) Craft with a metal hull shall be fitted with a lightning conductor on all non-metal masts. The conductor shall be as required in c) and be terminated to the nearest point of the metal hull.

J. Cable Selection

J 100 General

101 *General*

These technical requirements for cables and cable installations are considered relevant for the system design phase of a project. However, they apply as well to the final installation on the vessel.

Other relevant requirements related to cables can be found elsewhere in the rules, especially:

— I401- requirements for the routing of electric cables
— Sec.9 - technical requirements for cables as electrical components
— Sec.10 - requirements for the installation of cables

— Sec.11 - requirements for cables used in hazardous areas.

102 *Fire resistant cables*

When it is essential that a circuit shall function for some time in a fire, and carrying the cable for such a circuit through an increased fire risk area cannot be avoided (see Guidance note), then the cable shall be of a type capable of passing the test defined in IEC 60331-21 "Tests for electrical cables under fire conditions - circuit integrity", or adequately protected against direct exposure to fire.

Guidance note:

Machinery, machinery parts or equipment handling combustibles are considered to present an increased fire risk.

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103 *Voltage rating*

a) The rated voltage of a cable shall not be less than the nominal voltage of the circuits in which it is used.

b) In systems with high-resistance earthed neutral, without automatic disconnection of circuits having insulation faults, and on every system with insulated neutral (IT-systems), the rated phase to earth voltage (U_0) of the cables shall not be less than given in Table J1.

Table J1 Rated voltage for high voltage cables

Highest system voltage (U_m) (kV)	*Rated voltage (U_0) (kV)*	
	With automatic disconnection upon earth fault	*Without automatic disconnection upon earth fault*
7.2	3.6	6.0
12.0	6.0	8.7
17.5	8.7	12.0
24.0	12.0	18.0
36.0	18.0	-

J 200 Cable temperature

201 *Cable temperature class*

The temperature class of power cables shall be at least 10°C above the ambient temperature. However, 60°C power cables are generally not permitted in engine and boiler rooms (for temperature classes, see Sec.9).

J 300 Choice of insulating materials

301 *Short circuit and cable*

The conductor cross-section of cables shall be sufficient to prevent the insulation from being damaged by high temperatures occurring by short circuits at the cable end.

Guidance note:

The following maximum conductor temperatures by short circuits of 5 s maximum duration have been specified in IEC 60502-2, "Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV":

160°C for polyvinyl chloride insulation

250°C for ethylene propylene rubber and cross-linked polyethylene insulation.

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302 *PVC insulated conductors*

a) With reservations as specified in 201, PVC-insulated conductors without further protection may be used for installation in closed piping system in accommodation spaces, when the system voltage is maximum 250 V. Such conductors may also be used for internal wiring of switchboards and other enclosures and for control wiring installed in closed piping system on machinery components. Other types of flame retardant switchboard wires may be accepted for the same purpose. See Sec.9 D400.

b) Due to brittleness at low temperatures, cables with PVC insulation and or main (inner) sheath, shall normally not be installed in refrigerated chambers, and holds for temperatures below –20°C, or across expansion joints on weather decks.

303 *Rubber insulated cables*

Due to poor mechanical strength, the use of silicon-rubber-insulated cables is limited to applications where a high temperature resistant cable is necessary (where the ambient temperature can be above 70°C).

J 400 Current rating

401 *Earthing connections and conductors*

a) All earthing connections of copper shall have sufficient cross-section to prevent the current density exceeding 150 A/mm² at the maximum earth fault currents that can pass through them.

b) Minimum cross-section of earthing conductors shall be as listed in Table J2.

Table J2 Earthing connections and conductors

	Arrangement of earth conductor	*Cross-section Q of associated current carrying conductor (One phase or pole) (mm²)*	*Minimum cross-section of earth conductor*
1	i) Insulated earth conductor in cable for fixed installation.	Q ≤ 16	Q
	ii) Copper braid of cable for fixed installation. iii) Separate, insulated earth conductor for fixed installation in pipes in dry accommodation spaces, when carried in the same pipe as the supply cable. iv) Separate, insulated earth conductor when installed inside enclosures or behind covers or panels, including earth conductor for hinged doors as specified in Sec.3 D401 d).	16 < Q	1/2 of the current-carrying conductor, but not less than 16 mm²
2	Uninsulated earth conductor in cable for fixed installation, being laid under the cable's lead sheath, armour or copper braid and in metal-to-metal contact with this.	Q ≤ 2.5	1 mm²
		2.5 < Q ≤ 6	1.5 mm²
		6 < Q	Not permitted
3	Separately installed earth conductor for fixed installation other than specified in 1 iii) and 1 iv).	Q < 2.5	Same as current-carrying conductor subject to minimum 1.5 mm² for stranded earthing connection or 2.5 mm² for unstranded earthing connection
		2.5 < Q ≤ 120	1/2 of current-carrying conductor, but not less than 4 mm²
		120 < Q	70 mm²
4	Insulated earth conductor in flexible cable.	Q ≤ 16	Same as current-carrying conductor
		16 < Q	1/2 but minimum 16 mm²

Conductor current rating

The highest continuous load carried by a cable shall not exceed the current rating specified in Tables J2 to J6, with consideration given to the correction factors given in 500.

J 500 Correction factors

501 *Different temperature classes*

If cables of different temperature classes are carried in the same bunch or pipe, the current ratings for all cables shall be based on the lower temperature class.

502 *Multicore cables*

For cables with more than 4 cores, the current rating are given by the following equation:

$J_N = J_1 / \sqrt[3]{N}$

N = number of cores

J_1 = the current rating for a 1-core cable.

This applies by equal load on all cores. If some cores in such multi-core cables are not used, or are used for very small currents only, the current rating for the other cores may be increased after consideration in each case.

503 *Ambient temperature*

When the actual ambient air temperature clearly differs from 45°C, the correction factors as given in Table J6 apply.

504 *Bunching*

The current ratings specified in the Tables J3 to J5 are based on maximum 6 cables, which can be expected to be under full load simultaneously being bunched together. If bunching of larger formations is used for cables expected to be under full load simultaneously, a correction factor of 0.85 shall be applied.

505 *Periodic load*

For cables used for loads that are not continuous, i.e. operates for periods of half or one hour and the periods of no-load is longer than 3 times the cable time constant T (in minutes), the current rating may be increased by a duty factor, D_f, calculated from:

$$D_f = \sqrt{\frac{1.12}{1 + e^{-\frac{ts}{T}}}}$$

ts = the service time of the load currents in minutes

T = cable's time constant
= $0.245\ d^{1.35}$

d = overall diameter of the cable in mm.

506 *Intermittent load*

Cables used for loads that are not continuous, are repetitive and have periods of no-load of less than 3 times the cable time constant T (in minutes), the current rating may be increased by an intermittent factor, I_f, calculated from:

$$I_f = \sqrt{\frac{1 - e^{-\frac{tp}{T}}}{1 - e^{-\frac{ts}{T}}}}$$

ts = the service time of the load currents in minutes

tp = the intermittent period in minutes (i.e. the total period before of load and no-load before the cycle is repeated)

ts, T and d, see 505.

J 600 Parallel connection of cables

601 *General*

a) Parallel connection can be used for cables having conductor cross-section 10 mm² or above. All cables that are parallel connected shall be of the same length and cross-section. The current-carrying capacity is the sum of all parallel conductors' current-carrying capacities.

b) A two, three or four-core cable, in which all cores are of the same cross-section, can be used as single-core cable by parallel connection of all cores in each end. The current-carrying capacity of such single-core cable is the sum of the cores' current-carrying capacities.

c) With parallel connection of multi-core cables, one core of each cable shall be used for each phase and neutral connection, respectively.

d) With many parallel-connected cables, the current distribution may be uneven. However, no single cable shall, after installation, carry more than its capacity. This shall be demonstrated at full load of the consumer.

J 700 Additional requirements for A.C. installations, and special D.C. installations

701 *General*

a) Generally, multi-core cables shall be used on A.C. installations.

b) On three-phase, four-wire circuits, the cross-section of the neutral conductor shall be the same as for a phase conductor up to 16 mm^2, and at least 50% of that of a phase conductor for larger cross-sections, though not larger than 50 mm^2. The braiding in a cable is not accepted used as the neutral conductor.

702 *Single-core cables*

a) Single-core cables are not to have steel-wire braid or armour.

b) Single-core cables for the same circuit shall be laid closely together, except for the ventilation spaces when such are necessary (see 504) and shall be laid under the same clips or in the same pipe, so that the bunch is not divided by any magnetic material. Cable penetrations and glands for single-core cables shall be of non-magnetic material. If two or more parallel-connected cables per phase are used, the distribution of the different phases shall be such that the current distribution becomes as equal as possible.

c) For D.C.-installations with a high "ripple" content (e.g. thyristor (SCR) units), a) and b) are applicable.

J 800 Rating of cables

801 Rating of cables with temperature class 60°C is given in Table J3.

Table J3 Rating of cables with temperature class 60°C

Nominal cross-section (mm^2)	*Current rating (Based on ambient temperature 45°C)*					
	Single-core A		*2-core A*		*3 or 4-core A*	
1	8		7		6	
1.5	12		10		8	
2.5	17		14		12	
4	22		19		15	
6	29		25		20	
10	40		34		28	
16	54		46		38	
25	71		60		50	
35	87		74		61	
50	105		89		74	
70	135		115		95	
95	165		140		116	
120	190		162		133	
150	220		187		154	
185	250		213		175	
240	290		247		203	
300	335		285		235	
	D.C.	A.C.	D.C.	A.C.	D.C.	A.C.
400	390	380	332	323	273	266
500	450	430	383	365	315	301
630	520	470	442	400	364	329

802 Rating of cables with temperature class 85°C is given in Table J4.

Table J4 Rating of cables with temperature class 85°C

Nominal cross-section (mm2)	*Current rating (A) (Based on ambient temperature 45°C)*					
	Single-core		*2-core*		*3 or 4-core*	
1	16		14		11	
1.5	20		17		14	
2.5	28		24		20	
4	38		32		27	
6	48		41		34	
10	67		57		47	
16	90		77		63	
25	120		102		84	
35	145		123		102	
50	180		153		126	
70	225		191		158	
95	275		234		193	
120	320		272		224	
150	365		310		256	
185	415		353		291	
240	490		417		343	
300	560		476		392	
	D.C.	A.C.	D.C.	A.C.	D.C.	A.C.
400	650	630	553	536	445	441
500	740	680	629	578	518	476
630	840	740	714	629	588	518

803 Rating of cables with temperature class 95°C is given in Table J5.

Table J5 Rating of cables with temperature class 95°C

Nominal cross-section (mm^2)	*Current rating (A) (Based on ambient temperature 45°C)*		
	Single-core	*2-core*	*3 or 4-core*
1	20	17	14
1.5	24	20	17
2.5	32	27	22
4	42	36	29
6	55	47	39
10	75	64	53
16	100	85	70
25	135	115	95
35	165	140	116
50	200	175	140
70	255	217	179
95	310	264	217
120	360	306	252
150	410	349	287
185	470	400	329
240	570	485	400
300	660	560	460

804 Correction factors for ambient temperature are given in Table J6.

Table J6 Correction factors for ambient temperature

Cable temperature class	*Ambient temperature (°C)*										
°C	35 [1]	40	45	50	55	60	65	70	75	80	85
60 [2]	1.29	1.15	1.00	0.82	-	-	-	-	-	-	-
75	1.15	1.08	1.00	0.91	0.82	0.71	0.58	-	-	-	-
85	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.50	-	-
95	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

1) Correction factors for ambient temperature below 40°C will normally only be accepted for:

— cables in refrigerated chambers and holds, for circuits which only are used in refrigerated service
— cables on vessel with class notation restricting the service to non-tropical water.

2) 60°C cables shall not be used in engine and boiler rooms.

SECTION 3
EQUIPMENT IN GENERAL

A. General Requirements

A 100 References

101 *General*

a) This section contains technical requirements for all electrical equipment in general. Additional requirements for special types of equipment can be found in Sec.4 to Sec.9.

b) Requirements for electrical systems as a whole can be found in Sec.2. Requirements for installation of equipment can be found in Sec.10.

102 *Compliance with standards*

The requirements in this section are based on the IEC standard system in general.

Guidance note:

IEC Standards covering the general requirements for electrical components for ships are: IEC 60092-101 "Definitions and general requirements", and parts of IEC 60092-201 "Systems design - General".

For offshore units: IEC 61892, part 1, "General requirements and conditions", part 2 "Systems design", and part 3 "Equipment", apply.

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B. Environmental Requirements

B 100 Inclinations

101 *General*

a) Electrical equipment and components on ships and HS, LC and NSC shall be designed to operate satisfactorily under the following inclinations of the vessel:

— static conditions: list 15º, trim 5°
— dynamic conditions: rolling ±22.5º, pitch ±7.5º (may occur simultaneously)

b) Emergency installations on ships and HS, LC and NSC, except as stated in c), shall be designed to operate satisfactorily under the following inclinations of the vessel:

— static conditions: list 22.5°, trim 10°.

c) On ships for the carriage of liquefied gases and chemicals, the emergency power supply is to remain operational with the ship flooded up to a maximum final athwart ship inclination of 30º, when the deck is not immersed.

d) For mobile offshore units the inclination values are as follows:

— inclination 15° from normal level in any direction under normal static conditions
— inclination 22.5° from normal level in any direction under normal dynamic conditions
— inclination 25° from normal level in any direction for emergency installations.

Guidance note:

Other values may be accepted if justified by calculations for the particular vessel or offshore unit.

National authorities may require larger inclinations.

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B 200 Vibrations and accelerations

201 *General*

a) Electrical equipment and components shall be constructed to withstand, without malfunctioning, or electrical connections loosening, at least the following values:

— vibration frequency range 5 to 50 Hz with vibration velocity amplitude 20 mm/s
— peak accelerations ±0.6 g for vessels of length exceeding 90 m (duration 5 to 10 s)
— peak accelerations ±1 g for MOUs and vessels of length less than 90 m (duration 5 to 10 s).

b) For flexible mounted equipment, special considerations shall be given to the construction of the equipment since larger vibrations may occur.

B 300 Temperature and humidity

301 *Ambient temperatures*

a) Electrical equipment including components inside enclosures in switchboards etc., shall be constructed for continuous operation at rated load, at least within the ambient air temperature ranges listed in Table B1 and cooling water temperatures in 302.

b) Modifications of the equipment may be required if the actual ambient air temperatures will clearly exceed the limits in a).

c) If some equipment has a critical maximum ambient temperature by which it suddenly fails, this critical temperature should not be less than 15°C above the limits specified in the table.

d) For vessels with class notation restricting the service to non-tropical waters, the upper ambient air temperature limits according to Table B1 may be reduced by 10°C.

e) For electronic and instrumentation devices the requirements in DNV-OS-D202 applies.

Guidance note:

These rules do not appraise ambient conditions for transport or storage of electrical equipment.

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Table B1 Ambient air temperature ranges				
Location			*Minimum ambient air temperature range for continuous operation (°C)*	
			From	*To*
1		Engine rooms, boiler rooms, galleys and similar spaces, accommodation spaces.	0	+45
2		Open deck, dry cargo holds, steering gear compartments, deckhouses, forecastle spaces and similar spaces which are not provided with space heating.	–25	+45
3	a)	Refrigerated chambers and holds, general.	The minimum temperature specified for the installation, but not above –20	+45
	b)	Refrigerated chambers and holds, for equipment which only is used in refrigerated service.		+35

302 *Cooling water temperatures*

Electrical equipment shall be constructed for continuous operation under full rated load, at a seawater temperature range from 0 to +32°C. Electrical equipment on vessels with class notation restricting the service to non-tropical waters shall be constructed for continuous operation at a seawater temperature range from 0 to +25°C.

303 *Humidity*

Electrical equipment shall be constructed to withstand, and function safely in relative humidity up to 95%.

C. Equipment Ratings

C 100 Electrical parameters

101 *General*

a) Unless otherwise clearly stated by the purchaser, equipment shall be rated for continuous duty. (Duty type S1).

b) All conductors, switchgear and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the current which can normally flow through them. They shall be capable of carrying anticipated overloads and transient currents, for example the starting currents of motors, without damage or reaching abnormal temperatures.

102 *Voltage and frequency*

a) Equipment connected to the system shall be constructed for the frequency and voltage tolerances described in Sec.2. A200.

b) With respect to fast voltage transients, equipment connected to the system shall be capable of withstanding fast transients with peak voltage amplitude of 5.5 times U_N, and rise time or delay time of 1.2μs / 50μs.

103 *Harmonic distortion*

All equipment shall be designed to operate at any load up to the rated load, with a supply voltage containing the following harmonic distortion:

— total harmonic content not exceeding 5% of voltage root mean square value
— no single harmonic being greater than 3% of voltage root mean square value.

104 *Electromagnetic compatibility (EMC)*

Equipment producing transient voltage, frequency and current variations is not to cause the malfunction of other equipment on board, neither by conduction, induction or radiation.

C 200 Maximum operating temperatures

201 *General*

a) The temperature rise of enclosures and their different parts shall not be so high that fire risk, damage to the equipment, adjacent materials or danger to personnel occurs.

b) Normally, the temperature rise of enclosures for other equipment should not exceed 50°C, or 40°C for enclosures that are installed in contact with flammable materials such as wooden bulkheads. Exemptions may be considered for equipment that is especially protected against touching or splashing of oil.

c) For luminaries, resistors and heating equipment, see Sec.8.

D. Mechanical and Electrical Properties

D 100 Mechanical strength

101 *General*

Equipment shall have sufficient mechanical strength to withstand the strains they are likely to be exposed to when installed.

102 *Enclosures*

a) Enclosures shall be resistant to weather, oil and chemicals and have sufficient mechanical strength when intended to be installed in an area where risk of mechanical damage exists.

b) Metallic enclosures installed on deck or in compartments where severe corrosion problems can be expected shall be made of especially corrosion resistant material or dimensioned with a certain corrosion allowance.

c) Light metal alloys as i.e. aluminium shall be avoided as enclosure materials if not documented to be seawater resistant and installed so that local corrosion caused by contact does not occur.

d) Enclosures that are so placed that they are likely to be stepped or climbed on, shall be able to withstand the weight of a man. This applies for example to most electrical machines in the engine room, winch motors on deck, etc. A test to this effect, with a force of 1000 N applied by a flat surface 70 x 70 mm, may be carried out as type test or random test.

e) Enclosures shall withstand the ambient air temperatures which are specified in B, with the equipment at full load. The temperature rise of enclosures shall not be so high that fire risk, damage to adjacent materials or danger to personnel occurs.

f) When enclosures of other materials than metal are used, they should at least withstand immersion in water at 80°C for 15 minutes, without showing signs of deterioration, and the material shall be flame retardant according to IEC 60092-101. A test to this effect may be carried out as type test or random test. This also applies to screens of luminaires, and to windows in other enclosures, if made of other material than glass.

103 *Materials*

a) Electrical equipment shall be constructed of durable non-hygroscopic materials which are not subject to deterioration in the atmosphere to which it is likely to be exposed.

b) Electrical equipment shall be constructed of at least flame retardant materials.

Guidance note:

Even in "dry" locations, up to 96% relative humidity with a salt content of 1 mg salt per 1 m³ of air may occur; in machinery spaces also mist and droplets of fuel- and lubricating oil.

Tests for flame retardant properties are described in IEC 60092-101

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104 *Material detoriation due to cargo vapours*

Where the cargo gases or vapours are liable to damage the materials used in the construction of electrical apparatus, careful consideration shall be given to the characteristics of the materials selected for conductors, insulation, metal parts, etc. As far as is practicable, components of copper and aluminium, shall be encapsulated to prevent contact with gases or vapours.

Guidance note:

Attention is drawn to the possibility of gases and vapours being transferred from one point to another through cables or cable ducting unless appropriate precautions are taken, for example, adequate end sealing.

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D 200 Cooling and anti-condensation

201 *General*

a) Where electrical equipment depends upon external cooling, the following shall be complied with:

— an alarm shall be initiated when auxiliary cooling or ventilation motors stop running. Alternatively a flow monitoring alarm shall be initiated
— the windings in the cooled equipment for essential services shall be equipped with temperature detectors for indication and alarm of winding temperature
— the windings in the cooled equipment for important services shall be equipped with temperature detectors for alarm at high winding temperature.

b) Where the cooling of electrical equipment depends upon general room ventilation only, temperature detectors in the equipment are not required.

Guidance note:

These requirements will not be enforced when technically infeasible as for example for thyristors.

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202 *Water cooled heat exchangers*

a) Where cooling of equipment is arranged through air-water heat exchangers, these shall be arranged to prevent entry of water into the equipment, whether by leakage or condensation. Leakage alarm shall be provided.

b) Heat exchangers in high voltage equipment shall be of double tube type and shall be fitted with leakage alarm.

c) The construction and certification of the air-water heat exchangers shall comply with the requirements for pressure vessels, see the Rules for Classification of Ships, Pt.4 Ch.7.

d) For direct water cooling of semi-conductor equipment, see Sec.7.

203 *Anti condensation*

a) For equipment where condensation is likely, for example those that are idle for long periods, heating arrangements may be required.

b) All high voltage converters, transformers and rotating equipment not located in heated and ventilated spaces, shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

c) All equipment equipped with air/water heat exchangers shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

D 300 Termination and cable entrances

301 *Termination*

a) All equipment shall be provided with suitable, fixed terminals in an accessible position with sufficient space for connection of the external incoming cable or wiring.

b) All connections for current-carrying parts and earthing connections shall be fixed so that they cannot loosen by vibration. This also applies to fixing of mechanical parts when found necessary.

c) Terminals for circuits with different system voltages shall be separated, and clearly marked with the system voltage.

d) High voltage terminals, above 1000 V, shall not be located in the same box, or part of enclosure, as low voltage terminals.

e) Electrical equipment that needs to be connected to protective earth according to 400 shall be provided with suitable fixed terminal for connecting a protective earth conductor. The terminal shall be identified by a symbol or legend for protective earthing (PE).

302 *Cable entrance*

a) Cable entrances into enclosures shall be from below or from the side (except for enclosure IP 20), in order to prevent ingress of water or other liquids.

b) Cable entries from the top is accepted provided that the cable entrance is provided with glands or MCTs preventing water to enter the equipment.

c) Cable entrances shall be fit for the outer diameter of the cable in question.

D 400 Equipment protective earthing

401 *General*

a) Exposed metal parts of electrical machines or equipment that are not intended to be live but, which are liable, under fault conditions to become live, shall be earthed. Fixing devices between a high voltage enclosure and steel hull parts are not to be relied upon as the sole earthing connection of the enclosure.

b) In switchgear and controlgear a good reliable earth connection of all metallic non-current carrying parts shall be insured. In main and emergency switchboards a continuous earth-bar is required.

c) For the interconnections within an enclosure, for example between the frame, covers, partitions or other structural parts of an assembly, the fastening, such as bolting or welding is acceptable, provided that a satisfactory conductive connection is obtained.

d) Compartment doors can be earthed through their metallic hinges when they do not carry any electric components. If the doors do carry components such as switches, instruments, signal lamps, etc. with voltage exceeding 50 V

A.C. or 50 V D.C., the doors shall be connected to the switchboard or enclosure by a separate, flexible copper earth conductor. In high voltage equipment, this conductor shall have at least 4 mm² cross-section.

e) Each high voltage assembly shall be earthed by means of earth conductors. Each assembly shall be provided with a main earthing conductor of cross-section at least 30 mm² copper, with at least 2 adequate terminals for connection to the steel hull. Each unit enclosure and other metallic parts intended to be earthed shall be connected to this main earthing conductor or bar.

f) Earthed metallic parts of withdrawable components in high voltage equipment shall remain earthed, by means of a special earth device, until they have been fully withdrawn. The earthing shall be effective also when in test position with auxiliary circuits live.

g) The secondary winding of any current or voltage transformer installed in a high voltage system shall be earthed by a copper conductor of at least 4 mm^2 cross-section. Alternatively, unearthed secondary winding with overvoltage protection is accepted.

Exception:

Exception from this requirement is given for machines or equipment:

— supplied at a voltage not exceeding 50 V D.C. or A.C. between conductors
— supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device. Auto-transformers may not be used for the purpose of achieving this voltage
— constructed in accordance with the principle of double insulation.

D 500 Enclosures ingress protection

501 *General*

a) All equipment shall be constructed to prevent accidental touching of live parts, and shall have enclosures with a minimum degree of protection dependent upon the installation area, according to the installation requirements in Sec.10 Table B1, unless a higher degree is required by these rules.

b) For equipment supplied at nominal voltages above 500 V up to and including 1000 V, and which is accessible to non-qualified personnel, it is in addition required that the degree of protection against touching live parts shall be at least IP 4X.

c) High voltage switchgear and controlgear assemblies shall have enclosure type of at least IP 32.

d) High voltage transformers shall have enclosure type of at least IP 23, when located in spaces accessible only to qualified personnel, and at least IP 54 in other locations.

e) High voltage rotating electrical machines shall have a degree of protection by enclosure of at least IP 23, unless a higher degree is required by location. Connection boxes of high voltage rotating machines shall in all cases have a degree of protection of at least IP 44.

f) A separate locked room with warning signs, and without other installations, can be regarded as an enclosure by itself, that is, no requirement for equipment protection applies.

Guidance note:

Equipment located in machinery spaces may be considered as being accessible to qualified personnel only. The same applies to equipment located in other compartments that normally are kept locked, under the responsibility of the ship's officers.

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D 600 Clearance and creepage distances

601 *General*

The distance between live parts of different potential and between live parts and the cases of other earthed metal, whether across surfaces or in air, shall be adequate for the working voltage, having regard to the nature of the insulating material and the conditions of service.

602 *Clearance and creepage distances for low voltage equipment*

The minimum clearance and creepage distances for bare bus bars in low voltage equipment are given in Table D1, and shall be complied with when insulating materials with tracking index 175 V are used. For type tested assemblies and partially type tested assemblies the distances given in Sec.4 A110 may apply.

Table D1 Low voltage equipment clearances or creepage between phases (including neutral) and between phases and earth

Rated insulation voltage, A.C. root mean square or D.C. (V)	*Minimum clearances (mm)*	*Minimum creepage distances (mm)*
Up to 250 V	15	20
From 250 to 690 V	20	25
Above 690 V (Maximum 1000 V)	25	35

603 *Clearance and creepage distances for high voltage equipment*

a) Minimum clearance distances in high voltage equipment are given in Table D2.

b) Minimum creepage distances for main switchboards and generators are given in Table D3, and for other equipment in D4.

c) All insulating materials for fixing and carrying live parts shall have tracking index of at least 300 V according to IEC 60112.

Table D2 Clearances for high voltage equipment in systems with insulated neutral between phases (including neutral) and between phases and earth

Nominal voltage of the system, (V) [1]	*Minimum clearance distance for (mm)*	
	Main switchboards and generators	*Other equipment*
1000 - 1100	25	25
3000 - 3300	55	55
6000 - 6600	90	90
10000 - 11000	120	120
Above 11000 – maximum 15000	160	160

1) Intermediate values with corresponding distances are accepted.

Table D3 Minimum creepage distances for high voltage main switchboards and generators				
Nominal voltage of the system, (V) [1]	*Minimum creepage distance for proof (tracking index 300) (mm)*			
	300 V	*375 V*	*500 V*	*> 600 V*
1000 - 1100	26 [2]	24 [2]	22 [2]	20 [2]
3000 - 3300	63	59	53	48
6000 - 6600	113	108	99	90
10000 - 11000	183	175	162	150

1) Intermediate values with corresponding distances are accepted.

2) Minimum 35 mm is required for bus bars and other bare conductors in main switchboards.

Table D4 Minimum creepage distances for other high voltage equipment				
Nominal voltage of the system, (V) [1]	*Minimum creepage distance for proof (tracking index 300) (mm)*			
	300 V	*375 V*	*500 V*	*> 600 V*
1000 - 1100	18	17	15	14
3000 - 3300	42	41	38	36
6000 - 6600	83	80	75	70
10000 - 11000	146	140	130	120

1) Intermediate values with corresponding distances are accepted.

E. Marking and Signboards

E 100 General

101 *General*

a) All equipment shall be externally marked to enable identification in accordance with the documentation of the power distribution system, and be marked with the manufacturer's name. In addition the system voltage shall be indicated on switchgear and assemblies.

b) All equipment shall if necessary be marked to ensure correct use.

c) See Sec.11 for the requirements for the marking of hazardous area equipment.

d) All marking shall be made by flame retardant, non-corrosive materials and be permanently fixed.

e) Labels bearing clear and indelible indications shall be so placed that all components and all equipment can be easily identified.

102 *Rating plate*

All equipment shall be fitted with a rating plate giving information on make, type, current, voltage and power rating and other necessary data for the application.

Guidance note:

More detailed requirements for information that shall be noted on rating plates may be found in other applicable sections regarding each equipment type contained in this chapter (Sec.4 to Sec.9).

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103 *Labels for switchgear, terminals etc.*

a) Internal components in equipment and assemblies as switchgear, controlgear, fuse gear, socket outlets, lighting equipment and heating equipment shall be marked with make, type, current, voltage and power rating and other necessary data for the application (i.e. to which standard the equipment is produced).

b) The switchgear and fuse gear for each circuit shall be marked with circuit designation, cable cross-section and rating of fuses or necessary data for easy recognition of components and circuits according to relevant drawings.

c) If the switchboard contains two or more distribution systems with different voltages, the different parts shall be marked with the respective voltages at the partitions.

d) Terminals for circuits with different system voltages shall be clearly separated, and clearly marked with the voltage.

e) All terminals for connection of external instrumentation and control cables, as well as the conductor ends of these cables shall be marked for identification, preferably in accordance with the designation used in the wiring diagram or schematics or loop diagrams. See also Sec.4 A100.

104 *Signboards and warnings*

a) Each switchgear fed from more than one individually protected circuit shall be marked with a warning sign stating that these circuits shall be isolated when the main circuit is isolated for maintenance purpose. A warning sign is not required if all live circuits within the enclosure are disconnected together with the main power circuit.

b) When, for fuses above 500 V, the fuseholders permit the insertion of fuses for lower nominal voltage, special warning labels shall be placed, for example "Caution, 660 V fuses only".

c) Special "high voltage" warning signboards are required on all high voltage machines, transformers, cables, switch- and controlgear assemblies.

F. Insulation

F 100 Insulation materials

101 *General*

a) Insulating materials, general purpose type, for supporting conductors (not defined as for machines and cables) shall withstand the temperatures to which they are likely to be exposed. This is normally ambient temperature plus the heat from the conductor itself during full load.

b) A thermal classification in accordance with IEC 60085 shall be assigned to the insulation system when used in machines. The normally used classes are shown in Table F1, with the maximum exposure temperatures (including ambient) shown in the right column.

c) Insulating materials shall be at least flame retardant.

d) Insulating materials shall be tracking resistant in accordance with IEC 60112. A tracking index of at least 175 V will be required for low voltage equipment. For high voltage equipment the tracking index shall be minimum 300 V. See Guidance note below, and Sec.13 (definitions) regarding Tracking index.

Table F1 General insulation classes	
Insulation class (thermal class)	*Maximum temperature (°C)*
A	105
B	130
F	155
H	180
220	220

Guidance note:

Insulation classes shall be classified according to IEC 60085, "Recommendations for the classification of materials for the in-

sulation of electrical machinery and apparatus in relation to their thermal stability in service".

Tracking index (the materials ability to withstand creep current) shall be determined according to IEC 60112, "Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions".

Tests according to similar national standards may be considered.

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102 *Cable insulation*

For requirements regarding the insulation of electrical cables, see Sec.9.

SECTION 4
SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

A. Construction

A 100 General

101 *Applicable standards*

Switchgear and controlgear assemblies shall generally comply with IEC 60439 and IEC 60092-302 for low voltage equipment, and IEC 60298 and IEC 6092-508 for high voltage equipment. In case of gas insulated, enclosed high voltage systems, IEC 60466 apply.

102 *General*

All switchboards and assemblies shall be safe against accidental touching of live conductors during normal operation of the switchboard or assemblies.

103 *Internal arc withstand*

a) All switchboards and assemblies shall be safe for operators in front of, or at the rear, against effects of internal arcs occurring inside the enclosure. For high voltage assemblies, see B301.

b) A switchboard or assembly shall be designed to withstand the short circuit forces for minimum 1 s, created by the short circuit current and magnitude at the particular point of the system without endangering the integrity of the outer switchboard enclosure.

104 *Accessibility*

a) Instruments, handles, push buttons or other devices that should be accessible for normal operation are to be located on the front of switchboards and controlgear.

b) All other parts that might require operation are to be accessible. If placed behind doors, the interior front is to comply with enclosure type IP 20. When located in spaces accessible to non-qualified personnel, fuses with accessible current-carrying parts may be permitted, if the door is lockable. Operation in this context means for example reset of protective devices and replacement of control circuit fuses inside the assembly.

c) Doors, behind which equipment requiring operation is placed, are to be hinged.

d) Hinged doors, which are to be opened for operation of equipment, are to be provided with easily operated handles or similar. There is also to be arrangements for keeping the doors in open position.

e) All sections of switchboards and controlgear that require maintenance are to be accessible for maintenance work.

Guidance note:

Normally, all connections of conductors, bus bar joints and mechanical fastening of components and bus bars shall be accessible for maintenance.

If the construction does not allow periodical maintenance, the assembly may be designed for maintenance free operation during a 20-year service life.

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105 *Materials*

Framework, panels and doors are normally to be of steel or aluminium alloy, and are to be of rigid construction.

Guidance note:

Switchgear and assemblies constructed of other materials may be accepted provided requirements in Sec.3 are complied with.

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106 *Circuit separation*

a) There is to be arranged a separate cubicle for each generator, with flame retardant partitions between the different generator cubicles and between these and other cubicles. The partitions shall withstand the effect of an internal arc, and prohibit this from spreading to other cubicles.

b) Controlgear for essential or important consumers is to be separated from each other, and from other current carrying parts, by flame retardant partitions providing protection of the cubicle in case of an arcing fault occurring in the neighbouring cubicle.

The arrangement shall be so that maintenance work can be carried out in each unit without danger when isolated.

c) Controlgear for non-important consumers may be installed in a common cubicle provided this cubicle could be effectively isolated.

d) Consumer controlgear installed in main switchboards are to be placed in cubicles separated from all other parts of the switchboard by partitions of flame retardant material.

e) Equipment for different distribution systems are to be placed in separate switchboards (panels), or are to be separated from each other by partitions clearly marked with the actual voltages and system identifications.

f) Switchgear and controlgear assemblies supplied by different supply circuits shall not be placed in the same enclosure.

g) For separation due to system redundancy, see Sec.2.

107 *Handrails*

Main and emergency switchboards and other switchboards requiring operation shall have handrails of insulating materials.

108 *Nameplates and marking*

See Sec.3 E for general requirements regarding marking of equipment. In addition, the following apply in front of switchgear and controlgear assemblies, for each circuit.

a) The rating (voltage, current and fault current capabilities) of the protective devices for each circuit shall be permanently indicated at the location of the protective device.

b) All protection devices with adjustable settings are to have means that readily identify the actual setting at the location of the protective device.

c) Circuit designation for outgoing circuits and from where, on incoming feeders.

d) Switchboards provided with more than one supply circuit are to be marked with a warning that both or all supply circuits are to be disconnected before any maintenance work is carried out. Alternatively, a listing of all supply circuits shall be located inside the switchboard.

109 *Ingress protection*

Switchboards shall be of "dead front" type and have enclosure protection according to Sec.10 Table B1.

110 *"Type tested assemblies" and "Partly type tested assemblies"*

a) Electrical low voltage assemblies constructed and tested in accordance with IEC 60092-302, item 7.1.2.101 (referring to IEC 60439-1) are accepted as long as the following conditions are met:

— minimum clearance distance shall be 8 mm, minimum creepage distance shall be 16 mm
— the assembly has been type tested with impulse voltage test in accordance with IEC 60439-1
— maximum operating temperature of bus bars shall be documented to be acceptable with respect to fixing materials and internal temperature by a full current type test
— maximum temperature rise at termination points for external cables shall be 60ºC
— such assemblies shall not be installed in machinery space category "A" (see Sec.2 I103).

b) For bus bar trunking systems where the conductors are fixed for the whole length with an insulating rail or similar, distances in accordance with IEC 60947-4-1 Part 4 (Contactors and motor starters - Section 1), may be accepted.

B. Power Circuits

B 100 Power components in assemblies

101 *Main bus bar sectioning*

See Sec.2 for requirements regarding main bus bar division arrangement.

102 *Bus bar materials*

a) Bus bars and other conductors shall normally be made of copper or copper covered aluminium.

b) Copper coated aluminium or pure aluminium bus bar shall be adequately protected against corrosion by placing in an air conditioned environment, by special coating sealing of the aluminium or by the aluminium itself being seawater resistant.

103 *Rating of bus bars*

a) The shape, configuration and cross-section are to be such that the temperature rise will not exceed 45°C at rated load.

b) Bus bars and other conductors with their supports are to be so mechanically or thermally dimensioned and fixed that they can withstand for 1 s the forces occurring by the maximum short circuit current which can occur without detrimental effect.

c) The cross-section of bus bars for neutral connection on an A.C. three-phase, four-wire system, and for equaliser connection on a D.C. system, is to be at least 50% of the cross-section for the corresponding phases (poles).

d) For maximum temperatures of bus bars in type tested and partially type tested assemblies the requirement in A110 applies.

Guidance note:

Reference is made to IEC 60439 for current carrying capacity of bus bars.

The general equation of current ratings at different temperature rises is:

$$\frac{I_1}{I_2} = \sqrt{\frac{\Delta \vartheta_1}{\Delta \vartheta_2}}$$

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104 *Fuses*

Fuses shall normally comply with one of the following standards:

— IEC 60269 for low voltage fuses
— IEC 60282-1 for high voltage fuses.

105 *Circuit breakers, on-load switches, disconnectors, and contactors*

a) Switchgear and controlgear shall comply with:

— IEC 60947 for low voltage equipment
— IEC 60056, IEC 60470, IEC 60129 for high voltage equipment.

b) All fault switching and protecting components such as circuit breakers and fuses are to have a fault current withstand and interruption capacity of not less than the maximum short circuit current available at the relevant point of their installation.

c) All load switches and contactors are to have a rating not less than the maximum load current at their point of installation. Particularly, contactors shall be protected against the possibility of the contactor breaking current exceeding their load break capacity in fault situations.

d) Fuse switches using the fuse link contacts as making and breaking contacts are not accepted where switches are required according to Sec.3, but may be used as isolating switch.

e) The construction is to be such that accidental making or breaking, caused by the vessel's inclination, movements, vibrations and shocks, cannot occur.

f) Undervoltage and closing coils, including contactor coils, are to allow closing of the switchgear and controlgear when the voltage and frequency are 85 to 110% of the rated values, and are not to cause release at voltage and frequency above 65% of the rated values.

106 *Switch-gear*

a) Each outgoing circuit on a main switchboard or a distribution switchboard is to be provided with an accessible switch on the switchboard front for isolating purposes. One of the following solutions shall apply:

— a multipole circuit breaker
— a multipole fused circuit breaker
— a multipole load switch and fuses.

b) The arrangement is to be such that any fuses can be replaced without risk of touching live parts.

c) When multipole switch and fuses are used and the switch is installed between the bus bars and the fuses, the following apply:

— the switch is to have a breaking capacity of at least 6 times its full-load current
— the making capacity of the switch is to be so adapted in relation to the fuses' rupture characteristic that no damage to the switch occurs even when it is closed on a short circuit.

d) On a distribution board the multipole switch may be omitted when maximum 63 A fuses are used.

Guidance note:

For high voltage equipment switching off by an auxiliary circuit will be accepted provided that the off–control switch is placed in front of the relevant compartment and a manual off-switching

means is provided at the circuit breaker when front door is opened.

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107 *Disconnection and isolation for safety purposes*

Means are to be provided for the isolation of the supply to each controlgear and distribution board. The following alternative arrangements may be used:

- a multipole isolating switch at the controlgear
- the circuit switchgear on the switchboard from which the controlgear or distribution board is supplied. The switchgear used for this purpose is to be lockable in the "off" position, if remote from the consumer or its controlgear
- the circuit fuses on the switchboard from which the controlgear or distribution board is supplied. For non-important consumers supplied by a distribution switchboard, it is accepted that the switchgear or fuses for the supply circuit to this switchboard are used as common isolating device. The switchgear used for this purpose is to be lockable in the "off" position
- the disconnection device for high voltage switchgear (above 1000 V) shall have visible indication of contact positions.

108 *Safety earthing of high voltage circuits*

Each circuit is to be fitted with an integral means of earthing and short circuiting for maintenance purposes, or alternatively an adequate number of portable earthing and short circuiting devices, suitable for use on the equipment in question, is to be kept on board.

109 *Short circuit proof internal wiring*

Connections without sufficient short circuit protection for the conductor sizing are to be installed short circuit proof (defined in Sec.13).

Guidance note:

This requirement applies to branching of for control power and measuring signals from bus bars and generator terminals, to conductors between batteries and short circuit protection, and to conductors between separated bus bar sections.

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110 *Screening of horizontally installed bus bars*

Horizontally installed bus bars and bare conductors or connections are to be protected by screens, if they are placed such that there could be a risk of anything falling down on them.

111 *Clearance and creepage distances*

See Sec.3 D600 for clearance and creepage distances in switchgear and assemblies.

B 200 Batteries

201 *Batteries located in electrical assemblies*

a) Batteries may be installed as an integrated part of an electric assembly when the battery is of dry type and has a capacity less than 0.2 kVAh.

b) Batteries may be installed as a part of an electric assembly when the capacity of the battery is less than 5 kVAh for vented type accumulators, and less than 40 kVAh for dry type accumulators and as long as the following is complied with:

   - the batteries shall be separated from the rest of the assembly with flame retardant partitions
   - the battery section of the assembly shall have suitable ventilation holes at top and bottom, and be designed for air circulation upwards. There are not to be pockets that may accumulate gas
   - the enclosure for the battery section shall have adequate strength so that an exploding battery does not damage other parts of the assembly.

c) See Sec.2 I300 for requirements regarding the location and ventilation of battery installations.

B 300 Additional requirements for high voltage assemblies

301 *General design and construction*

a) High voltage switchgear and controlgear assemblies are to be metal-clad in accordance with IEC 60298, or of a construction giving equivalent safety with respect to personnel safety and system integrity. The switchgear shall able to withstand an internal short circuit arcing failure with the maximum duration and magnitude, which can occur on the particular point of the installation without harmful effect to operators.

b) The switchgear or switchboard shall be type tested to demonstrate that it will withstand the effects of an internal arc failure (e.g. testing in accordance with Appendix AA of IEC 60298).

c) There shall be separate compartments with IP rating to at least IP 20 towards other compartments in the cubicle for at least the following components:

   - control and auxiliary devices
   - each main switching device
   - components connected to one side of the main switching device (the outgoing circuit)
   - components connected to the other side of the main switching device (the bus bars).

d) Normally, partitions between the compartments shall be made of metal. Alternatively, a partition of other materials not intended to be earthed is accepted, provided it is verified that the safety is of at least the same standard.

e) Means are to be provided for the disconnection and isolation of all circuit breakers and fused circuit breakers, either by using withdrawable components or by installation of separate disconnectors (isolators).

Exception

For final feeder circuits where energising of the main switching device from the load side is not possible, the cable terminals and accessories (e.g. voltage and current transformers) may be placed in the same compartment as the main switching device.

302 *Mechanical interlocks*

a) The arrangement in high voltage enclosures is to be such that all operation and functional testing is safeguarded against accidental touching of live parts.

b) Doors that can be opened for operation or testing of high voltage parts (e.g. for replacement of fuses, or for functional testing of a circuit breaker) are to be interlocked so that they cannot be opened before the components inside have been isolated and made safe.

c) The openings between the contacts of a withdrawable high voltage component and the fixed contacts, to which it is connected in service, are to be provided with automatic shutters.

Guidance note:

Front doors of circuit breaker compartments might be opened for circuit breaker checking or emergency switching, without any interlocking, if high voltage parts still cannot be reached by accidental touching of the hands.

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303 *Control wiring*

a) The wiring of auxiliary circuits shall, with the exception of short lengths of wire at terminals of instrument transformers, tripping coils, auxiliary contacts etc., be either segregated from the main circuit by earthed metallic partitions (e.g. metallic tubes) or separated by partitions (e.g. tubes or sheathed cables) made of flame retardant insulating material.

b) Fuses of auxiliary circuits, terminals and other auxiliary apparatus requiring access while the equipment is in service, are to be accessible without exposing high voltage parts.

c) There is to be arranged an alarm for voltage loss after the last fuses in each auxiliary power system, where a voltage failure is not self detecting.

d) A possibility for manual operation of each circuit breaker is to be arranged. However, manual closing of the circuit breakers is not to be possible if the arrangement of the auxiliary circuits is such that the protection devices are put out of action and the circuit breakers are still closed after a power failure to the auxiliary circuits.

C. Control and Protection Circuits

C 100 Control and instrumentation

101 *General*

a) See Sec.2 for requirements regarding the distribution system for control circuits, and for control and protection of individual consumers depending of their application and the network system capabilities.

b) Power distribution for control circuits are generally to be branched off from the main circuit in which the switchgear is used, with exceptions as specified in Sec.2 F104.

102 *Control of duplicated consumers*

a) Control circuits for duplicated essential and important equipment are to be kept separated from each other, and not located in the same enclosure.

b) Controlgear for duplicated essential or important equipment are to be mutually independent and are to be divided between two motor control centres or distribution boards having separate supplies from different sides of the main switchboard and/or the emergency switchboard.

c) Where switchboards are fitted with bus ties or bus links, the duplicated circuits shall be fed from different side of the bus tie.

d) Duplicated equipment for essential or important functions shall not be dependent on any common circuits such as e.g. contactors for emergency stop.

103 *Signal lamps*

Signal lamps are to be arranged so that a lamp short circuit cannot jeopardise the control system.

104 *Panel-instruments in general*

a) Instruments, including current transformers, in switchgear and controlgear shall have a nominal accuracy of 2.5% or better.

b) The upper limit of the scale of ampere-meters and kilowatt-meters is to be at least 130% of the rated full load of the circuit. For generators arranged for parallel operation, the scale is to be arranged for reading of reverse current or power corresponding to at least 15% of the rated full load of the circuit. The upper limit of the scale of each voltmeter is to be at least 120% of the nominal voltage.

c) Amperemeters, kilowattmeters and voltmeters are to be provided with means to indicate rated current or power and rated voltage, respectively. Instruments are to have effective screening (e.g. by metal enclosures) in order to diminish faulty readings caused by induction from adjacent current-carrying parts.

105 *Kilowatt meters*

Normally, a kilowatt meter with connections for reading the actual three-phase load shall be used.

106 *Frequency meters*

Frequency meters are to have a scale ranging at least 8% above and below the systems operating frequencies

107 *Generator instrumentation*

a) Each A.C. generator shall be provided with instrumentation showing:

— current for each phase
— voltage
— frequency.

b) When generators are arranged for parallel operation, they shall in addition be provided with instrumentation showing the active power and be provided with synchronising devices as required by Sec.2 H105.

c) Simultaneous functional reading of active power and current shall be provided at operating station for manual operation and synchronisation.

Alternatives

Single voltmeters and amperemeters with switches for the alternative readings may be accepted.

Two separate frequency meters for several generators may be used, one with a change-over switch for connection to all generators, the other connected to the bus bars. A "double frequency meter" may be used for this purpose.

108 *Instrumentation for distribution systems including in and outgoing circuits of switchboards*

Each secondary distribution system is to be equipped with a voltmeter.

109 *Instrumentation for shore connections*

The shore connection circuit shall be equipped with:

— a phase sequence indicator
— a voltmeter or signal lamp.

D. Verification and Testing

D 100 General

101 *General*

a) Switchgear and controlgear assemblies shall be tested at the manufacturer’s works as described in 102 to 108.

b) The manufacturer shall submit test results together with the final documentation for the equipment. The documentation shall give information on make, type, serial no., and all technical data necessary for the application of the switchboard or assembly, as well as the results of the required tests.

c) The following tests are required:

— function test: all basic functions, including auxiliary functions, are to be tested

— insulation resistance test
— high voltage test
— general inspection of assembly.

102 *Visual inspection*

Switchboards and assemblies are subject to a visual inspection for verification of general workmanship, creepage and clearance distances, IP rating, ventilation and quality of materials and components.

103 *Function testing*

a) All circuits shall be verified installed as shown in the as-build documentation.

b) Control and protection shall be tested for correct functioning.

104 *Load testing*

The testing of switchgear and controlgear assemblies with full power, eventually together with the intended load, is not required by these rules. Such tests shall be separately agreed between the manufacturer and the customer.

105 *Site testing*

Final approval of the switchgear or controlgear assembly shall include complete function tests with intended loading, after installation onboard.

106 *Power frequency and insulation resistance test for low voltage assemblies*

a) Switchgear and assemblies with rated voltage above 60 V shall be subject to a voltage test between the circuits and between live parts and the enclosure. The test voltage shall be minimum equal to twice the rated voltage plus 1000 V with a minimum of 1500 V. The test voltage is to be applied for 1 minute at any frequency between 25 and 100 Hz.

b) For switchgear and assemblies with rated voltage below 60 V, the test voltage given in a) shall be minimum 500 V.

c) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec.5 Table C3. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level. The insulation level shall be at least 1 MOhm.

d) The secondary winding of current transformers shall be short circuited and disconnected from earth during the test.

e) The secondary winding of voltage transformers shall be disconnected during the test.

Guidance note:

Electronic equipment should be disconnected, short circuited and or isolated during high voltage test and insulation resistance measuring.

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107 *Power frequency test for high voltage assemblies*

a) Each high voltage assembly is to be subjected to a 1 minute power frequency voltage test.

b) Replicas reproducing the field configuration of the high voltage connections may replace voltage transformers or power transformers. Overvoltage protective devices may be disconnected or removed.

c) Test voltages are given in Table D1.

d) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec.5 Table C3. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level.

e) All auxiliary circuits are to be subjected to a 1 minute voltage test between the circuits and the enclosure according to 106.

Guidance note:

The environmental conditions during voltage tests are normally to be as specified in IEC 60060-1, "High-voltage test techniques, Part 1, General definitions and test requirements", that is temperature 20°C, pressure 1013 mbar and humidity 11 g water per m³ (corresponding to about 60% relative humidity). Correction factors for test voltages at other environmental conditions are given in IEC 60060-1.

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108 *Test voltages for high voltage switchgear assemblies*

Test voltages for high voltage switchgear assemblies are given in Table D1.

Table D1 Test voltages for high voltage assemblies

Nominal voltage of the system (kV) [1]	*1 minute power frequency test voltage, (kV) (root mean square value)*
	To earth and between phases
1 - 1.1	2.8
3 - 3.3	10
6 - 6.6	20
10 - 11	28
15	38

1) Intermediate values for test voltages may be accepted, other than these standard test voltages.

SECTION 5
ROTATING MACHINES

A. General

A 100 References

101 *General*

The design and function of rotating machines shall generally comply with the requirements of IEC 60092-301. For basic machine design, the relevant parts of IEC 60034 apply.

A 200 Requirements common to generators and motors

201 *Rating or duty*

a) Electrical machines, including any excitation system, shall be designed for continuous duty.

b) Unless otherwise clearly stated, the rating of electrical machines shall be continuous full load duty type S1.

c) Generally, maximum environmental temperatures for rotating machines shall be as given in Sec.3 Table B1.

202 *Insulation*

a) All windings for machines are to be treated to resist moisture, sea air, and oil vapours.

b) For general requirements for insulation materials and terminations, see Sec.3 D.

203 *Temperature rise in windings (insulation)*

The maximum permissible heat rise in windings is given in Table A1, with these deviations:

a) If the temperature of the cooling medium will be permanently lower than the values given in Sec.3 B300, then the permissible temperature rise may be increased with the difference between the actual temperature and the temperature given in Sec.3 B300, up to a maximum of 25°C.

b) If the ambient temperatures clearly exceed the maximum upper limits, then the temperature rises are to be decreased accordingly.

c) In Table A1 allowance has been made for the temperature in certain parts of the machine being higher than measured. The temperatures at such "hot spots" are assumed not to exceed the values given in Sec.3 Table F1.

d) For vessels with class notation restricting the service to non-tropical waters the design limits for temperature rises given in Table A1 may be increased by 10°C. Alternatively, the upper ambient air temperature limits according to Table A1 may be reduced by 10°C.

e) Where water cooled heat exchangers are used in the machine cooling circuit, the temperature rise is to be measured with respect to the temperature of the cooling water at the inlet to the heat exchanger. Temperature rises given in Table A1 may be increased by 8°C provided the inlet water does not exceed 32°C.

f) If inlet water temperature is above 32°C, permissible temperature rise in Table A1 may be increased by 8°C and then reduced by the amount by which the maximum cooling water temperature exceeds 32°C.

g) If the inlet cooling water temperature is permanently less than 32°C, the permissible temperature rise in Table A1 may be increased by 8°C and may be further increased by an amount not exceeding the amount by which the cooling temperature is less than 32°C.

Table A1 Limits of temperature rise of machines for vessels for unrestricted service[1] based on ambient temperature of 45°C

	Part of machine [1]	*Method of measurement of temperature* [2]	*Maximum temperature rise in for air-cooled machines (°C) Insulation class*				
			A	*E*	*B*	*F*	*H*
1.	a) A.C. winding of machine having output of 5000 kVA or more	ETD R	60 55	-[3] -	80 75	100 95	125 120
	b) A.C. winding of machine having output of less than 5000 kVA	ETD R	60 55	- 70	85 75	105 100	125 120
2.	Winding of armature with commutators	R T	55 45	70 60	75 65	100 80	120 100
3.	Field winding of A.C. and D.C. machine with excitation other than those in item 4.	R T	55 45	70 60	75 65	100 80	120 100
4.	a) Field windings of synchronous machines with cylindrical rotors having D.C. excitation	R			85	105	130
	b) Stationary field windings of D.C. machines having more than one layer	ETD R T	55 45	70 60	85 75 65	105 100 80	130 120 100
	c) Low resistance field windings of A.C. and D.C. machines and compensating windings of D.C. machines having more than one layer	R, T	55	70	75	95	120
	d) Single-layer windings of A.C. and D.C. machines with exposed bare surfaces or varnished metal surfaces and single compensating windings of D.C. machines	R, T	60	75	85	105	103

1) Temperature rise of any part of a machine shall in no case reach such a value that there is a risk of injury to any insulating or other material in adjacent parts.

2) R indicates temperature measurement by the resistance method, T the thermometer method and ETD the embedded temperature detector method. In general for measuring the temperature of the windings of a machine the resistance method shall be applied. (See IEC 60034-1). For stator windings of machines having a rated output of 5000 kW (or kVA) the ETD method shall be used. Determination by ETD method requires not less than six detectors suitably distributed throughout the winding. Highest reading shall be used to determine the temperature for the winding.

3) For high voltage machines having rated output of 5000 kVA or more, or having a core length of 1 m or more, the maximum temperature rise for class E insulation shall be decreased by 5°C.

204 *Machine short time overloads*

a) General purpose rotating machines shall be designed to withstand the following excess torque:

- A.C. induction motors and D.C. motors: 60% in excess of the torque that corresponds to the rating, for 15 s, without stalling or abrupt change in speed (under gradual increase of torque), the voltage and frequency being maintained at their rated value
- A.C. synchronous motors with salient poles: 50% in excess of the torque that corresponds to the rating, for 15 s, without falling out of synchronism, the voltage, frequency and excitation current being maintained at their rated values
- A.C. synchronous motors with wound (induction) or cylindrical rotors: 35% in excess of the torque that corresponds to the rating, for 15 s, without losing synchronism, the voltage and frequency being maintained at their rated value.

b) Induction motors for specific applications the excess torque may be subject to special agreement. See IEC 60034-1 clause 8.3.

c) General purpose rotating machines shall be designed to withstand the following excess current:

- A.C. generators: 50% in excess of the rated current for not less than 30 s, the voltage and frequency being maintained as near the rated values as possible
- A.C. motors: 50% in excess of the rated current for not less than 120 s, the voltage and frequency being maintained as near the rated values as possible
- commutator machines: 50% in excess of the rated current for not less than 60 s, operating at highest full-field speed.

205 *Balance*

Machines shall be so constructed that, when running at any and every working speed, all revolving parts are well balanced.

206 *Lubrication*

a) Lubrication of rotating machines is to be effective under all operating conditions.

b) Each self-lubricated sleeve bearings shall be fitted with an inspection lid and means for visual indication of oil level or use of an oil gauge. Similar requirement applies to self contained oil lubricated roller bearings.

c) Provision shall be made for preventing the lubricant from gaining access to windings or other insulated or bare current-carrying parts.

207 *Shafts and shaft currents*

a) Shafts are to comply with the requirements in the Rules for Classification of Ships, Pt.4 Ch.4 both with regard to strength, bearings, balancing and certification.

b) Means are to be provided to prevent damaging levels of circulating currents between shaft, bearings and connected machinery.

c) When all bearings on a machine are insulated, the shaft shall be electrically connected to the machine's earth terminal.

208 *Machine overspeed*

Rotating machines are to be capable of withstanding 1.2 times the rated maximum speed during 2 minutes.

209 *Nameplate*

Each machine is to be provided with nameplate of durable, flame retardant material, giving the following information:

- make, type, serial no.
- performance standard
- IP rating
- rated values for: output apparent power, voltage(s), frequency, current(s), power factor, speed
- for A.C. machines: the winding connection
- thermal classification of insulation
- duty type, if other than S1
- maximum permissible cooling medium temperature
- technical data necessary for the application of the machine
- total mass.

A 300 Instrumentation of machines

301 *Temperature detectors embedded in stator winding*

All high voltage machines, and low voltage machines having a rated output above 5000 kW (or kVA), are to be provided with temperature detectors in their stator windings, for monitoring and alarm, also see Sec.3 D201.

Guidance note:

Overvoltage protection may be required for circuits with temperature detectors.

See Sec.12 A604 regarding rotating machines supplying or driving electric propulsion and having temperature detectors embedded in their stator windings for monitoring and alarm.

For the requirements in regard to temperature detectors, reference is made to IEC 60034-11.

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B. Additional Requirements for Generators

B 100 General

101 *General*

Exciter and voltage regulation equipment is considered as part of the generator.

Guidance note:

The design of generators shall comply with other relevant parts of these rules:

Rules for Classification of Ships, Pt.4 Ch.3 regarding governing of auxiliary combustion machines when driving generators.

DNV-OS-D202 regarding instrumentation equipment and computer based equipment for monitoring and control.

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102 *Available neutral point*

Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for installation of equipment for short circuit protection of the generator windings.

103 *De-excitation*

Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for external signal for initiation of de-excitation of the generator.

104 *Voltage waveform*

For A.C. generators, the voltage is to be approximately sinusoidal, with a maximum deviation from the sinusoidal curve of 5% of the peak value.

B 200 Voltage and frequency regulation

201 *Voltage build-up*

a) The construction shall normally be such that the generator, when started up, takes up the voltage without the aid of an external electric power source.

b) External power sources may be used to take up the voltage on main generators provided that redundancy for this ex-

ternal source is arranged as required for starting arrangement.

202 *Stationary voltage regulation*

a) The voltage regulation is to be automatic, suitable for shipboard condition, and such that the voltage is kept within 97.5% to 102.5% of the rated voltage under all steady load conditions. This is between no-load and full-load current and at all power factors which can occur in normal use, but in any case with power factor from 0.7 to 0.9 lagging, also taken into consideration the effect of the prime mover's speed characteristic.

b) There is to be provision at the voltage regulator to adjust the generator no load voltage.

c) The limits in a) may be increased to ±3.5% for emergency sets.

Guidance note:

Sec.2 B102 requires that a single failure shall not endanger the vessel's manoeuvrability, provisions may be necessary for monitoring of the voltage regulation.

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203 *Transient voltage regulation*

a) Maximum values (current and power factor) of sudden loads to be switched on and off shall be specified. Specified sudden load should not be less than 60% full load current at power factor of 0.4 lagging or less.

b) The voltage variations under transient conditions shall comply with the following:

- when the generator is running at no load, at nominal voltage, and the specified sudden load is switched on, the instantaneous voltage drop at the generator terminals is not to be more than 15% of the generators nominal voltage.
- the generator voltage is to be restored to within ±3% of the rated voltage within 1.5 s.
- when the specified sudden load is switched off, the instantaneous voltage rise is not to be more than 20% of the rated voltage.
- the generator voltage is to be restored to within ±3% of the rated voltage within 1,5 s.

c) For non-paralleling emergency generating sets the regulation limits and time in b) might be increased to ±4% within 5 s.

d) Under fault conditions, inclusive faults in the AVR's circuit, the generator voltage shall not exceed 120% of the rated voltage.

e) On installations where two or more generators are normally run in parallel, the maximum load that can be switched on may be divided between the generators in relation to their rating and expected maximum duty as individual generator.

f) See the Rules for Classification of Ships, Pt.4 Ch.3 and Sec.2 E102 for requirements for the governor of a generator prime mover.

Guidance note:

Special consideration should be given to the overvoltage that may occur when switching off the generators at full load or overload. This overvoltage should not reach a level that may damage power supplies for AVR's, undervoltage coils, instruments etc. connected on the generator side of the generator circuit breaker.

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B 300 Generator short circuit capabilities

301 *Short circuit withstand and contribution capabilities*

A.C. synchronous generators, with their excitation systems, shall, under steady short circuit condition be capable of maintaining, without sustaining any damage, a short circuit current, which shall be at least 3 times the rated full load current, for a duration of at least 2 s. (IEC 60092-301 modified clause 4.2.3)

B 400 Parallel operation

401 *Load sharing*

a) Generators for parallel running shall be such that the sharing of active and reactive power is stable under all load conditions. Oscillations smaller than ±20% of each generator's rated current can be accepted.

b) In the range 20 to 100% of the rated reactive load of each generator, its actual reactive load (mean value, if oscillations occur) is not to differ from its proportionate share of the total reactive load by more than 10% of the rated reactive load of the largest generator in parallel, or not more than 25% of the smallest generator's rated reactive load, if this is less than the former.

c) Requirement for sharing of active power is given in the Rules for Classification of Ships, Pt.4 Ch.3.

Guidance note:

The sharing of power is mainly determined by the prime movers' governor characteristics, to which further requirements are given in the Rules for Classification of Ships, Pt.4 Ch.3. Power oscillations, however, are determined both by the prime movers' and generators' characteristics.

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402 *Parallel operation on nets with earthed neutral*

When generators are run in parallel on nets with earthed neutral, it is to be ensured that the equalising current resulting from harmonics does not exceed 20% of the rated current of each generator.

C. Verification and Testing

C 100 Factory testing

101 *General*

a) Electrical machines shall be tested at the manufacturer's works with the tests specified in this part of the rules. Type tests shall be carried out on a prototype of a machine or the first of a batch of machines. Routine tests shall be carried out on each machine.

b) The type tests (TT) and routine tests (RT) that the machines shall undergo are listed in Table C1

c) The tests in Table C1 shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the machine, as well as the results of the required tests.

d) The result of type tests, and the serial number of the type tested machine, shall be specified in the documentation of test results for a routine tests.

Table C1 Testing and inspection of electrical machines

No.	*Task*	*Required test for generators*	*Required test for motors*
1	Examination of technical documentation. Air gap to be measured or verified.[1)]	TT, RT	TT, RT
2	Visual inspection, verification of data on name plate.	TT, RT	TT, RT
3	Verification of degree of enclosure protection (IP).	TT	TT
4	During the running tests, the vibration or balance of the machine including operation of the bearing or lubrication system. Reference: 34-14 (1996-11)	TT, RT	TT, RT
5	Overspeed test: 20% in excess of the rated r.p.m. for 2 minutes.	TT	TT
6	High voltage test, 1 minute.	TT, RT	TT, RT
7	Winding's resistance to be measured.	TT, RT	TT, RT
8	Temperature-rise test at full load.	TT	TT
9	Measurement of insulation resistance.	TT, RT	TT, RT
10	No load current at rated voltage and frequency.		TT, RT
11	Locked rotor test at rated current. [2)]		TT, RT
12	Overload or overcurrent test (IEC 60034-1/8.2 and 8.3).	TT	TT
13	A.C. generator: Measuring of voltage regulation during steady and transient loading and unloading, see Sec.2 A 204.	TT, RT	
14	A.C. generator: Measuring of open circuit voltage characteristics (no load curve).	TT, RT	
15	A.C. generator: Measuring of short circuit characteristics (short circuit curve).	TT, RT	
16	A.C. synchronous motor or generator: Measuring of excitation current at rated voltage, current and power factor.	TT, RT	TT, RT
17	A.C. Synchronous generator: Measuring of steady short circuit condition.	TT	
18	For high voltage machines a steep fronted impulse test, or equivalent, of the coil interturn insulation is to be carried out according to IEC 60034-15. Tests on each separate fully processed coil after inserting in the slots are preferred. Due to various technologies involved, alternative proposals to verify withstand level of interturn insulation may be considered, e.g. type tests with fully produced sample coils.	RT	RT

1) Measuring of air gap only for machines of size 1.5 MVA and above.

2) For A.C. induction motors only.

Guidance note:

Overspeed test (5)

Dielectric test to be performed on rotors after overspeed test IEC 60034-1-8.5.

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Guidance note:

High voltage tests (6)

a) A 1 minute high voltage test is to be applied to a new and completed machine with all its parts in place under conditions equivalent to normal working conditions. The test is to be in accordance with IEC 60034-1-8.1 "Dielectric tests", and is to be carried out at the maker's works at the conclusion of the temperature-rise test.

b) For voltage levels to be used, please see IEC 60034-1 Table 14, normally (for ac windings of machines between 1 kW and 10.000 kW) the test voltage is 1000 V + twice the rated voltage with a minimum of 1500 V.

c) After rewinding or other extensive repair of a machine, it is to be subjected to a high voltage test with a test voltage of at least 75% of that specified in IEC 60034-1-8.1.

d) On carrying out high-voltage test, it may be necessary to short circuit semi-conductors in order to avoid damage of such parts.

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Guidance note:

Temperature rise measurement and testing (8)

a) The temperature rise of a machine is to be measured at the rated output, voltage and frequency, and the temperature test is to be carried out at the duty for which the machine is rated and marked, in accordance with the testing methods specified in IEC Publication No. 60034-1.

b) For machines with maximum continuous rating (duty type S1), the temperature rise test shall be continued until thermal equilibrium has been reached, that is when the temperature rise varies by not more than 2°C over a period of 1 h.

c) For acceptable methods of winding temperature measurement and corresponding maximum temperatures, please see Table A1. See guidance note below about the variety of temperature measurement methods.

d) The measurement of final winding temperature at end of the test is to be performed within the time limits given in Table C2.

e) If measurement of final winding temperature are to be carried out by resistance measurements according to Table C2, the temperature has to be measured as a function of time after shutdown, and correct temperature determined by extrapolation back to the initial switch off time point.

f) The initial reading shall never be delayed more than twice the time limits given in Table C2. (See IEC 60034-1 7.6.2 for extended guidance on this subject).

Table C2 Resistance measurement time after switch off

Rated output, P (kW) (kVA)	*Time delay after switching off power (s)*
$P \leq 50$	30
$50 < P \leq 200$	90
$200 < P \leq 5000$	120
$5000 < P$	By agreement

g) When the *resistance method* is used, the temperature for copper windings, Θ_1 - Θ_2, may be obtained from the ratio of the resistances by the formula:

$$\frac{\Theta_2 + 235}{\Theta_1 + 235} = \frac{R_2}{R_1}$$

Θ_2 = winding temperature at the end of the test

Θ_1 = winding temperature at the moment of the initial resistance measurement.

The temperature rise is the difference between the winding temperature at the end of the test, and the ambient air temperature at the end of the test. (Alternatively the water inlet temperature at the end of the test, for water/air heat exchangers.)

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

h) When the *embedded temperature detector (ETD) method* is used, there shall be at least six detectors suitably distributed throughout the machine windings. They shall be located at the various points at which the highest temperatures are likely to occur, and in such a manner that they are effectively protected from contact with the coolant. The highest reading of an ETD element shall be used to determine compliance with requirements for temperature limits.

i) When there is two or more coil-sides per slot, the ETD elements shall be placed between the insulated coil sides. If there is only one coil-side per slot, the ETD method is not a recognised method for determination of temperature rise or temperature limits in order to verify the compliance of the rating.

j) The *thermometer method* is recognised in the cases in which neither the ETD method nor the resistance method is applicable. See IEC 60034-1 for guidance. The measured temperature rises shall not exceed the following values:

65 K for class A insulation

80 K for class E insulation

90 K for class B insulation

115 K for class F insulation

140 K for class H insulation.

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Guidance note:

Alternative methods for temperature rise calculations

Temperature tests at full load may be difficult to realise for large machines, due to insufficient test power being available. One of the following simulated tests, or equivalent, will be subject for approval for synchronous generators and induction motors:

— synchronous feedback, or back to back method, according to IEEE Std. 115-1983, 6.2.2
— zero power factor method, according to IEEE Std. 115-1983, 6.2.3
— open-circuit and short circuit loading method, according to IEEE Std. 115-1983, 6.2.4
— "Erwaermungsmessungen an Asynchron-Motoren mit Hilfe des Zweifrequenzverfahrens" "Brown Boveri Mitteilungen" 8-1976
— "Equivalent loading of induction machines for temperature test". IEEE Transactions on Power Apparatus and Systems Volume Pas-96 No.4, July/August 1977, pages 1126-1131. Author: Schwenk H. R. (19).

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Guidance note:

Insulation resistance test (9)

a) The insulation resistance of a new, clean dry machine, is to be measured immediately after the temperature test has been carried out and after high voltage test has been carried out using a direct current insulation tester between:

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

The minimum values of test voltage and insulation are given in Table C3. The temperature at which the resistance is measured is to be near the operating temperature, or an appropriate method of calculation may be used.

b) On carrying out insulation resistance test, it may be necessary to short circuit semi-conductors in order to avoid damage of such parts.

Table C3 Minimum insulation resistance values

Rated voltage U_n (V)	*Minimum test voltage (V)*	*Minimum insulation resistance (MΩ)*
$U_n \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$(U_n / 1000) + 1$
$7200 < U_n \leq 15000$	5000	$(U_n / 1000) + 1$

Guidance note:

Overload testing (12)

Overloads as stated in A204 are difficult to test on large machines. In case overloads cannot be tested, documentation or calculations based on manufacturers proven methods and experience will be accepted.

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102 *Site testing*

a) All machines shall be tested at site, after installation, so that acceptable starting and running performance are verified with full capacity of driven equipment, alternatively full generator load.

b) Setting of motor protection shall be verified.

SECTION 6
POWER TRANSFORMERS

A. General

A 100 General

101 *Reference*

The design of transformers shall in general comply with the requirements of IEC 60092-303. (In addition, dry type transformers shall comply with IEC 60726, and liquid cooled transformers with IEC 60076, as referenced to in IEC 60092-303.)

A 200 Design requirements for power transformers

201 *General*

a) Transformers shall be double wound. Starting transformers may be of autotransformer type.

b) Normally, transformers are to be of the dry air-cooled type.

c) All windings for air-cooled transformers are to be treated to resist moisture, sea air, and oil vapours.

d) For the general requirements for insulation materials and terminations, see Sec.3 D.

202 *Liquid immersed transformers*

a) Liquid immersed transformers, filled with non-flammable liquid, may be accepted in engine rooms or similar spaces if they have provision, when installed, for containing or safe draining of a total liquid leakage.

b) Normally, liquid immersed transformers are to be of the sealed type. However, conservator type may be accepted if the construction is such that liquid is not spilled, when the transformer is inclined at 40°.

c) Liquid immersed conservator type transformers shall have a breathing device capable of stopping (trapping) moisture from entering into the insulating liquid.

d) Arrangement for containment of accidental leakage shall be arranged.

e) A liquid gauge indicating the normal liquid level range shall be fitted.

f) Liquid immersed transformers shall be provided with monitoring as required in Table A1.

Table A1 Monitoring of liquid immersed transformers

Item	*Alarm*	*Load reduction or trip*	*Comments*
Liquid level, low	X	X	
Liquid temperature, high	X	X	
Gas pressure, high		X	Trip
Interturn short circuit		X	Trip

203 *Temperature rise*

Temperature rise for transformers, above ambient, according to Sec.3 B300, shall not exceed the following values (measured by the resistance method):

a) Dry type transformer windings:

- insulation class A: 50°C
- insulation class E: 65°C
- insulation class B: 70°C
- insulation class F: 90°C
- insulation class H: 115°C
- insulation class 220: 140°C

b) Liquid immersed transformers:

- temperature rise for windings: 55°C
- temperature rise for liquid when the liquid is in contact with air: 45°C
- temperature rise for liquid when the liquid not is in contact with air: 50°C.

204 *Parallel operation*

Transformers for parallel operation are to have compatible coupling groups and voltage regulation, so that the actual current of each transformer will not differ from its proportionate share of the total load by more than 10% of its full load current.

205 *Voltage regulation*

Transformers supplying secondary distribution systems for general use shall normally have a maximum 2.5% voltage drop from no load to full load at resistive load.

206 *Short circuit withstand and protection*

Transformers are to be constructed to withstand a primary or secondary terminal short circuit with a duration of minimum 1 s, with rated primary voltage and frequency, without damage to internal parts or enclosure.

207 *Forced cooling*

Power transformers with forced cooling shall be equipped with temperature detectors for monitoring and alarm as required by Sec.3 D200.

208 *Enclosure requirement*

Transformers for separate installation are to have separate enclosures complying with the IP protection requirements, in relation to its intended location, as stated in Sec.10, Table B1.

209 *Nameplate*

Each power transformer is to be provided with nameplate of durable, flame retardant material, giving the following information:

- make, type, serial no.
- performance standard
- rated values for: output apparent power, voltage(s), frequency, current(s), power factor
- duty type, if other than S1
- thermal classification of insulation
- IP code of enclosure and termination box
- vector group of windings
- maximum permissible cooling medium temperature
- short circuit impedance value
- liquid type (if applicable)
- total mass.

B. Inspection and Testing

B 100 General

101 *Factory testing*

a) Transformers shall be tested at the manufacturer's works with the tests specified in this part. Tests noted as type tests (TT) shall be carried out on a prototype or the first of a batch of identical transformers. Tests noted as routine tests (RT) shall be carried out on each transformer.

b) Required inspection and tests for distribution transformers above 5 kVA rating is the following:

- inspection of enclosure, terminations, and instrumentation or protection (RT)
- temperature rise test (TT)
- measuring of insulation resistance (RT)
- high voltage power frequency test (RT)
- measuring of voltage ratio at no load (RT)
- measuring of winding resistance (RT)
- short circuit voltage or impedance, no load and full-load losses (TT)
- short circuit test can be required as routine test or type test.

c) The tests shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the transformer, as well as the results of the required tests.

d) The result of type tests, and the serial number of the type tested transformer, shall be specified in the documentation of test results for a routine test.

e) For testing at site, after installation, see Sec.10.

102 *Temperature rise test*

Temperature test at full load may be difficult to realise on large transformers, due to insufficient test power being available. One of these simulated tests, or equivalent will be subject for approval:

- back to back method, according to IEC 60726. Clause 21.1.2.
- simulated load method, according to IEC 60726. Clause 21.1.3.

103 *High voltage testing*

a) A high voltage test is to be applied to a new and completed transformers.

b) The test is to be carried out immediately after the temperature rise test, when such is required.

c) The test is to be applied between each winding and the other windings, frame and enclosure all connected together. The test is to be made with an A.C. voltage at the level 1 kV plus twice the winding's rated voltage, with a minimum of 2.5 kV. The frequency can be chosen between 25 Hz and twice the rated frequency.

d) New transformers up to and including 5 kVA rating are to withstand an applied high voltage test as specified in a) above, but without the requirement of minimum 2.5 kV test voltage in case of a lower rated voltage.

e) The full test voltage is to be maintained for 1 minute.

f) Single phase transformers for use in a polyphase group are to be tested in accordance with the requirements for the transformers as connected together in the system.

g) After rewinding or other extensive repair the transformer is to be subjected to a high voltage test with a test voltage of at least 75% of that specified in c) and d) above.

104 *Insulation resistance testing*

The insulation resistance of a new, clean dry transformer is to be measured immediately after the temperature rise test, when such is required, and the high voltage test has been carried out. Test voltage and minimum insulation resistance is given in Table B1. The test is to be carried out between:

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

Table B1 Test voltages and minimum insulation resistance

Rated voltage U_n (V)	*Minimum test voltage (V)*	*Minimum insulation resistance (MΩ)*
$U_n \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$(U_n / 1000) + 1$
$7200 < U_n \leq 15000$	5000	$(U_n / 1000) + 1$

SECTION 7
SEMI-CONDUCTOR CONVERTERS

A. General Requirements

A 100 General

101 *References*

a) The design of semi-conductor assemblies shall comply with the requirements of IEC 60092-304.

b) Static converters assemblies based on semi-conductor devices for installation in the power system are to comply with the requirements given in this chapter.

Guidance note:

See Sec.4 for the requirements for electrical assemblies.

See DNV-OS-D202 regarding instrumentation equipment and computer based equipment.

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102 *Electromagnetic compatibility*

a) Converter assemblies shall be compatible with the ship network, so that generated line harmonics do not cause interference with other equipment.

b) Transformers and reactors applied in connection with converter assemblies shall be designed to withstand any additional stresses caused by non-sinusoidal voltages and currents.

Guidance note:

See Sec.2 with respect to requirements for system voltage, frequency and harmonic distortion.

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103 *Environmental conditions*

The power part of a converter unit shall comply with the environmental conditions given in Sec.3. Instrumentation and control equipment integrated in a converter shall comply with the requirements in DNV-OS-D202.

A 200 Mechanical requirements

201 *Accessibility*

Stacks of semi-conductor elements, fuses in the power circuit or other equipment likely to be changed out, are to be so arranged that they can be removed from equipment without dismantling the complete unit.

202 *Cooling*

Where forced cooling is provided, the apparatus is, unless otherwise particularly required, to be so arranged that the converter cannot remain loaded unless effective cooling is provided, or other effective means of protection against over temperature is provided.

A 300 Design requirements, electrical, for semi-conductor assemblies

301 *Electrical rating and duty*

a) The specified converter assembly capacity shall at least include a 100% continuous load, and a specified overload capacity given by a current of maximum duration.

b) Where required by the application, the overload capacity may be specified in several steps with corresponding maximum duration, or the converter rated load may be referred to a worst case duty cycle.

c) As a motor starter, the converter shall as a minimum withstand two consecutive start attempts without being overloaded by temperature.

d) For converter assemblies supplying motors, required torque is to be considered in view of the application.

302 *Output voltage*

Requirements for supply systems in Sec.2 are regarded as relevant for secondary side of converter assemblies applied to supply a constant frequency or constant voltage output.

303 *Short circuit current capabilities*

Converter assemblies serving as power supplies shall be able to supply a short circuit current sufficient for selective tripping of downstream protective devices, without suffering internal damage.

304 *Protection and monitoring*

a) Monitoring facilities in the control unit shall normally be provided to identify faults in the control or power circuits.

b) Inverters shall have the possibility for monitoring of the output voltage, frequency and current.

c) See Sec.2 G103 with respect to protection of batteries.

305 *Parallel operation*

a) When converter assemblies are operated in parallel with other power sources, the control circuits are to ensure stable parallel operation and prevent overloading of any unit.

b) When a converter system has parallel power circuits the load shall be distributed equally between the parallel paths.

306 *Nameplate*

Each semi-conductor assembly is to be provided with nameplate of durable, flame retardant material, giving the following information:

— make, type, serial no.
— rating
— performance standard
— IP code
— rated input voltage and frequency
— rated output voltage, frequency, current
— rated ambient temperature
— rated cooling water temperature (if applicable).

B. Testing

B 100 Testing

101 *General*

a) Converter assemblies shall be tested at the manufacturer's works. Type tests (TT) shall be carried out on a prototype of a converter or the first of a batch of identical converters. Routine tests (RT) shall be carried out on each converter.

b) The tests shall be documented The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the converter, as well as the results of the required tests.

c) The result of type tests, and the serial number of the type tested converter, shall be specified in the documentation of test results for a routine tests.

d) All converter assemblies are to withstand a high voltage test of duration 1 minute applied between the terminals and earthed parts, with frequency between 25 Hz and 100 Hz as described in Sec.4 D100.

e) The following tests are required:

- Function test (RT): All basic functions, including auxiliary functions, are to be tested under light load conditions. Input voltage and frequency are to be varied according to Sec.2 if applicable. Main output characteristics are to be measured.
- Current test (TT): Full load current and over current test according to rating as required in A301 a).
- Insulation resistance test (RT).
- High voltage test (RT).
- Short circuit current capability test for power supplies (TT). See A303.
- General inspection of assembly (RT). See Sec.4 for relevant assembly requirements.

Guidance note:

In case short circuit capability cannot be tested, documentation or calculations based on manufacturers proven methods and experience will be accepted.

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102 *Load testing*

Factory acceptance testing of semi-conductor converters with full power, together with the intended load if relevant, is not required for certification in accordance with these rules. Such tests shall be separately agreed between the manufacturer and the customer. (See 103 for site testing.)

103 *Site testing*

a) Final approval of the semi-conductor assembly shall include complete function tests with intended loading, after installation onboard, including a discharge test for UPS and D.C. power supplies.

b) The functional tests of semi-conductor power converters intended for rotating machines shall be performed with all ship systems simultaneously in operation, and in all characteristic load conditions.

SECTION 8
MISCELLANEOUS EQUIPMENT

A. General

A 100 Battery boxes and lockers

101 *References*

Other requirements for batteries, and battery installation, are found in Sec.2 D100, Sec.2 I300, Sec.4 B200 and Sec.10 B300.

102 *Marking*

All batteries are to be provided with nameplates of flame retardant material, giving information on the application for which the battery is intended, make, type, voltage and capacity. Instructions are to be fitted either at the battery or at the charging device, giving information on maintenance and charging.

103 *Battery boxes and lockers*

a) Dedicated battery boxes shall have ventilation holes at the top. There are not to be pockets that may accumulate gas.

b) In battery boxes, the cells shall be placed at one height only.

c) In battery boxes with side cover there shall be a minimum of 300 mm space above each cell. In battery boxes with a top cover there shall be a minimum of 300 mm space above each cell when the cover is open.

d) Normally, boxes shall not contain electrical equipment other than intrinsically safe monitoring devices. Lighting, if necessary shall be mounted outside the box or locker.

104 *Battery lockers*

The requirements for battery boxes are also applicable to battery lockers. In addition, the following requirements apply:

— the locker shall be prepared for an exhaust duct
— the batteries may be assembled at several heights, with a minimum free distance between each of 300 mm.

A 200 Socket outlets and plugs

201 *General*

a) Socket outlets and plugs with a rated current not exceeding 63 A in A.C. installations and 16 A in D.C. installations, shall be constructed for making and breaking the rated current by insertion and withdrawal of the plug, unless they are provided with an interlock as described in b).

b) Socket outlets with a rated current above 63 A A.C. or 16 A D.C. shall be provided with interlocks so that the plug can only be inserted and withdrawn when the switch is in the "off" position.

c) The maximum voltages for socket outlets is normally 250 V.

d) Socket outlets for portable appliances, which are not handheld during operation (e.g. welding transformers, refrigerated containers), shall be interlocked with a switch regardless of rating, maximum 1000 V can be accepted. At each such socket outlet, a warning sign is to be fitted, with text: DANGER (maximum voltage) V A.C. ONLY FOR CONNECTION OF.... (type of equipment)....

e) Higher voltage socket outlets can only be used for special applications.

f) All socket outlets shall be provided with an earthing contact, except that this may be omitted in the following cases:

— socket outlets on systems with voltage below 50 V A.C. or D.C.
— socket outlets with double insulated transformers for handheld equipment
— socket outlets in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material.

g) Precautions are to be taken so that a plug for one voltage cannot be inserted in a socket outlet for a different voltage. Alternatively, warning signboards are to be fitted.

A 300 Lighting equipment

301 *General*

a) The temperature rise of parts of luminaries that are in contact with the support shall generally not exceed 50°C.

b) The temperature limit is 40°C for parts installed in contact with flammable materials, such as for example wood.

c) For temperature rise of terminals: see Sec.3.

d) For other parts, temperatures according to recognised national or international standards, which take due consideration of the ambient temperatures on vessels, will be accepted.

e) Normally, gas discharge lighting equipment shall not be used.

302 *Lampholders*

a) Types of lampholders according to Table A1 may be used.

b) Lampholders of type E40 should be provided with an effective means for locking the lamp in the holder.

c) All lampholders for incandescent lamps with a rating above 5 W shall be made of incombustible material.

d) It shall not be possible to insert a lamp for one voltage into a lampholder for a different voltage unless warning signboards are fitted.

Table A1 Accepted type of lampholders

Designation			*Maximum lamp rating*	
			Voltage	*Load*
1.	Lampholders for screw cap lamps	E 40	250 V	3000 W 16 A
		E 27	250 V	200 W 4 A
		E 14	250 V	15 W 2 A
2.	Lampholders for bayonet cap lamps	B 22	250 V	200 W 4 A
		B 15d	250 V	15 W 2 A
		B 15s	55 V	15 W 2 A
3.	Lampholders for tabular fluorescent lamps	G 13	250 V	80 W
		G 5	250 V	13 W

The designations for 1. are according to IEC 60238, for 2. and 3. to IEC 60061 - 2. The voltage and current ratings of 1. are according to IEC 60238, except for E14, the power rating of 3. to IEC 60061 - 2.

303 *Starting devices*

Starting devices which develop higher voltages than the supply voltage are generally to be placed within the luminaries.

304 *Discharge of capacitors*

Each capacitor of 0.5 µF or more shall be provided with an arrangement that reduces the voltage to not more than 50 V within 1 minute after disconnection from the supply.

A 400 Heating equipment

401 *General*

Each separate heating element rated more than 16A is considered as a separate consumer, for which a separate circuit from a switchboard is required.

402 *Temperature rises for heaters*

The temperature rises in Table A2 are accepted.

Table A2 Temperature rises for heaters

Part	*Temperature (°C)*
Enclosure parts against the bulkhead	*60*
Operating handles, if of metal	*35*
Operating handles, if of insulating material	*60*
Other accessible parts	*130 1)*
Surface of heating elements inside enclosures with through air convection	*280*

1) Heating elements having a temperature rise exceeding 130°C are generally to be considered as "live parts" and shall be provided with suitable enclosures.

Guidance note:

It is recommended to provide each heater with an interlocked over temperature thermostat with manual reset, accessible only by use of a tool. National regulations of the flag state might require such an over temperature cut out.

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403 *Space heaters*

a) Space heaters are generally to be of the convection type, and suitable for installation on bulkheads. Radiation heaters and other space heater types may be accepted after consideration in each case.

b) Space heaters are generally to be constructed with the top plate inclined about 30°, tight against the bulkhead in order to prevent clothing or other flammable material from covering the heaters.

c) Space heaters are normally to be installed on a free bulkhead space, with about 1 m free air above, and so that for example doors cannot touch the heaters. If not constructed as specified in b), an inclined perforated plate of incombustible material shall be mounted above each heater. Space heaters are not to be built into casings of woodwork or other combustible material.

404 *Heating batteries for ventilation systems*

For heating batteries in ventilation systems, the heating elements shall be interlocked with the fans, and both a working thermostat and an over-temperature thermostat with manual reset are required.

405 *Space heaters combined with air-condition cabinets*

The following additional requirements apply for space heaters integrated in air-conditioning cabinets:

— the maximum temperature rises specified in 402 shall be complied with, even when the air supply is completely shut off
— each cabinet shall be provided with an interlocked over temperature thermostat with manual reset, accessible only by use of tool
— combined cabinets for ceiling installation are accepted, the ceiling shall be constructed of incombustible materials.

406 *Water heaters*

a) Water heaters are normally to have insulated heating elements and shall be installed as separate units.

b) The requirements for temperature rises specified for cooking equipment in 500 apply.

c) Each water heater shall be provided with a thermostat, sensing the water temperature and maintaining this at the correct level.

Guidance note:

Electrode heaters and electrically heated steam boilers may be accepted after assessment of the arrangement in each case.

Heating by electric elements in the ship's water tanks may be accepted after design assessment of the arrangement in each case.

For pressure vessels, the requirements in the Rules for Classification of Ships, Pt.4 Ch.7 apply.

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407 *Oil heaters*

a) Electric oil heaters are normally to be installed as separate units. Heating by electric heating elements in the ship's oil tanks is generally not allowed, but may be accepted after special design assessment of the arrangement in each case.

b) The requirements for temperature rises specified for cooking equipment in 500 apply. In addition, the surface temperature of the heating elements shall be below the boiling point of the oil, under normal working conditions. Further limitation of the heating elements' temperature may be required.

c) Each oil heater shall be provided with a working thermostat, sensing the oil temperature and maintaining this at correct level under normal working conditions. In addition, each oil heater shall be provided with an interlocked over-temperature thermostat with manual reset, and with the sensing device installed in close proximity to the heating elements, so arranged that it will trip the elements, should they tend to overheat, or become dry. Other arrangements, ensuring equivalent protection, may be accepted after design assessment in each case

Guidance note:

Lubricating oil may deteriorate even at much lower element temperatures. The oil manufacturer should be consulted regarding the maximum acceptable element temperature.

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408 *Heating cables, tapes, pads, etc.*

a) Heating cables, tapes, pads, etc. are not to be installed in contact with woodwork or other combustible material. If installed close to such materials, a separation by means of a non-flammable material may be required.

b) Earth fault breakers shall be provided with a maximum release current of normally 30 mA. For heat trace installations a maximum release current of 300 mA is accepted.

c) Heat tracing shall not expose surroundings or insulated piping material to higher temperature than the material is suited for.

A 500 Cooking and other galley equipment

501 *General*

a) Cooking equipment is generally to have insulated heating elements. Special equipment, such as for example high frequency ovens or electrode pots, are to be suitable for marine use, and installed in accordance with the manufacturer's instructions.

b) Electrode pots giving earth -connection of the system shall be fed from separate isolating transformers.

c) For oil pots, the requirements for oil heaters in 407 apply

d) The temperature rises in Table A3 are accepted.

Table A3 Temperature rises cooking and other galley equipment

Part	*Temperature (°C)*
Enclosure parts against the bulkhead and decks	50
Operating handles, if of metal	25
Operating handles, if of insulating material	50
Other accessible surface parts, except hot plates with adjacent top plates	50
Hot plates with adjacent top plates, and heating elements	No limit [1)]

1) Construction and temperatures shall be such that damage and hazards are avoided, when the equipment is used as intended.

SECTION 9
CABLES

A. Application

A 100 General

101 *General*

a) This section of the rules contains requirements for selection, construction and rating of fixed electrical cables for permanent installation. Other applicable requirements in other sections shall also be complied with.

b) For flexible cables, the requirements apply only as far as practicable. The use of flexible cables shall be limited to applications where flexibility is necessary, and the lengths of such flexible cables shall be kept as short as practicable. Special requirements may be made for the type, installation and protection of flexible cables, depending upon the application.

c) Requirements for cables for special applications are found in other parts of the rules. For cable selection see Sec.2 and for cable installation see Sec.10.

102 *Duty*

a) Unless otherwise clearly stated, the rating of electrical cables for power supply to equipment shall be for continuous full load duty. Maximum environmental temperatures shall be as given in Sec.3 Table B1.

b) Requirements for cable sizing, and the tables for the current rating of different cable sizes, can be found in Sec.2.

103 *Compliance with IEC*

The design of all electrical cables installed shall comply with the requirements of applicable IEC Publications.

Guidance note:

1) The construction of power cables for permanent installations should normally comply with the specifications of International Electrotechnical Commission's (IEC) Publication No. 60092-353. «Electrical installations in ships, Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltage 1 kV and 3 kV».

2) In IEC 60092-350, 0,6/1,0 kV gives as rated voltages for ship power cables.

3) IEC 60092-3 has been withdrawn, however until a new IEC standard for 150/250 V cables has been issued, IEC 60092-3 should be used.

4) Cables intended for use on systems operating up to 60 V A.C. or D.C. should comply with IEC 60092-375.

5) Cables intended for use on systems operating up to 250 V A.C. or D.C. (not susceptible to interference) should comply with IEC 60092-376. Only for 1 mm^2 conductors. See 3) above.

B. General Cable Construction

B 100 General

101 *Conductors*

All conductors shall be stranded according to IEC 60228 class 2 or class 5.

Guidance note:

Class 5 will be in amendment 3 of IEC 60092-353.

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102 *Conductor cross section*

a) Conductor cross sections shall be based on the rating of the over current and short circuit protection used. However the minimum cross section shall be:

- 0.22 mm^2 for data cables
- 0.5 mm^2 for 60 V cables
- 1.0 mm^2 for 250 V and 0,6/1 kV cables with the following exceptions: 0.75 mm^2 may be used for flexible cables supplying portable consumers in accommodation spaces, and also for internal wiring of lighting fittings, provided that the full load current is a maximum of 6 A and that the circuit's short circuit protection is rated at a maximum of 10 A
- 10 mm^2 for voltages above 1 kV.

b) Minimum cross sections of earth conductors are given in Sec.2. Earth conductors in cables shall be insulated, except for earth conductors as specified in Sec.2 Table J2.

c) For current rating of cables see Sec.2 J.

C. High Voltage Cables

C 100 General

101 *Construction of high voltage cables*

a) Types of cables and insulated conductors shall comply with the requirements for cable construction in B.

b) The construction and testing of cables for permanent installations shall normally comply with the recommendations of IEC 60092-354, "Electrical installations in ships, Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV, 10 kV and 15 kV", and IEC 60502, "Extruded solid dielectric insulated power cables for rated voltages from 1 kV to 30 kV", with the following additional requirements:

- as insulating materials only cross linked polyethylene (XLPE) or ethylene propylene rubber (EPR) shall be used as listed in IEC 60092-351
- conductor screening is required for all cables with XLPE insulation, and for EPR-insulated cables with rated voltage U_0/U above 3,6/6 kV. Conductor screening shall be non-metallic and consist of either semi-conducting tape or a layer of extruded semi-conducting compound, or a combination of the two
- insulation screening is required for all cable and shall consist of a non-metallic semi-conducting part in contact with a metallic part (see further IEC 60092-354)
- as sheath materials one of the types specified in IEC 60092-359 shall be used
- wire braid and armour shall comply with the requirements in D300.

Guidance note:

Other constructions and materials will be accepted when specially designed for special purposes.

For example «fire resisting» cables for circuits with short time duty (such as fire pumps), since the need for fire resisting char-

acteristics of such cables make it difficult to apply screening as specified above.

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D. Low Voltage Power Cables

D 100 Cables rated 0.6/1 kV and 1.8/3 kV

101 *Insulating materials*

a) The temperature classes and materials given in Table D1 may be used.

Table D1 Temperature classes for insulating materials

Material	*Temperature (°C)*
Polyvinyl chloride or (PVC)	60
Ethylene propylene rubber (EPR)	85
Halogen free ethylene propylene rubber (HF EPR)	85
Hard grade ethylene propylene rubber (HEPR)	85
Halogen free hard grade ethylene propylene rubber (HF HEPR)	85
Cross linked polyethylene (XLPE)	85
Halogen free cross linked polyethylene (HF XLPE)	85
Halogen free cross linked polyolefin (HF 85)	85
Silicone rubber, (S 95).	95
Halogen free silicone rubber (HF S 95).	95

b) Electrical and mechanical characteristics shall comply with the specifications of table II, III and IV respectively of IEC 60092-351.

102 *Minimum thickness of insulating walls*

The minimum average thickness of insulating walls shall be used in accordance with Table D2.

Table D2 Minimum average thickness of insulating walls

Nominal cross section of conductor (mm^2)	*Designation of the insulating compound*		
	PVC/A (mm)	*EPR (mm)*	*XLPE (mm)*
	Rated voltage 0.15/0.25 kV		
1.5	0.7	0.8	0.7
2.5	0.8	0.8	0.7
4	0.8	0.9	0.7
6	0.8	0.9	0.7
Nominal cross section of conductor (mm^2)	*Designation of the insulating compound*		
	PVC/A (mm)	*EPR HF EPR S 95 (mm)*	*XLPE HF XLPE HF 85 HEPR HF HEPR (mm)*
	Rated voltage 0.6/1.0 kV		
1.5	0.8	1.0	0.7
2.5	0.8	1.0	0.7
4	1.0	1.0	0.7
6	1.0	1.0	0.7
10	1.0	1.0	0.7
16	1.0	1.0	0.7
25	1.2	1.2	0.9
35	1.2	1.2	0.9
50	1.4	1.4	1.0
70	1.4	1.4	1.1
95	1.6	1.6	1.1
120	1.6	1.6	1.2
150	1.8	1.8	1.4
185	2.0	2.0	1.6
240	2.2	2.2	1.7
300	2.4	2.4	1.8
Nominal cross section of conductor (mm^2)	*Designation of the insulating compound*		
		EPR HF EPR (mm)	*XLPE HF XLPE HEPR HF HEPR (mm)*
	Rated voltage 1.8/3 kV		
10		2.2	2.0
16		2.2	2.0
25		2.2	2.0
35		2.2	2.0
50		2.2	2.0
70		2.2	2.0
95		2.4	2.0
120		2.4	2.0
150		2.4	2.0
185		2.4	2.0
240		2.4	2.0
300		2.4	2.0

— For smaller cross sections than 1.5 mm^2, the insulation thickness shall not be less than specified for 1.5 mm^2.
— Table D2 is according to IEC 60092-3 for 0,15/0,25 kV cables and IEC 60092-353 for 0.6/1.0 kV and 1.8/3 kV cables.

D 200 Protective sheaths

201 *General*

a) All cables shall have a protective sheath over the core insulation, except for "switchboard wires" according to 400 (see also Sec.10 C700 regarding the installation of such wires in pipes).

b) The minimum average thickness of insulating walls given in Table D2 applies. For other standard cross sections, intermediate values may be used (for 60 V communication cables, see F, and for 250 V control cables, see E).

c) Mechanical and particular characteristics of sheath materials shall comply with the specifications of table II and III respectively of IEC 60092-359.

d) Thickness of sheaths is to comply with sub-clause 13.2 of IEC 60092-353.

e) Sheath materials shall be such that the cables are at least flame retardant according to IEC 60332-1. (For cable bunches, see Sec.10 C404.)

202 *Temperature classes for protective sheaths*

The temperature classes and materials shall be used in accordance with Table D3.

Table D3 Temperature classes for protective sheaths

Material	*Temperature (°C)*
Thermoplastic based on polyvinylchloride or copolymer of vinylchloride and vinylacetate, type ST 1	60
Thermoplastic: based on polyvinylchloride or copolymer of vinylchloride and vinylacetate, type ST 2 Halogen free, type SHF1	85
Elastomeric or Thermosetting: based on polychloroprene rubber, type SE 1 based on chlorosulphonated polyethylene or chlorinated polyethylene rubber, type SH Halogen free, type SHF2	85

D 300 Wire braid and armour

301 *General*

a) Cables designated as copper, copper alloy, aluminium alloy or galvanised steel wire braided shall comply with clause 14 of IEC 60092-353.

b) Braid and/or armour shall be separated from the core insulation by an inner non-metallic sheath, by tape or fibrous braid or roving.

c) Irrespective of the metal used, the nominal diameter of the braid wire shall be in accordance with Table D4.

Table D4 Nominal diameter of braided wire

Diameter of core assembly under braid [1] (mm)	*Minimum diameter of threads in braid [2] (mm)*
D ≤ 10	0.2
10 < D < 30	0.3
D ≥ 30	0.4

1) Diameter under braid is fictitious and calculated by the method of IEC 60092-350 Appendix A.

2) The "coverage density" of the braid shall be in accordance with subclause 7.2 of IEC 60092-350.

D 400 Switchboard wires

401 *General*

a) Switchboard wires may be single core wires without further protection, complying with the specifications for insulating materials in 101.

b) The insulation on switchboard wires shall be at least flame retardant according to IEC 60332-1. Insulation material shall be one of the following: PVC, HEPR, HFHEPR, XLPE, HFXLPE or HF85.

c) Single core conductors may also be used for installation in closed piping system in accommodation spaces, when the system voltage is a maximum of 250 V, and for control wiring installed in closed piping system on machinery components.

D 500 Lightweight electrical cables

501 *General*

For high speed, light craft and naval surface craft cables approved in accordance with the DNV type approval programme "Standards for Certification No. 2.9, Type Approval Programme No. 6-827.11-1: Lightweight Electrical Cables for High Speed, Light Craft and Naval Surface Craft", are accepted.

E. Control Cables

E 100 Construction

101 *General*

a) Conductors shall have a cross section of 1.0 mm² and shall consist of plain or metal coated annealed copper of the category "circular non-compacted".

b) Characteristics of the insulation shall be as specified in D100.

c) The minimum average thickness of the insulation shall be as specified in sub-clause 4.2 of the IEC 60092-376.

d) For protective sheath materials, the requirements in D200 apply. The minimum sheath thickness is specified in subclause 8.2 of IEC 60092-376.

e) For metal wire braid and armour, the requirements of D300 apply. Alternatively, the dimensions of metal braid armour may instead comply with clause 9 of IEC 60092-376.

Guidance note:

If it is found necessary to provide cables with a screen in order to reduce electromagnetic noise and interference, then this should be in the form of a copper wire braid, or another equivalent effective screening.

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F. Instrumentation and Communication Cables

F 100 General

101 *General*

a) Conductors shall have a minimum cross section of 0.5 mm^2, and shall be stranded. This requirement does not apply to internal wiring in consoles and control boxes.

b) Twisted pair data cables (as IBM Cat 5) 0.22 mm^2 can be accepted under the assumption that the strands of the whole cable are kept as part of the termination, as for coaxial cables.

c) Characteristics of insulation materials shall be as specified for low voltage cables in D100 and D200.

d) The minimum average thickness of the insulation shall be as specified in clause 13 and tables II and III of the IEC 60092- 375.

e) For protective sheath material the requirements in D400 apply. For minimum sheath thickness as specified in clause 13, tables II and III of IEC 60092-375 apply.

f) For metal wire braid and armour same requirements as for low voltage cables in D300 apply. Dimensions of copper wire braid as specified in the tables II and III of IEC

SECTION 10
INSTALLATION

A. General Requirements

A 100 General

101 *General*

Reference is made to other sections of this chapter, especially Sec.2 for requirements affecting location, arrangements, and installation of systems in an early project stage, and Sec.3 to Sec.9 for requirements affecting the various equipment.

Equipment in hazardous areas shall be selected, located and installed according to Sec.11.

102 *References to standards*

The requirements in this section are based upon IMO codes and regulations and the relevant IEC standards.

B. Equipment

B 100 Equipment location and arrangement

101 *General*

a) All electrical equipment shall be installed "electrically safe". This is to prevent injury to personnel, when the equipment is handled or touched in the normal manner.

b) All electrical equipment shall be selected and installed so as to avoid EMC problems. Thus preventing disturbing emissions from equipment, or preventing equipment from becoming disturbed and affecting its intended function(s).

c) Electrical equipment shall be placed in accessible locations so that those parts, which require manual operation, are easily accessible.

d) Heat dissipating electrical equipment as for example lighting fittings and heating elements, shall be located and installed so that high temperature equipment parts do not damage associated cables and wiring, or affect surrounding material or equipment, and thus become a fire hazard.

e) Semi-conductor converters stacks or equipment shall be installed in such a manner that the circulation of air to and from the stacks, associated equipment or enclosures is not obstructed. The temperature of the cooling inlet air to converter shall not exceed the ambient temperature for which the stacks are specified.

f) All equipment of smaller type (luminaires, socket outlets etc) shall be protected against mechanical damage either by safe location or by additional protection, if not of a rugged metallic construction.

g) See Sec.2 I for additional requirements for vessel arrangement.

102 *Ventilation of spaces with electrical equipment*

The ventilation shall be so arranged that water or condensation from the ventilator outlets does not reach any unprotected electrical equipment. See also Sec.2 I101.

103 *High voltage switchgear and controlgear assemblies*

Access to high voltage switchgear rooms and transformer rooms shall only be possible to instructed personnel.

Guidance note:

Equipment located in machinery spaces may be considered as being accessible only to instructed personnel. The same applies to equipment located in other compartments that are usually kept locked, under the responsibility of the ship's officers.

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104 *Passage in front or behind switchgear*

The passageways in front of and behind main and emergency switchboards shall be covered by mats or gratings of oi resistant insulating material, when the deck is made of a conducting material.

105 *Transformers*

Liquid immersed transformers shall be installed in an area or space with provisions for complete containment and drainage of liquid leakage.

106 *Heating and cooking appliances*

a) All combustible materials close to heating and cooking appliances shall be protected by incombustible or insulating materials.

b) Cabling and wiring (feeding) shall be suitable for the eventual higher temperature in the termination room of such equipment.

c) Additional protection of IR–type of open heating elements shall be installed, if necessary to guard against fire and accidental touching.

B 200 Equipment enclosure, Ingress Protection

201 *Enclosure types in relation to location*

Equipment enclosures shall comply with Table B1 in relation to the location of where it is installed.

Table B1 Enclosure types in relation to location

Location		*Switchgear and transformers*	*Luminaires*	*Rotating machines*	*Heating appliances*	*Socket outlets*	*Miscellaneous such as switches and connection boxes*	*Instrumentation components*
Engine and boiler rooms	Above the floor	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44	IP 44
	Below the floor	N	IP 44	IP 44	IP 44	N	IP 44	IP 56
	Dry control rooms and switchboard rooms	IP 21 1)	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
	Closed compartments for fuel oil and lubrication oil separators	IP 44	IP 44	IP 44	IP 44	N	IP 44	IP 44
Fuel oil tanks 2)		N	N	N	N	N	N	IP 68
Ballast and other water tanks, bilge wells 2)		N	N	IP 68	IP 68	N	N	IP 68
Ventilation ducts		N	N 13)	IP 44 13)	N	N	N	13)
Deckhouses, forecastle spaces, steering gear compartments and similar spaces		IP 22 3)	IP 22	IP 22 3)	IP 22	IP 44	IP 44	IP44
Ballast pump rooms and similar rooms below the load line		IP 44 14)	IP 44	IP 44 14)	IP 44	IP 56 5)	IP 56 5)	IP 56 5)
Cargo holds 4)		N	IP 55	IP 44	N	IP 56 5)	IP 56 5)	IP 56 5)
Open deck, keel ducts		IP 56	IP 55	IP 56 6)	IP 56	IP 56 5)	IP 56 5)	IP 56
Battery rooms, paint stores, gas bottle stores or areas that may be hazardous due to the cargo or processes onboard 7)		N	EX 12)	EX 12)	EX 12)	N	EX 12)	EX 12)
Dry accommodation spaces		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20 8)	IP 22
Bath rooms and showers		N	IP 44 11)	N	IP 44	N 9)	IP 56 11)	IP 56 11)
Galleys, laundries and similar rooms 10)		IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44

(N: Normally, not accepted for installation in this location.)

1) Switchboards in dry control rooms and switchboard rooms with IP 21 shall have a roof with eaves. If there is a chance of dripping water from piping, condensed water, etc. then a higher IP rating may be necessary.

2) For cable pipes and ducts through fuel oil and water tanks, see C703.

3) Such equipment shall be provided with heating elements for keeping it dry when not in use. The heating elements shall normally be automatically switched on when the equipment is switched off. Continuously connected heating elements may be accepted provided the maximum allowed temperatures are maintained when the equipment is in operation.

4) For enclosures in cargo holds, placed so that they are liable to come into contact with the cargo or cargo handling gear, see 101. For truck battery charging arrangements, see Sec.2 I305. For electrical installations in cargo holds for dangerous goods, see the Rules for Classification of Ships, Pt.5 Ch.11 Sec.2 B300. For special category spaces in passenger vessels and ferries see the Rules for Classification of Ships, Pt.5 Ch.2 Sec.2 F. For such cargoes, also national regulations apply. For vessels carrying cars with fuel in their tanks see the Rules for Classification of Ships, Pt.4 Ch.10.

5) IP 44 may be accepted, when placed in a box giving additional protection against ingress of water. Equipment for control and indication of watertight doors and hatches shall have watertightness based on the water pressure that may occur at the location of the component, if intrusion of water can affect the control or indication system.

6) Motors on open deck shall have ingress protection IP 56, and either:

— be naturally cooled, i.e. without external cooling fan
— be vertically mounted and equipped with an additional steel hat preventing ingress of water or snow into any external ventilator
— or be equipped with a signboard requiring that the motor shall only be used in port, and be provided with additional covers (e.g. tarpaulins) at sea.

7) For arrangement and connection of batteries, see Sec.2. For installations in paint stores, gas bottle stores or areas that may be hazardous due to the cargo or processes onboard, the requirements in Sec.11 shall be complied with.

8) Connection boxes may be accepted installed behind panels in dry accommodation spaces provided that they are accessible through a hinged panel or similar arrangement.

9) Socket outlets shall be so placed that they are not exposed to splash, e.g. from showers. Circuits for socket outlets in bathrooms shall either be fed from a double insulated transformer, or be equipped with earth fault protection with a maximum release current of 30 mA.

10) Stoves, ovens and similar equipment may be accepted with IP 22 when additionally protected against water splash by hose or washing of the floor.

11) Lower degree of protection may be accepted provided the equipment is not exposed to water splash.

12) Type of ingress protection shall be as for deckhouses. Minimum explosion group and temperature class shall be one of those specified in Table B2 (Some national regulations may limit the choice of type of protection).

13) Luminaires and instrumentation components may be accepted after special consideration. It shall be observed that a ventilation duct may be a hazardous area, depending upon the area classification at the ends of the duct.

14) Electric motors and starting transformers for side thrusters shall be equipped with heating elements for standstill heating.

Table B2 Minimum explosion groups and temperature classes for different locations		
Location	*Explosion group*	*Temperature class*
Battery rooms	II C	T1
Stores for welding gas bottles	II C	T2
Lamp rooms and paint stores	II B	T3

B 300 Batteries

301 *General*

Battery installations are to comply with the requirements in Sec.2 I regarding requirements for their location, compartments etc.

302 *Materials*

The following requirements apply to all stationary accumulator batteries:

a) Battery stands, boxes and lockers shall be fixed to the vessel's structure. The batteries shall be fixed or supported on the shelves. Shelves and fixings shall be constructed to withstand the forces imparted from the batteries, during heavy sea.

b) All materials used for the construction, including ventilation ducts and fans, shall be corrosion resistant or shall be protected against corrosion by suitable painting, with consideration given to the type of electrolyte actually used.

c) The materials shall be at least flame retardant, except that impregnated wood can be used for the support of battery cells, and for battery boxes on deck.

d) Except when corrosion resistant materials are used, the shelves in battery rooms and lockers and the bottom of battery boxes shall be covered with a lining of corrosion resistant material, having a minimum thickness of 1.5 mm and being carried up not less than 75 mm on all sides (e.g. lead sheath for lead and acid batteries, steel for alkaline batteries). If the shelves in battery rooms and lockers are of corrosion resistant materials and the floor is not, either the shelves or the floor shall be covered with such lining.

303 *Testing*

The following tests and inspections shall be performed before batteries are put into service:

— ventilation shall be verified, including natural ventilation
— capacity tests, voltage measurements
— alarms and monitoring functions.

304 *Marking and signboards*

See 503 for the requirements for marking and signboards, with respect to battery installations.

B 400 Protective earthing and bonding of equipment

401 *General*

a) Earth conductors shall normally be of copper. However, other suitable materials may be accepted if, for example the atmosphere is corrosive to copper.

b) The earth conductor's cross section shall be equivalent to that of copper with regard to conductivity. Applicable arrangements and cross sections are given in Sec.2 Table J2.

c) The connection to the hull of earth conductors or equipment enclosure parts, which shall be earthed, shall be made by corrosion resistant screws or clamps, with cross section corresponding to the required cross section of earth given in Sec.2 J303.

d) Earthing screws and clamps shall not be used for other purposes. Suitable star washers and conductor terminals shall be used, so that a reliable contact is ensured.

e) Metal enclosures or other exposed conductive parts being a part of electrical equipment shall be earthed by fixing the metal enclosure or exposed parts in firm (conductive) contact to the hull (main earth potential) or by a separate earth conductor.

f) For distribution systems with neutral earthed through an impedance or direct terminated and distributed neutral (TN-S), protective earthing (PE) shall be carried out by connecting exposed parts direct to feeding switchboard main PE, via an earth conductor in the supply cable.

g) Portable equipment shall always be earthed by an earth conductor contained in the flexible supply cable.

h) All extraneous conductive parts supporting electrical equipment and cable support systems, that is ladders, pipes and ducts for electrical cables, are considered to be in firm electrical contact with the hull as long as elements are welded or mechanically attached (metal to metal without paint or coating) with a star washer, thereby ensuring a firm conductive contact. If firm electrical contact is not achieved, the parts shall be bonded by a separate copper conductor between extraneous parts and the hull.

i) Additional precautions shall be applied regarding earthing of portable electrical equipment for use in confined or exceptionally damp spaces where particular risks due to exposure and conductivity may exist.

j) High voltage metal enclosures and the steel hull shall be connected by a separate earth conductor. The enclosures fixing device shall not be the sole earthing connection of the enclosure.

k) If a separate earthing conductor is chosen for equipment, then the connection of the separate earth conductor to the hull, (safe earth potential) shall be made in an accessible position. The conductor shall be terminated by a pressure type cable lug onto a corrosion protected bolt, which shall be secured against loosening. Other suitable terminating systems for direct receipt of the conductor may be considered.

Guidance note:

Additional precautions in k) might be: The equipment having extra safe low voltage, or for ordinary 230 V equipment, by using a safety transformer system or by having an earth fault switch of maximum 30 mA in front of the circuit.

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402 *Exceptions to the earthing or bonding requirements*

a) If one of the following conditions is fulfilled, the requirements in 401 above may be omitted:

— equipment supplied at a voltage not exceeding 50 V D.C. or A.C. between conductors. Auto-transformers shall not be used for the purpose of achieving this voltage
— equipment supplied at a voltage not exceeding 250 V by safety isolating transformer and the transformer is supplying only one consumer device
— equipment constructed in accordance with the principle of double insulation.

b) Parts fixed to non-conductive materials, and separated from current carrying parts and from earthed parts in such a way that they cannot become live under normal or electrical fault conditions.

c) Bearing housings which are insulated in order to prevent circulating currents.

d) Cable clips do not need protective earthing.

403 *Dimension of protective earth and bonding conductors*

For dimension of protective earth and bonding conductors, see Sec.2.

B 500 Equipment termination, disconnection, marking

501 *General*

All equipment shall be installed and terminated in accordance with manufacturer's instructions to ensure that correct functions and safe properties are contained.

502 *Multipole disconnection of equipment circuits*

a) All electric circuits connecting final consumers shall be provided with multipole disconnection device.

b) The multipole device shall be an on load switching device. MCBs with accessible on and off levers, intended for load switching, may be accepted.

c) All consumers other than motors shall be controlled by at least a multipole switchgear, except that single pole switches can be used for luminaires or space heaters in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material.

Guidance note:

Multipole disconnection means that all active poles are disconnected simultaneously. However, any N-conductor is not regarded as an active pole, and need not be disconnected.

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503 *Signboards for equipment*

a) Labels (nameplates) of flame retardant material, bearing clear and indelible indications, shall be so placed that all equipment necessary for the operation can be easily identified. All labels shall be permanently fixed.

b) All equipment shall, if necessary, be marked so as to ensure correct use. Signboards giving guidance for safe use, or conditions for use, shall be fitted, if necessary, in order to avoid inadvertent or dangerous operation of equipment and or systems.

c) "High voltage" warning signboards are required on all high voltage equipment.

d) High voltage cables shall be suitably marked with "high voltage" warning signboards, at least for every 20 m, so that a signboard is always visible.

e) On rotating machines, on deck, that are not naturally cooled, i.e. with external cooling fan, a signboard shall be fitted on the machines requiring that the machines shall only be used in port and be provided with additional covers (e.g. tarpaulins) when at sea.

f) At each socket outlet for portable appliances where 1000 V is accepted, (e.g. welding transformers, refrigerated containers etc., which are not hand-held during operation) an additional warning sign shall be fitted, with the text: DANGER (maximum voltage) V A.C. ONLY FOR CONNECTION OF ....(type of equipment)....

g) Signboards shall be fitted in battery rooms and on doors or covers of boxes or lockers, warning against risk for explosive gas, smoking and the use of naked lights.

h) All batteries shall be provided with labels (nameplates) of flame retardant material, giving information on the application for which the battery is intended, make, type, voltage and capacity. Instructions shall be fitted either at the battery or at the charging device, giving information on maintenance and charging.

i) Battery systems above 50 V shall be marked with special visible warning signboard, i.e. “Warning xxx voltage”.

C. Cables

C 100 General

101 *General*

a) Cable sizing with respect to current carrying capacity and short circuit withstand capabilities shall comply with the requirements in Sec.2.

b) For requirements for cable construction and materials, see Sec.9.

c) A.C. wiring shall be carried out, as far as practicable, in twin or multicore cables.

d) For installations in connection with hazardous areas, requirements for selection of cables, cable routing and fixing, see Sec.11.

Guidance note:

Use of cables with low emission of smoke in case of a fire, should be considered for all indoor installations. In areas where equipment sensitive to corrosion is installed or kept, use of Halogen free cables should be considered to avoid corrosive smoke in case of a fire, as far as is practicable.

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102 *Painting of cables*

Electrical cables may be coated or painted, but this shall not adversely affect the mechanical, chemical or fire resistant characteristics of the sheath.

Guidance note:

The Society has experience from cables damaged by two component epoxy painting bonding to the sheath material.

Unless the yard has experience with the combination of paint and cable type used, the manufacturers should be consulted by the yard.

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103 *Cable sheath*

Cables with metal sheath or braid or armour shall be provided with an outer sheath for corrosion protection when installed on deck, through cargo holds, in pump rooms, keel ducts and similar wet or corrosive spaces. This also applies to cables carried in pipes in such spaces, and to cables that are carried in pipes through water or fuel oil tanks.

Guidance note:

Any additional armour provided, but not required by the rules, does not need a protective outer sheath as long as the protective armour is not used as a conductor for protective earthing.

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104 *Corrosion protection*

Sheath or braid or armour of lead, bronze or copper shall not be installed in contact with aluminium alloy structures, except in dry accommodation spaces.

105 *Flexible cables*

The use of flexible cables shall be limited to applications where flexibility is necessary, and the lengths of such flexible cables shall be kept as short as practicable. Special requirements may be made to the type, installation and protection of flexible cables, depending upon the application.

106 *High voltage cables*

Installation of high voltage cables in accommodation spaces is not permitted unless required by the application. The necessity for special protection shall be evaluated when high voltage cables are installed in accommodation spaces, for prevention of harmful effects to personnel from cable short circuits, and strong electromagnetic fields.

107 *Fibre optic cables*

Tensile stress applied to fibre optic cables for any reason during the installation period or during normal operation shall not exceed the maximum allowed value stated by the manufacturer.

C 200 Routing of cables

201 *General*

For more requirements regarding the routing of cables, see Sec.2 I400.

202 *Segregation of low and high voltage cables*

a) Low voltage power cables shall not be bunched together with, or run through the same pipes as, or be terminated in the same box as, cables for high voltage.

b) High voltage cables shall be separated from low voltage cables and control cables by at least 300 mm unless mechanically separated by earthed metal partitions or pipes.

203 *Segregation of power cables and cables for control circuits*

a) Unscreened cables for sensitive control or signal circuits (below 50 V) shall not be run in the same bunch or pipe as cables for power circuits, (above 50 V). This is in order to avoid interference from the power circuit.

b) For segregation of cables in installations for hazardous areas, see Sec.11 D200.

Guidance note:

Crossovers or installation of power cables and control cables beside each other are generally not considered a problem if signal cable is screened.

A distance of 50 mm between power and unbraided or unscreened control cables on a cable tray is considered acceptable.

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204 *Special precautions for single core cables*

When the use of single core cables is necessary for circuits having a normal current of 20 A and above the following apply:

a) The cables shall be non- armoured or braided or the armour or braiding material shall be of a non-magnetic type.

b) The non-magnetic armour or braiding shall be earthed at one end, only.

c) Conductors belonging to the same circuit shall be contained within the same pipe, conduit or trunking, clamps that fix them shall include all phases.

d) The phases shall be laid as close as possible and preferably in a triangular formation.

e) Magnetic material shall not be used between single core cables for one consumer. All phases belonging to the same circuit shall be run together in a common gland or bulkhead penetration (MCT), unless the penetration system is of non-magnetic material. Unless installed in a triangular formation, the distance between the cables and magnetic material shall be 75 mm.

f) Circuits with several single core cables for each phase (forming groups) shall follow the same route and have the same cross sectional area.

g) The cables belonging to the same phase shall as far as practicable alternate with those of the other phases, so that an unequal division of current is avoided.

205 *Accessible cable runs*

a) Cable runs shall be accessible, except for cables carried in pipes.

b) Cable runs shall be accessible for later inspection. Free distance above trays, and cables laid on trays, shall be a minimum of 100 mm. Distance between cable trays, or towards adjacent structures shall be a minimum of 50 mm.

c) When cable runs are carried behind wall lining in accommodation spaces (except when carried in pipes), the panels shall be hinged or fixed for example by screws, so that they can be removed for inspection without damaging the cable or the bulkhead.

d) Exceptions can be made for cables to light fittings, switches, socket outlets etc. in dry accommodation spaces, when the deckhead and bulkhead constructions are made of incombustible materials.

C 300 Penetrations of bulkhead and decks

301 *General*

a) Penetrations of watertight bulkheads and decks shall be carried out either with a separate gland for each cable, or with boxes or pipes filled with a suitable flame retardant packing or moulded material, in order to ensure the integrity of the watertightness of the bulkhead or deck. The installation shall be in accordance with the manufacturers' installation instructions.

b) Penetrations of a recognised make shall be used where fire resisting separation is needed.

Guidance note:

Penetrations of watertight bulkheads should be placed as high as practicable.

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302 *Thermal insulation*

Cable runs shall not be laid in or covered with thermal insulation (e.g. through refrigerated cargo holds), but may cross through such insulation.

303 *Hot oil pipes near to penetrations*

The distance from cable penetrations to flanges of steam or hot oil pipes shall not be less than 300 mm for steam or hot oil pipes with diameter $D \leq 75$ mm, and not less than 450 mm for larger pipes.

304 *Chafing*

Penetrations of bulkheads and decks shall be such that the cables are not chafed.

305 *Mechanical support of penetrations*

The cable shall have mechanical fixing on both sides of a bulkhead penetration.

C 400 Fire protection measures

401 *General*

The cable installation shall be protected against fire, fire spreading, thermal, mechanical, corrosive and strain damage.

402 *Flammable materials*

Cables shall not be installed in contact with flammable materials such as wooden bulkheads, when the conductor temperature exceeds 95°C at full load, at the actual ambient temperature.

403 *Precautions against fire spreading in cable bunches*

Cables that are installed in bunches shall have been tested in accordance with a recognised fire test for cables installed in bunches, such as the test specified in IEC 60332-3, or be provided with protection according to 404 and 405.

Guidance note:

A cable bunch is defined as five or more cables laid close together in trunks from machinery spaces and in spaces with a high risk of fire, and more than 10 cables in other areas.

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404 *Cable bunches not complying with IEC 60332-3 or other recognised standard fire spread test.*

a) Cable bunches, not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least class B-0 penetration properties at the following locations:

— cable entries at the main and emergency switchboards
— where cables enter engine control rooms
— cable entries at centralised control panels for propulsion machinery and essential auxiliaries
— at each end of totally enclosed cable trunks
— at every second deck or approximately every 6 m for vertical runs
— at every 14 m for horizontal runs, except that in the cargo area fire stops need only be fitted at the boundaries of the space.

Additional fire stops need not be fitted inside totally enclosed cable trunks.

b) Alternatively, for additional fire stops, fire protective coating may be applied to the cable bunch according to the following:

— to the entire length of vertical runs
— to at least 1 m in every 14 m for horizontal runs.

405 *Fire resistance of penetrations*

Where "A" or "B" class bulkheads or decks are penetrated for the passage of electrical cables, arrangements shall be made to ensure that the fire resistance of the bulkheads or decks, is not impaired.

C 500 Support and fixing of cables and cable runs

501 *General*

a) Cable ladders, trays and cable pipes shall not be used for carrying water, oil or steam pipes. Exemptions may be considered in each case.

b) For installations in connection with hazardous areas, requirements for selection of cables, cable routing and fixing, see Sec.11.

502 *Cable ladder or tray material and mechanical requirements*

a) Cable ladders and trays with their fixing devices shall be made of corrosion resistant steel or type tested non-metallic materials with equal properties.

b) When fixed to aluminium structures, aluminium alloy cable ladders and trays may be used. Other materials may be accepted upon special consideration.

c) Cables with IEC 60228 Class 5 conductors shall be installed on continuous cable trays (vented or non-vented) such as to prevent undue sag, and if horizontal, on the top of the tray giving support to the cable.

Guidance note:

The term "cable ladder" includes support brackets. The term "cable tray" means constructions being formed by continuous tray plates or structural steel.

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503 *Mechanical protection of cables and cable runs*

a) Cables shall be so installed that they are not likely to suffer mechanical damage. If necessary, they shall be protected by providing the cable runs with covers of plates, profiles or grids, or by carrying the cables in pipes.

b) Below the floor in engine and boiler rooms and similar spaces, cables that may be exposed to mechanical damage during maintenance work in the space, shall be protected in accordance with a).

c) On weather decks in cargo hold areas, and through cargo holds, all cables that may be exposed to mechanical damage, shall be protected by covers of steel plates, steel grids or profiles of at least 4 mm thickness, or by being carried in steel pipes.

Guidance note:

As an alternative the covers can be made of perforated steel plates or grids with mesh opening maximum 25 mm, having at least the same impact strength as a 4 mm steel plate. Exemptions can be accepted when the location of the cable run is such that in all probability cargo or cargo handling gear cannot come into contact with the cable run. When cable runs are fixed to aluminium structures, aluminium may be used instead of steel.

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504 *Cable bends*

a) The internal radius of low voltage cable bends, which are not subjected to movement by expansion, shall be in accordance with the manufacturers' recommendation, but normally, not less than given in Table C2.

b) The minimum internal bending radius for high voltage cables shall be in accordance with the manufacturers' recommendations.

Table C2 Cable bending radii

Cable construction		*Overall diameter of cable (D)*	*Minimum internal radius of bend*
Insulation	*Outer covering*		
Thermoplastic or thermosetting with circular copper conductors	Unarmoured or unbraided	≤ 25 mm	4 D
		> 25 mm	6 D
	Metal braid screened or armoured	Any	6 D
	Metal wire armoured Metal tape armoured or metal sheathed	Any	6 D
	Composite polyester or metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with sector shaped copper conductors	Any	Any	8 D

505 *Fixing of cables*

a) Cables shall be fixed by clips, saddles or bands, of corrosion resistant metal, except when carried in pipes.

b) The spacing between supports or fixing shall be suitably chosen according to the type of cable and the probability of vessel movement and vibration at the actual point of installation, as given in Table C3.

c) Cables shall be supported so close to an enclosure entry through a cable gland that it runs straight through the

gland, and the gland does not take up any mechanical forces from the cable.

d) When cables are installed on horizontal ladders or trays, the fixing distance may be 3 times larger than given in Table C3. However, when cable runs are subjected to water splashing on weather decks the maximum distance between fixings of cable and its support (cable trays or pipes) shall be 500 mm.

e) When cable runs are installed directly on aluminium structures, fixing devices of aluminium shall be used. For mineral insulated cables with copper sheath, fixing devices in metallic contact with the sheath shall be of copper alloy.

f) When cables tested in accordance with IEC 60092-332-3 are installed vertically, the fixing distance shall be in accordance with the test requirements. However, the fixing distance shall not be more than 407 ±10 mm.

Table C3 Spacing of fixing points for cables

External diameter of cables		*Non-armoured or unbraided cables (mm)*	*Armouredor braided cables (mm)*
Exceeding (mm)	*Not exceeding (mm)*		
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

506 *Fixing in accommodation*

In accommodation spaces, clips, saddles and bands of a non-metallic, flame retardant material may be used for horizontal runs.

507 *Fixing in engine room or other areas of heat and light radiation.*

a) For installations in engine room and similar areas, metallic cable clips or bands shall be used.

b) Flame retardant polymer material may be used for cable fixing (clips) if the material is resistant to heat and light radiation, affecting the material during the lifetime of the vessel.

c) When cables are fixed on a tray by means of clips or straps of non metallic material, and these cables are not laid on top of horizontal cable trays or supports, metal cable clips or saddles shall be added at regular distances (e.g. 1 to 2 m) in order to retain the cable during a fire.

508 *Fixing of single core cables*

In order to guard against the effects of electrodynamic forces developing on the occurrence of a short circuit or earth fault, single core cables shall be firmly fixed, using supports of strength adequate to withstand the dynamic forces corresponding to the prospective fault current at that point of the installation. The fixing clamps of the cables should not damage the cable when the forces affect the cables during a 1 s short circuit period.

Guidance note:

Manufacturer's instructions for installation with respect to prospective fault current shall be followed.

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C 600 Cable expansion

601 *Expansion of cable runs*

Cable runs and bulkhead penetrations shall be installed so that they do not take up hull forces caused by the vessel's movements, different load conditions and temperature variations.

602 *Cables across expansion joints*

a) The installation of electric cables across expansion joints in any structure shall be avoided. Where this is not practicable, a loop of electric cable of length sufficient to accommodate the expansion of the joint shall be provided. The internal radius of the loop shall be at least 12 times the external diameter of the cable.

b) All cables shall be fastened on each side of an expansion loop, such that all relative movement between structure and cable is taken up at this point, and not in the rest of the cable run.

603 *Cable trays along main decks*

a) Cable trays or pipes run in the length of the vessel shall be divided into a number of sections each rigidly fixed to the deck at one point only and sliding supports for the rest of the section.

b) The expansion and compression possibility shall ensure that the cables do not become fully stretched during operation. The expansion and compression possibility shall be at least ±10 mm for every 10 m section length from the fixing point.

c) The cables shall be fixed to the tray as required by 500, and at each expansion and compression point, the cable shall have adequate room for bending and stretching.

d) When pulled in pipes, the cable shall be fixed to the pipe at both ends of each section. Each pipe section shall be installed without the possibility for expansion within the section.

Guidance note:

When pipes are joined by the use of expansion joints, the pipe ends will not satisfy the above requirements.

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C 700 Cable pipes

701 *Cable pipes*

a) Cables that are carried in the same pipe shall be of such construction that they cannot cause damage to each other.

b) The pipes shall be suitably smooth on the interior and protected against corrosion. The ends shall be shaped or bushed in such a way that the cable covering is not damaged.

c) Cables that are carried in pipes with length exceeding 10 m horizontally shall be bronze or steel wire braided or steel armoured to avoid damage when pulling in.

d) When cable pipes are installed vertically due attention shall be paid to the cable's mechanical self carrying capacity. For longer pipes, suitable installation methods shall be used.

e) Cable pipes shall not include expansion elements required by 600.

702 *Cable pipe material*

a) Cable pipes shall be made of steel or type tested non-metallic materials.

b) The cable pipe material shall not have less resistance against fire than required from the cable itself.

c) Aluminium cable pipes may be used if fixed to aluminium structures.

703 *Wall thickness of cable pipes*

a) The following minimum wall thickness, d, applies:
For D ≥ 160 mm: d = 4 mm

For D < 160 mm: $d = 1.5 + 1.56 \frac{D}{100}$

Where D is nominal internal diameter of pipe, and d is wall thickness.

b) For use on deck and in water and fuel oil tanks, the minimum wall thickness in Table C4 applies.

Table C4 Pipe wall thickness

Internal diameter of pipe [1] *(mm)*	*Minimum wall thickness (mm)*
D ≤ 57.0	3.5
57.0 < D ≤ 152.4	4.2
152.4 < D	5.0

1) For closed ducts of non-circular shape, the corresponding cross section applies as criterion.

704 *Corrosion protection of cable pipes*

Steel cable pipes on deck, through cargo holds, in keel ducts, pump rooms and similar wet spaces, and in water and fuel oil tanks shall be internally and externally galvanised, or shall have an equivalent effective corrosion protection.

705 *Condensation in cable pipes*

Cable pipes with connection and draw boxes shall be arranged so that condensed water is drained out of the system.

706 *Bending radius of pipes*

The bending radius of cable pipes shall be sufficiently large so that "drawing-in" of the cables does not cause damage to the cables, and in no case less than:

— the minimum bending radius of the cables according to 504
— twice the internal diameter of the pipe.

707 *Filling of cable pipes*

The sum of the cables' total cross section, based on the cables' external diameter, is not to exceed 40% of the pipe's internal cross section. This does not apply to a single cable in a pipe.

708 *Connection and draw boxes*

a) Connection and draw boxes shall have at least the same wall thickness as required for the pipes, and shall be of steel, with exemption for aluminium alloy pipes, where galvanised cast iron or aluminium alloy shall be used.

b) All connection and draw boxes shall be accessible (for boxes behind panels in accommodation spaces, see Table B1, footnote 8).

C 800 Splicing of cables

801 *Splicing*

a) Splicing of cables by using a kit or system from a recognised manufacturer is accepted.

b) The two cables spliced shall have the same basic construction.

Guidance note:

Splicing is meant as the direct continuation of cable lengths and not transfer into a distribution box.

The splicing kit should contain the following as minimum:

— connectors for conductors, of correct size
— replacement insulation
— replacement inner sheet or common covering
— connector for braiding or armour
— replacement outer sheath with minimum fire properties as the original sheath
— splicing instructions.

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802 *Splicing in junction boxes*

a) Junction boxes may be used for splicing of cables when the following is complied with:

— the boxes shall be located in accessible places
— cables for main and emergency circuits shall not be spliced in the same box
— cables for different systems and/or voltages shall be clearly marked and separated.

b) Junction boxes used for splicing shall be marked with voltage level(s) and box identification.

c) All conductors shall be connected in permanently fixed terminals.

C 900 Termination of cables

901 *Marking of cables*

All terminals for connection of external instrumentation and control cables, as well as the conductor ends of these cables shall be clearly marked for identification, preferably in accordance with the designation used in the wiring diagram.

902 *High voltage cables*

High voltage cable shall have ending or termination kits approved or recommended from the cable manufacturer.

The termination kit shall be appropriate for the voltage level in question.

903 *Cable entrance*

Cable entrances in equipment shall at least have the same IP rating as the equipment itself in order to maintain the integrity of the enclosure.

Guidance note:

See Sec.11 for requirements for cable glands, with respect to equipment in hazardous areas.

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904 *Earthing of cable metal covering*

a) All metal coverings (braiding or armour) of power cables shall be electrically connected to the metal hull (earth) of the vessel at both ends of the cable. Single point earthing is permitted for final sub circuits and in those installations (such as for control or instrumentation) where it is required for technical reasons.

b) The electrical continuity of all metal coverings shall be ensured throughout the length of the cables, at joints, tappings and branching of circuits.

c) When metal coverings (braiding or armour) are earthed at one end only, the floating end shall be properly insulated.

d) The braiding or armour shall be connected directly from the cable to a dedicated earth terminal or bar, except for short circuit proof installation where the braiding shall be insulated with a crimp-on sleeve.

e) Single core cables for A.C. and special D.C. cables with a high ripple content (e.g. for thyristor equipment) shall be earthed at one end only.

f) The metal covering or braiding or armour of cables may be earthed by means of glands intended for that purpose. The glands shall be firmly attached to, and in effective metal contact with the earthed enclosure, of equipment.

g) Special clamp-on connections for making the connection from metal covering or armour or braiding, to the earth terminal might be accepted if being of a recognised type intended for the purpose. Earth connection of metal covering shall not be made by ordinary soldering or other untested solutions.

h) Screens around individual pairs for earthing for EMC purposes in cables for control, electronic, communication and instrumentation equipment, shall normally be earthed at one end only. Cables having both individual screen and common screen (or braiding) shall have these metal coverings separated from each other at the "floating" end, when earthed at one end only.

i) The connection of the earth conductor, to the parts that shall be earthed, and to the hull, shall be made by corrosion resistant screws or clamps, with a cross section corresponding to the earth conductor. Such earthing screws and clamps shall not be used for other purposes. Suitable washers and conductor terminals shall be used, so that a reliable contact is ensured.

Guidance note:

The requirement for earthing of the cable metal sheath, armour and braid, in 904 is not made with respect to earthing of equipment or consumers, but for the earthing of the cable itself.

Armour or braiding might be accepted as a PE- conductor for the equipment itself if cross section is sufficient and the cable type is constructed for that purpose.

For cables without an insulating sheath over the metal sheath or armour or braiding, the earthing of the cable itself may be carried out by fixing the cable to the hull constructions, or to parts that are welded or riveted to the hull constructions, by corrosion resistant clamps or metal clips.

For earthing of instrument and control circuits for guarding against disturbances (EMC) see also DNV-OS-D202.

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905 *Conductor ends (termination)*

a) All conductor ends shall be provided with suitable pressured sockets or ferrules, or cable lugs if appropriate, unless the construction of the terminal arrangement is such that all strands are being kept together and are securely fixed without risk of the strands spreading when entering the terminals.

b) IEC 60228 Class 5 conductors shall be fitted with pressured ferrules as required by a).

c) Termination of high voltage conductors shall be made by using pressure based cable lugs unless the actual equipment has connection facilities for direct connection of the stripped conductor tip.

d) Spare cable conductors shall either be terminated or insulated. For Ex installations, see Sec.11.

C 1000 Trace or surface heating installation requirements

1001 *General*

a) Heating cables, tapes, pads, etc. shall not be installed in contact with woodwork or other combustible material. If installed close to such materials, a separation by means of a non-flammable material may be required.

b) Heat tracing shall be installed following the system documentation from the manufacturer.

c) Serial resistance trace heating cables shall not be spliced.

d) Trace heating cables shall be strapped to equipment and pipes using a heat resistant method that does not damage the cable.

e) Space between fixing points should be a maximum of 300 mm.

f) Where practicable and where exposed to weather, the cables shall pass through the thermal insulation from below, via a gland to avoid mechanical damage to the trace cable.

g) The trace cable system with feeder connection boxes, thermostats, etc shall be mounted to avoid or be protected against mechanical damage.

h) Flexible conduits should be used as mechanical protection for the feeder cable to the trace start junction box installed on the pipe.

i) Trace heating cables shall be installed in such a way as to allow dismantling of joints and valves, instruments etc. without cutting or damaging the cable. Trace heating cables shall be installed along the lower semi-circle of the pipes.

j) The outside of traced pipes thermal insulation or protective cladding shall be clearly marked at appropriate intervals to indicate the presence of electric tracing of surface heating equipment.

k) Trace circuits shall be readable marked (or identified) at both the switchboard and the field end, for fault finding purposes.

l) Circuits, which supply trace and surface heating, shall be provided with an earth fault circuit breaker. Normally the trip current shall be 30 mA. Higher trip currents (maximum 300 mA) for the circuit breaker will be accepted if 30 mA is impossible, due to capacitive current leakage in the trace cable circuit.

D. Inspection and Testing

D 100 General

101 *General*

Before an installation is put into service or considered ready for operation, it shall be inspected and tested. The aim for this testing is to verify that the physical installation is correct. The installation shall be verified in accordance with relevant documentation. There shall be no hazard to personnel, no inherent fire hazard, and the installation shall function as required for the safe operation of the vessel.

D 200 Equipment installation

201 *Location and ingress protection*

It shall be verified that all equipment is suitably installed with respect to ventilation, ingress protection and accessibility. (Ingress Protection according to Table B1)

202 *Escape routes*

Switchboards more than 7 m long shall not form dead end corridors. Two escape routes shall be available as required by Sec.2 I103 e.

D 300 Wiring and earthing

301 *General*

All equipment shall be verified with respect to proper installation with respect to external wiring and protective earthing.

302 *High voltage testing of cables*

After installation, with termination kit applied, high voltage cables shall be subject to one of the following alternative high voltage tests, with the voltage applied between the conductors and the screen:

i) A power frequency test voltage (A.C.) applied for 5 minutes. With the designed rated power frequency voltage between the phase and earth or screen given as U_0, the test voltage (A.C.) shall be:

— $0.7*(2.5 * U_0 + 2)$ kV for cables with U_0 not exceeding 3.6 kV

— 0.7*2.5 * U_0 kV for cables with U_0 in excess of 3.6 kV.

ii) A power frequency test at the normal operating voltage of the system, applied for 24 hours.

iii) A D.C. voltage of 1.7 times the value for the 5 minute power frequency test voltage, applied for 15 minutes.

Guidance note:

The 5 minutes power frequency test is seldom used at the installation site due to the high reactive power needed for this method.

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303 *Insulation resistance testing of circuits and equipment*

All outgoing power circuits from switchboards (cables and consumers) connected during installation shall undergo insulation resistance testing to verify its insulation level towards earth and between phases where applicable (i.e. switchboards assembled at site.)

The insulation resistance tests (megger tests) shall be carried out by means of a suitable instrument applying a D.C. voltage according to Table D1.

Table D1 Insulation resistance test voltage

U_n (A.C.) equipment	*D.C. megger voltage*
Up to 100 V	250 V
100 to 250 V	500 V
380 to 690 V	1000 V
1 to 3 kV	2.5 kV
3 to 15 kV	5 kV

Guidance note:

The insulation resistance value obtained might vary due to climatic conditions, length of cable circuits, power of megger, etc. Therefore an exact value limit is sometimes difficult to state and reasonable values obtained below the following limits might be accepted. The average ohm-value obtained from insulation resistance measurement shall in general be 1 MOhm between phases and earth for circuits operating at a voltage above 50 and up to 400 V (minimum 0.3 MOhm below 50 V).

For circuits with nominal voltage above 400 V the minimum resistance should be:

$$\left(\frac{\text{Nominal Voltage}}{1000}\right) + 1 \text{ MOhm}$$

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D 400 Distribution system properties

401 *Testing of consumers (cable end equipment)*

a) Function and load testing for essential and important equipment.

b) Consumers for essential and important functions shall be tested under normal operating conditions to ensure that they are suitable and satisfactory for their purposes.

c) Setting of protective functions shall be verified.

d) Consumers having their protective function (overload, short circuit and eventual earth fault protection) wired up during installation, shall be tested for correct function. See also guidance note to 403.

402 *Testing of electric distribution systems*

a) Upon completion, the electric distribution system shall be subject to final tests at a sea trial.

b) The final test at sea assumes that satisfactory tests of main components and associated subsystems have been carried out.

c) The test program is to include tests of the distribution in normal conditions, and in any abnormal condition in which the system is intended to operate.

d) Start-up and stop sequences shall be tested, together with different operating modes. Also when controlled by automatic control systems when relevant.

e) Interlocks, alarms and indicators shall be tested.

f) All control modes shall be tested from all control locations.

403 *Testing of generators and main switchboards*

All generating sets together with their switchboard equipment (switchgear or protection and cabling) shall be run at the rated load for one hour, and tested to verify that the following are within satisfactory limits:

— electrical characteristics in general, including temperature rise of insulation and control of the generator itself
— engine room ventilation
— voltage regulation (normal and transient conditions)
— speed governing (normal and transient conditions)
— overspeed trips
— testing of overload protection
— other protection like: earth fault, differential, under or overvoltage, frequency (if applicable)
— synchronising systems (if any)
— load sharing
— reverse power protection.

The voltage and speed regulation under normal and transient conditions shall be within the limits given in Sec.2 A, Sec.2 E, Sec.5 B and the Rules for Classification of Ships Pt.4 Ch.3.

Guidance note:

Testing of overload and short circuit protection: Secondary current injection is accepted as a method for verification of correct operation. For moulded case circuit breakers, smaller MCBs with integrated protection units, or ACBs with integrated protection units (not wired up at site) tested at manufacturers, a verification of protection settings is sufficient.

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404 *Testing of voltage drop*

Tests may be required to verify that the allowable voltage drop is not exceeded.

405 *Testing of current distribution*

Current distribution in parallel connected cables shall be verified.

406 *Testing of battery supplies*

a) UPS systems and regular D.C. battery backed up power supply (transitional, emergency or clean power) systems serving essential or important functions shall be function tested for dip free voltage when feeding power is being switched off (black out simulation).

b) The battery backed up power supply system shall be run on expected load (in battery feeding mode) for a period determined by the requirements for the actual system and by the relevant rules This test is required in order to show the correct capacity of the systems.

c) Alarms shall be verified for correct function.

SECTION 11
HAZARDOUS AREAS INSTALLATIONS

A. General

A 100 General

101 *Reference to international standards, regulations and definitions*

a) The requirements in this section are based upon the following standards: IEC 60079 part 0 to, and including part 19 regarding equipment construction. IEC 61892 part 7 "Mobile and fixed offshore units; Hazardous areas", IEC 60092-502 "Special features-tankers", and IMO MODU Code, for equipment selection and installation requirements.

b) For definitions related to installations in hazardous areas, see Sec.13 A600.

B. Documentation

B 100 General

101 *General*

Electrical installations in hazardous areas shall be documented to comply with these rules.

102 *Compilation of documented data*

For electrical installations in hazardous areas, the information in Table B1 shall be compiled in a list or schedule of Ex-equipment (see Sec.1 with respect to any formalities for a classed vessel).

Table B1 Schedule of information on installations in hazardous areas

Information element	*Description*
Identification	Tag number or other reference used for marking of the specific equipment. This shall be the same in the documentation as on the physical installation
Equipment type	Descriptive title of equipment, e.g. "cable gland", "fire detector"
Location of equipment	The relevant location of the equipment, according to the hazardous area classification drawing
Manufacturer	Name and nationality of manufacturer
Type designation	Manufacturers' type designation
Certification body, certificate number and type of protection	Identification of certifying body, the Ex certificate number and type of Ex protection
Special conditions	If the certificate number ends with "X" or "U", compliance with the special conditions given in the certificate shall be stated
Is-circuit limits and values	For intrinsic safe circuits the maximum parameters and values contained in the circuit with respect to voltage versus capacitance (Ceq) and current versus inductance (Leq) shall be listed for each circuit. The maximum values for the applied safety barrier shall be included
T_E -time	For motors and transformers located in a zone 1, certified as "increased safe", Ex-e, the T_E -time shall be listed together with the release time of the associated over current protection
IP-rating	Ingress protection rating of the equipment

Guidance note:

The IP rating shall be listed so that correspondence with IP rating required according to the requirements in Sec.10 is demonstrated.

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C. Equipment Selection

C 100 General

101 *General*

For the selection of electrical equipment that shall be installed in hazardous areas the following requirements apply:

a) The Ex protection type shall be in accordance with any requirements for the area or zone in question, or as found in any applicable additional class notation.

b) Unless described in additional class notations, the hazardous area shall be categorised into hazardous zones in accordance with a relevant IEC standard, and the equipment shall be acceptable in accordance with 200 for installation in the hazardous zone category.

c) For installations covered by the rules for tankers for oil, chemical carriers or liquefied gas carriers, the requirements in the Rules for Classification of Ships, Pt.5 Ch.3, Pt.5 Ch.4 or Pt.5 Ch.5 apply, with respect to what equipment that may be installed in different areas and spaces.

d) Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes and when permitted by the relevant rules.

C 200 Ex protection according to zones

201 *Zone 0*

a) Electrical equipment installed into zone 0 shall normally be certified safe for intrinsic safety Ex-ia.

b) For zone 0 systems, the associated apparatus (e.g. power supply) and safety barriers shall be certified for Ex-ia application.

202 *Zone 1*

a) Electrical equipment installed into zone 1 shall be certified safe with respect to one of the following protection methods:

- Ex-i (intrinsic safe) category a or b
- Ex-d (flameproof)
- Ex-e (increased safety)
- Ex-p (pressurised)
- Ex-m (moulded)
- Ex-s (special protection).

b) For Ex-i circuits, the associated apparatus, for example power supply and safety barriers shall be certified safe as well.

c) Normally, Ex-o (oil filled) and Ex-q (sand filled) are not accepted. However, small sand filled components as i.e. capacitors for Ex-e light fixtures are accepted.

d) Requirements for cables are found in D200.

203 *Zone 2*

Equipment for zone 2 installation shall be in accordance with one of the following four alternatives:

a) Certified safe for zone 1 application.

b) Certified safe for zone 2 application.

c) Have a manufacturer conformity declaration stating that it is made in accordance with an Ex-n standard.

d) Documented by the manufacturer to be suitable for zone 2 installation. This documentation shall state compliance with a minimum enclosure protection of IP44, maximum temperature for internal or external surfaces according to the temperature class for the area and that the equipment contains no ignition sources during normal operation.

204 *Exceptional conditions or ESD*

Equipment which is arranged to operate during exceptional conditions, in which the explosion hazard extends outside the defined hazardous zones, is to be suitable for installation in Zone 2. Arrangements are to be provided to facilitate the selective disconnection of other equipment in those areas not suitable for installation in Zone 2.

205 *Battery rooms, paint stores, and gas bottle stores*

a) Electrical equipment installed in battery rooms, paint stores or gas bottle stores, and in ventilation ducts serving such spaces shall be suitable for installation in zone 1 with the following requirements for gas group and ignition temperature:

   — battery rooms: minimum gas group II C and temperature class T1
   — paint stores: minimum gas group II B and temperature class T3
   — gas bottle stores: minimum gas group II C and temperature class T2.

b) Cables routed through such spaces shall either be suitable for installation in hazardous area zone 1, or be installed in metallic conduit.

c) Switches, protective devices, motor controlgear of electrical equipment installed in a such spaces are to interrupt all poles or phases and are to be located in non-hazardous spaces.

d) Areas on open deck within 1m of inlet and exhaust ventilation openings or within 3 m of exhaust outlets with mechanical ventilation are classified as zone 2.

e) Enclosed spaces giving access to the such areas may be considered as non-hazardous, provided that:

   — the door to the space is a gastight door with self-closing devices and without holding back arrangements (a watertight door is considered gastight)
   — the space is provided with an acceptable, independent, natural ventilation system ventilated from a safe area
   — warning notices are fitted adjacent to the entrance to the space stating that the store contains flammable liquids or gas.

C 300 Additional requirements for equipment and circuit design

301 *Ex-e motors (increased safety)*

Motors certified Ex-e shall, when installed in zone 1, have an overload or thermal protection that disconnects the motor before the TE-time is exceeded in a situation with locked rotor or some kind of machine stalling condition.

302 *Frequency converter driven Ex-e and Ex-d motors*

a) Ex-e motors driven by a power converter are not accepted installed in zone 1 unless the converter and the motor are certified together. The certificate shall state allowed motor-converter combinations.

b) The requirement in a) applies also for Ex-d motors unless the motors are equipped with embedded RTDs in the windings and an over temperature trip device.

c) For Ex-n motors driven by converters, a conformity declaration as described in 203 is required. This declaration shall include information on accepted type of converter.

303 *Ex-p equipment*

a) For zone 1 installation, Ex-p protected equipment shall normally be certified safe as a complete system by an independent test institution (complete system being the equipment, the enclosure, the purging and the control system).

b) For zone 2 installation, Ex-p protected equipment may either be certified safe as for zone 1, or be verified safe by a competent person before taken into service. Such verification shall be documented in a verification report.

c) In zone 1 applications, automatic shutdown and or isolation of equipment inside enclosures will be required upon loss of pressurisation. If automatic shutdown increases the hazard to the vessel, then other protection methods shall be utilised for equipment that has to remain connected. In zone 2 applications, a suitable alarm at a manned control station for indication of loss of overpressure is accepted, instead of the automatic shutdown.

304 *Ex-i circuits*

a) All intrinsic safe circuits shall have a safety barrier in form of a zener barrier or galvanic isolation certified safe for the application in front of the circuit part going into hazardous areas.

b) The complete intrinsic safe circuit shall not contain more than the maximum allowed, inductance, (Leq) and or capacitance (Ceq) than the barrier is certified for. The Leq and Ceq, shall be the total of the cable out to the hazardous area plus the values of connected equipment.

D. Installation Requirements

D 100 General

101 *General*

For general installation requirements, see Sec.10. The following clauses are requirements especially for hazardous area installations.

102 *Ingress protection*

a) Ingress protection of equipment in relation to its location shall in general be as described in Sec.10.

b) Minimum degree of enclosure protection for Ex-e equipment is IP 54.

c) Minimum IP degree of enclosures for Ex-n protected equipment is IP 44.

Guidance note:

A comparison between the IEC based IP-rating and the NEMA types used in the USA is given in Table D1.

Table D1 Corresponding values for NEMA-Type and IP-rating			
NEMA-Type	*Description of NEMA-Type*	*IP-rating*	*Description of IP-rating*
1	General purpose, indoor	11	Protection from solid objects larger than 55 mm
2	Suitable where severe condensation present	32	Protection against dripping water, spillage (not rain)
3	Weathertight against rain and sleet	54-55	Dustproof and resistant to splashing water (5) and rain (4) (normal outdoor weatherproof)
3R	Less severe than NEMA 3	14	Protected from water only (rarely used in the IEC system)
4	Watertight. Resistant to direct water jet spray	56	Dustproof and heavy water jets (like on an open deck)
4X	Same as NEMA 4 although corrosion resistant, stainless or non-metallic	no equivalent	
5	Dusttight	52	Dustproof and resistant to dripping water (not rain)
6	Limited submersion in water	67	Protected against effect of immersion maximum 1 m (depth)
7	Explosion-proof. (Contains gaseous internal ignition)	no direct equivalent	Flameproof (Ex-d) works by the same principal
12	Dusttight and dripproof	52	Dustproof and resistant to dripping water (not rain)
13	Oiltight and dusttight. (Constructed with special gasketing to resist oil and liquid chemical penetration)	54-55	Dustproof and resistant to splashing water and rain. (normal outdoor weather proof)

103 *Ex-d equipment*

a) Ex-d enclosures and its flameproof joints shall not be installed nearer to a bulkhead or solid object than 10 mm for gas group II A, 30 mm for II B, and 40 mm for II C.

b) Flameproof joints shall be protected against corrosion with suitable non-hardening grease.

c) Gaskets can only be applied if originally fitted in the equipment from the manufacturer, and the equipment has been certified or tested with gaskets.

d) One layer of soft tape around the flameproof joint opening for corrosion protection is allowed for Ex-d enclosures installed in areas with gas groups II A and II B, but not II C areas.

e) Tape into (on the threads of) flameproof joints of threaded type, is not allowed.

f) Flameproof joints might be covered with a thin layer of paint on the outside. However, this is not accepted in II C areas.

D 200 Wiring and termination

201 *Wiring*

a) All cables installed in hazardous areas shall have an outer overall sheath of a insulating non-metallic material.

b) Power and signal (non-intrinsic safe) cables in zone 0 and zone 1 shall have a metallic braiding or armour between conductors and the outer insulating sheet. The metallic covering shall serve as mechanical protection and be earthed for PE-protection purposes according to the installation requirements in Sec.10. See 206 for screening of intrinsic safe wiring.

c) In zone 0 only wiring for Ex-ia circuits are allowed.

d) In zone 1 trough runs of cables other than the ones intended for Ex-equipment, shall be limited.

e) In zone 2, trough runs of cables are accepted

202 *Flexible cables*

a) Flexible cables for non-intrinsically safe circuits shall be limited in hazardous areas and shall not be used permanently in zone 1.

b) Fixed installation of shorter flexible lengths with a good support from connection boxes to equipment will be accepted into zone 2.

203 *Penetrations of bulkheads and decks*

Cable penetrations through bulkheads and decks shall be gas tight, and of a recognised make, if used as sealing between zones or between hazardous areas and non-hazardous areas.

204 *Cable entrance into equipment*

a) In the case of direct entry into an Ex-d enclosure a certified safe gland shall be applied according to the following instructions:

— Zone 1: Either barrier or compound filled type of gland shall be used, or a rubber compression type gland might be used provided it is not a II C area, and the Ex-d internal volume is below 2 dm^3.
— Zone 2: Both barrier or compound filled type and compression type gland is accepted.

b) For Ex-e, Ex-n and general non-sparking equipment the cable gland shall maintain the required IP-rating for the enclosure in question.

c) Unused openings for cable glands shall be blanked off by suitable plugs according to the equipment's Ex-protection method. For Ex-e and Ex-n type of protection, the sealing plug shall maintain the required IP-rating for the enclosure in question. For Ex-d equipment, with direct entry, the sealing plug shall be certified safe (Ex-d) for the relevant application.

205 *Termination and wiring inside Ex-e and Ex-d enclosures*

a) Only one conductor is allowed to be connected into an Ex-e terminal.

b) In certified empty Ex-e enclosures, only the maximum amount of wiring and equipment stated in the certificate shall be installed within the enclosure.

c) All components inside an Ex-e enclosure shall be certified safe with protection Ex-e, -d, -m or other approved method for zone 1 application.

d) Certified empty Ex-d (flameproof boxes) shall have a final certificate taking into account the equipment installed within the Ex-d enclosure during installation.

206 *Intrinsically safe circuit wiring and termination*

a) Cables for intrinsically safe circuits shall have a common metallic screen or braiding. Multicore cables for Ex-i circuits shall have individual screened pairs.

b) Terminals for intrinsically safe circuits and terminals for non-intrinsically safe circuits shall be separated by recognisable marking (light blue), and with a physical distance of 50 mm.

c) Cable screens for shielding against interference with IS-circuits, shall be earthed at the supply end only.

d) If cables have armour or braiding in addition to screening, then the armour or braiding shall be connected to the protective earth system at the power supply end only.

e) Category Ex-ia- circuits intended for zone 0, and category Ex-ib-circuits shall not be run in the same cable.

f) Ex-i circuits and non-intrinsically safe circuits shall not run in the same cable.

g) Inside cabinets, screened wiring of non-intrinsically safe circuits can be laid in the same channel or tray as screened intrinsically safe circuits. Unscreened conductors in intrinsically safe and non-intrinsically safe circuits do not need any separating distance provided that the parallel wiring length is below 1m, and that the intrinsically safe and non-intrinsically safe conductors are not laid in the same cable or wiring bundle or wiring channel. For lengths longer than 1 m, the conductors shall be run at least 50 mm apart, or with an earthed metallic partition between the conductors.

SECTION 12
ELECTRIC PROPULSION

A. General

A 100 General

101 *Application*

a) The technical requirements in this section are in addition to those in Sec.2 to Sec.11 and apply to propulsion systems, where the main propulsion is performed by some type of electric motor(s).

b) Prime movers for generators providing electric power for propulsion shall be considered as propulsion prime movers. Prime movers and associated instrumentation and monitoring shall comply with the rule requirements for propulsion prime movers. Associated speed governing and control shall be arranged as for auxiliary prime movers.

c) Prime movers that drive generators for the supply of power for vessel service only, are defined as auxiliary prime movers, even if they may be connected to the propulsion power system and thus contribute to propulsion power.

d) Local and remote control systems for electric propulsion machinery shall comply with main class rules.

e) For instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are additional to those given in DNV-OS-D202.

Guidance note:

Attention should be given to any relevant statutory requirements of national authority of the country in which the vessel shall be registered.

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A 200 System design

201 *System arrangement*

a) Electrical equipment in propulsion lines, which have been built with redundancy in technical design and physical arrangement, shall not have common mode failures endangering the manoeuvrability of the vessel, except for fire and flooding, which are accepted as common mode failures.

b) Vessels having two or more propulsion motors and converters, or two electric motors on one propeller shaft, shall be arranged so that any unit may be taken out of service and electrically disconnected without affecting the operation of the others.

c) Vessels having only one propulsion motor will be accepted as being built with redundancy in technical design and physical arrangement, with respect to single failures, as long as the motor is equipped with two independent sets of armature windings. These sets shall not be laid in the same slots in the iron core.

d) Vessels having only one propulsion motor of non-self exciting type having armature windings as required by c), but only one common field winding will be accepted without further redundancy when equipped with more than one external exciter.

202 *Ventilation*

The general requirements in Sec.2 will normally imply that loss of ventilation or cooling to spaces or equipment with forced air-cooling, shall not cause loss of propulsion. Sufficient power necessary for manoeuvring shall be available after any single failure. Where the propulsion system is arranged in different lines with the associated equipment for power distribution to these lines arranged in different rooms, failure of ventilation or cooling shall only render one propulsion line out of operation. However, redundancy requirements for main class and relevant additional class notations shall be adhered to.

A 300 System capacity

301 *Torque*

a) The torque available at the propeller shaft shall be adequate for the vessel to be manoeuvred, stopped, or reversed when the vessel is sailing at full speed.

b) Adequate torque margin shall be provided to guard against the motor pulling out of synchronism during rough weather conditions or manoeuvres.

c) Sufficient run-up torque margin shall be provided to ensure a reliable start under all ambient conditions.

d) Required locked rotor torque shall be considered in view of the operation of the vessel.

Guidance note:

For thrusters, a gear oil temperature of 0°C should be considered.

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302 *Torsional vibrations in propulsion unit*

The following torsional vibration calculations are to be submitted (when applicable) for all propulsion units (motor, torque transmission system and propeller) above 200 kW rated power:

a) Torsional vibration calculations for steady state conditions, see B100.

b) Torsional vibration calculations for transient conditions:

- Starting operations. This applies when requested by the Society in order to prove that starting procedures due to impacts loads caused by direct start-up or star-delta switchover of asynchronous motors is not detrimental to any power transmitting parts, see B401.
- Short circuit in electric motors. This applies to plants with motors where short circuits can occur. Transient vibration calculations due to short circuiting will be required if the ratio between torsional dynamic stiffness (kNm/rad) and rated torque (kNm) exceeds 10 (considering the excitation frequency of 50 Hz or 60 Hz), that is $K_{dyn}/T_o > 10$, in any parts of the shaft lines, see B402.

Any changes to components after the calculations are completed are not acceptable unless verified through new analysis or equivalent methods.

303 *Overload capacity*

The system is to have sufficient overload capacity to provide the necessary torque, power, and for A.C. systems reactive power, needed during starting, manoeuvring and crash stop conditions.

A 400 Electric supply system

401 *Electric supply system*

a) The electric distribution system shall comply with the requirements in Sec.2.

b) The required split of the main switchboard shall be by bus tie breaker(s) capable of breaking any fault current that might occur at the location where it is installed.

c) Frequency variations shall be kept within the limits given in Sec.2. During crash-stop manoeuvres, it will be accepted that voltage and frequency variations exceed normal limits, if other equipment operating on the same net is not unduly affected.

A 500 System protection

501 *Automatic voltage regulator failure*

Where a single failure in the generators' excitation systems may endanger the manoeuvrability of the vessel, provisions shall be made to monitor the proper operation of the excitation system. Upon detection of abnormal conditions, an alarm shall be given on the navigating bridge and in the engine control room and actions to bring the system into a safe operational mode shall be automatically executed.

Guidance note:

An accepted action will be to automatically open the bus tie breaker in the main switchboard so that different sections of the main bus bar work independently of reactive load sharing.

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502 *Overspeed and regeneration*

a) When necessary, overspeed protection of propulsion motors shall be arranged, preventing the speed during manoeuvring or fault conditions to exceed the limits for which the machine has been designed.

b) Regenerated power shall not cause any alarms in the propulsion system, neither in planned operating modes nor during emergency manoeuvres. Where necessary, braking resistors for absorbing or limiting such energy shall be provided.

503 *Motor excitation circuits*

a) Circuit protection in an excitation circuit shall not cause opening of the circuit, unless the armature circuits are disconnected simultaneously.

b) For a motor with one excitation winding and two armature windings, a failure in one of the armature circuits, shall not entail disconnection of the excitation circuit in operation.

A 600 Control systems

601 *General*

The following control functions are part of the electric propulsion system:

— propulsion control
— power plant control.

602 *Propulsion control*

a) The electric propulsion system shall be equipped with means for "emergency propulsion control". These means shall be understood as a method of controlling the equipment that constitutes the propulsion system. These means shall be independent of the normal propulsion remote control system.

b) Failure of the remote propulsion control system shall not cause appreciable change of the thrust level or direction and shall not prohibit local control.

c) The normal propulsion remote control system shall include means for limiting the thrust levels when there is not adequate available power. This may be an automatic pitch or speed reduction.

d) The thrust is not to increase substantially in case of loss of an actual value signal from a discrete transmitter or loss of a reference value in the system.

e) Means for emergency stop of propulsion motors shall be arranged at all control locations. The emergency stops shall be independent of the normal stop, and separate for each propulsion line.

Guidance note:

It is accepted that ahead and astern thrust output will be different due to the propeller characteristics.

It is accepted that an emergency stop system has common power supply for several propulsion motors, as long as each motor can be stopped by this system independently of the other motors, and as long as a single failure in this emergency stop system cannot cause loss of manoeuvrability.

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603 *Power plant control*

a) When electric propulsion is utilised, the electric power generation and distribution system shall be equipped with an automatic control system having at least the following functions:

— ensure adequate power for safe manoeuvring is available at all times
— ensure even load sharing between on-line generators
— execute load tripping and/or load reduction when the power plant is overloaded
— ensure that adequate power for safe manoeuvring is available also if one running generator is tripped. If necessary by tripping of non-essential consumers
— no changes in available power shall occur if the automatic control system fails, that is no start or stop of generators shall occur as an effect of a failure
— control the maximum propulsion motor output.

b) The control system shall initiate an alarm, to the operator, when adequate power is no longer available.

Guidance note:

The control system may have a selector for transit or manoeuvre mode, enabling operation with different levels of reserve power in these two modes of operation.

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604 *Monitoring and alarms*

a) Safety functions installed in equipment and systems for electric propulsion shall not result in automatic shut down unless the situation implies that the equipment is not capable of further functioning, even for a limited time. Automatic reduction of propulsion power is accepted.

b) Priming control shall not prevent blackout start, if arranged.

c) Shutdowns caused by a safety function shall, as far as possible, be arranged with a pre-warning alarm.

d) For installations with one propulsion motor having two separate armature windings, the converters shall be arranged for automatic restart if an excitation failure in the motor may cause shutdown of both propulsion converters.

e) Critical alarms for propulsion shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.

f) Monitoring with alarm shall be arranged for:

— high temperature of cooling medium of machines and semi-conductor converters having forced cooling
— high winding temperature of all propulsion generators and motors

— loss of flow of primary and secondary coolants of machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself. Auxiliary contacts from motor starters may be used for this purpose
— lubricating oil pressure for machines with forced oil lubrication
— leakage of water-air heat exchanger for cooling of machines and semi-conductor converters
— earth fault for main propulsion circuits
— earth fault for excitation circuits. (This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
— fuses for filter units, or for other components where fuse failure is not evident.

g) A request for manual load reduction shall be issued, visually and acoustically on the bridge, or an automatic load reduction shall be arranged in case of:

— low lubricating oil pressure to propulsion generators and motors
— high winding temperature in propulsion generators and motors
— failure of cooling in machines and converters.

Guidance note:

High-high, or extreme high, temperatures may, when higher than the high alarm limit, cause shut down of the affected equipment. For redundancy requirements, see 200. Critical alarms for propulsion machinery are alarms causing automatic shutdown or load reduction of parts of the propulsion power.

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605 *Instruments*

a) A temperature indicator for directly reading the temperature of the stator windings of generators and propulsion motors shall be located in the control room.

b) The following values shall be displayed in the control room or on the applicable converter:

— stator current in each motor
— field current in each motor (if applicable).

c) For each generator: A power factor meter or kVAr meter.

d) On the bridge and in the control room, instruments shall be provided for indication of consumed power and power available for propulsion.

e) At each propulsion control stand, indications, based on feedback signals, shall be provided for pitch or direction of rotation, speed, and azimuth, if applicable.

f) Indications as listed for control stands shall be arranged in the engine control room, even if no control means are provided.

Guidance note:

When the rated power of semi-conductors is a substantial part of the rated power of the generators, it should be ensured that measurements are displayed in true root mean square values. Temperature indicators may be omitted for winding temperatures that are displayed on the alarm system display.

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B. Torsional Vibrations

B 100 General

101 *Documentation*

The calculations are to contain:

— objectives
— description of the method
— plant or system layout
— conditions
— assumptions
— conclusion.

The source of all essential data is to be listed. For data that cannot be given as constant parameters (e.g. see 102), the assumed parameter dependency and/or tolerance range is to be specified.

The conclusion is to be based on a comparison between calculated dynamic response and the permissible values for all the sensitive parts in the plant.

102 *Parameter uncertainty*

In all vibration calculations the variation of essential data such as dynamic characteristics of flexible couplings, bearings, and foundations, are to be considered. In particular, rubber couplings that have wide tolerances for stiffness and damping are to be considered. Normally, it is not required to perform calculations with all combinations of these extreme data, but as a minimum the influence of such wide tolerances is to be qualitatively considered and addressed in the conclusions.

For couplings having stiffness with strong dependency on vibratory torque and/or mean torque and/or temperature (as a consequence of power loss) it may be required to carry out either iterative direct calculations or simulation calculation where these dependencies are included.

103 *Symbols and definitions*

Symbols and definitions are to be in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G101 and Pt.4 Ch.3 Sec.1 G102.

B 200 Vibration measurements

201 *Reference*

Rule requirements are to be in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G201 and Pt.4 Ch.3 Sec.1 G202.

B 300 Steady state - torsional vibration

301 *Extent of calculations*

Natural frequency calculations are to be carried out in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G301 item a).

In the case where there is a resonant condition in the running range, forced response calculations in conjunction with stress calculations are required to prove that failure of the shafting will not occur as a result of high cycle fatigue.

302 *Calculation method*

To be in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G302 items a), c), d), h) and j).

If excitations caused by the electric motor are included in the forced vibration calculation the excitation models shall be documented.

303 *Acceptance criteria*

To be in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G303 items d), e), f), g) and h).

B 400 Transient torsional vibration

401 *General*

Transient vibration caused by the electric motor are not to be detrimental to the power transmitting elements, such as couplings and gears.

Transient torsional vibration can be analysed by simulation using numeric integration in the time domain. The purpose of the calculation is to determine the peak torque and torque amplitudes that occur before the safety system (circuit breaker) becomes active.

The plant can be described as a lumped mass system, but essentially simplified as described in the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G302 item e).

402 *Starting operations*

Impact load analyses of direct start-up and star-delta switchover for asynchronous motors are to be analysed, upon request by the Society, see A302 item b).

403 *Short circuit in electric motors*

Impact load analyses of short circuit excitation torque is to be analysed for propulsion units according to A302 item b).

If the short circuit excitation torque (in the air gap between rotor and stator) is not specified, it can be assumed as:

$T = T_0 \cdot [10 \cdot e^{-t/0.4} \cdot \sin(\Omega t) - 5 \cdot e^{-t/0.4} \cdot \sin(2\Omega t)]$
$\Omega/2\pi$ = net frequency (50 or 60 Hz)
t = time (s).

The duration to be considered is 1 s.

404 *Acceptance criteria*

Transient torsional vibrations are to be in compliance with the Rules for Classification of Ships, Pt.4 Ch.3 Sec.1 G405.

C. Verification

C 100 Factory testing or manufacturer's testing

101 *Survey and test upon completion*

a) Upon completion, the electric propulsion system shall be subject to final tests at a sea trial.

b) The final test at sea assumes that satisfactory tests of all subsystems have been carried out.

c) The test program is to include tests of the propulsion plant in normal and abnormal conditions.

d) Start-up and stop sequences shall be tested, also as controlled by the power management system, when relevant.

e) Safety functions, alarms and indicators shall be tested.

f) All control modes shall be tested from all control locations.

g) Required level of redundancy shall be verified through tests.

SECTION 13
DEFINITIONS

A. Definitions

A 100 General

101 *Electrical installations*

The term electrical installations is an all-inclusive general expression that is not limited to the physical installations. For physical installations, the wording, "installation of…" is used.

102 *Normally*

The term "normally", or "normally not", when used in these rules, shall basically be understood as a clear requirement in line with "shall", or "shall not". However, upon request, other designs may be accepted.

If the rules are used for a vessel classed by DNV, then the Society shall be requested, in writing, to accept a deviating design. A request giving the reasons for the design shall be submitted.

A 200 Operational conditions

201 *Normal operational and habitable condition*

Normal operational and habitable condition: A condition under which the vessel, as a whole, is in working order and functioning normally. As a minimum, the following functions shall be operational: Propulsion machinery, steering gear, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, emergency boat winches, anchor winches. Additionally, designed comfortable conditions for habitability, including; cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water. All utility systems for the listed functions shall be included.

202 *Emergency condition*

An emergency condition is a condition under which any services needed for normal operational and habitable conditions are not in working order due to the failure of the main source of electrical power.

203 *Dead ship condition*

Dead ship condition is the condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power. Batteries and or pressure vessels for starting of the main and auxiliary engines are considered depleted. Emergency generation is considered available. For a more detailed definition of dead ship, see the Rules for Classification of Ships, Pt.4 Ch.1.

204 *Blackout condition*

Blackout is a sudden loss of electric power in the main distribution system. All means of starting by stored energy is available.

A 300 Services

301 *Essential services*

a) Essential (primary essential) services are those services that need to be in continuous operation for maintaining the vessel's manoeuvrability in regard to propulsion and steering. Additional class notations may extend the term essential services. Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment and or systems for essential services covered by main class:

- control, monitoring and safety devices or systems for equipment for essential services
- scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and freshwater cooling water pumps for main and auxiliary engines
- viscosity control equipment for heavy fuel oil
- ventilation necessary to maintain propulsion
- forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations, for steam plants on steam turbine vessels, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services
- steering gears
- azimuth thrusters which are the sole means for propulsion or steering - with lubricating oil pumps, cooling water pumps
- electrical equipment for electric propulsion plant - with lubricating oil pumps and cooling water pumps
- pumps or motors for controllable pitch propulsion or steering propellers, including azimuth control
- hydraulic pumps supplying the above equipment
- electric generators and associated power sources supplying the above equipment.

302 *Important services*

a) Important (secondary essential) services are those services that need not necessarily be in continuous operation for maintaining for the vessel's manoeuvrability, but which are necessary for maintaining the vessels functions as defined in the Rules for Classification of Ships, Pt.1 Ch.1 Sec.2, or other relevant parts of the rules. Important electrical consumers are electrical consumers serving important services. Additional class notations may extend the term important services. Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment or systems for important services covered by main class:

- anchoring system
- thrusters not part of steering or propulsion
- fuel oil transfer pumps and fuel oil treatment equipment
- lubrication oil transfer pumps and lubrication oil treatment equipment
- pre-heaters for heavy fuel oil
- seawater pumps
- starting air and control air compressors
- bilge, ballast and heeling pumps
- fire pumps and other fire extinguishing medium appliances
- ventilating fans for engine and boiler rooms
- ventilating fans for gas dangerous spaces and for gas safe spaces in the cargo area on tankers
- inert gas fans
- navigational lights, aids and signals
- internal safety communication equipment
- fire detection and alarm system
- main lighting system
- electrical equipment for watertight closing appliances
- electric generators and associated power sources supplying the above equipment
- hydraulic pumps supplying the above equipment
- control, monitoring and safety systems for cargo containment systems
- control, monitoring and safety devices or systems for equipment to important services.

303 *Emergency services*

a) Emergency services are those services that are essential for safety in an emergency condition.

b) Examples of equipment and systems for emergency services:

- equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the emergency source of electrical power
- equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the accumulator battery for the transitional source(s) of emergency electrical power
- equipment and systems for starting and control of emergency generating sets
- equipment and systems for starting and control of prime movers (e.g. diesel engines) for emergency fire fighting pumps
- equipment and systems that need to be in operation for the purpose of starting up manually, from a "dead ship" condition, the prime mover of the main source of electrical power (e.g. the emergency compressor)
- equipment and systems that need to be in operation for the purpose of fire fighting in the machinery spaces. This includes emergency fire fighting pumps with their prime mover and systems, when required according to the Rules for Classification of Ships, Pt.4 Ch.10 Sec.2 B
- equipment and systems that are needed for the purpose of exhausting or removing for example CO_2 fire extinguishing medium from the machinery spaces after a fire, in order to allow for access to the spaces.

c) Further requirements for emergency services are given in Sec.2.

304 *Non-important services*

Non-important services are those services not defined as essential or important; or those services that are not defined, according to 301, 302 and 303.

A 400 Installation

401 *Short circuit proof installation*

Short circuit proof installation means one of the following three methods:

- bare conductors mounted on isolating supports
- single core cables without metallic screen or armour or braid, or with the braid fully insulated by heat shrink sleeves in both ends
- insulated conductors (wires) from different phases kept separated from each other and from earth by supports of insulating materials, or by the use of outer extra sleeves.

A 500 Area definitions

501 *Open deck*

Open deck is a deck that is completely exposed to the weather from above or from at least one side.

A 600 Hazardous area

601 *Area definitions*

a) A hazardous area is an area (zones and spaces) containing a source of hazard and or in which explosive gas and air mixture exists, or may normally be expected to be present in quantities such as to require special precautions for the construction and use of electrical equipment and machinery. Hazardous areas are divided into zone 0, 1, and 2 in accordance with an area classification.

b) If electrical installations are based on an areas' classification, this classification shall be based on a relevant IEC standard.

602 *Certified safe equipment*

Certified safe equipment is equipment certified by an independent national test institution or competent body to be in accordance with a recognised standard for electrical apparatus in hazardous areas.

603 *Marking of certified safe equipment*

Certified safe equipment shall be marked in accordance with a recognised standard for electrical apparatus in hazardous areas. This includes at least:

- Ex-protection type and Ex certificate number
- temperature class, according to Table A2
- gas and equipment group, according to Table A1.

Table A1 Equipment and gas groups

Gas groups (IEC surface industry = II)	*Representative gas*	*NEC 500 (US surface industry = class 1)*
II A	Propane	Group D
II B	Ethylene	Group C
II C	Hydrogen	Group B
II C	Acetylene	Group A

Table A2 Temperature classes

Temperature classes (equipment maximum temperature) IEC and EN norms	*Ignition temperature of gas or vapour (°C)*	*Corresponding NEC (US) temperature classes*
T1	Above 450	T 1
T2	Above 300	T 2 *
T3	Above 200	T 3 *
T4	Above 135	T 4 *
T5	Above 100	T 5
T6	Above 85	T 6

* Intermediate values of temperature classes by letter marking ABCD exist.

Guidance note:

According to the "ATEX"-directive that will enter into force in Europe by 2002, all electrical equipment suitable for installation in a hazardous area shall be marked in accordance with the requirements given in this directive. The new marking shall be in addition to Ex-marking related to the various protection methods (enabling easy identification for in which zone it can be installed).

ATEX directive divides equipment into 3 safety categories, marked on equipment:

- Category 1 equipment is allowed, if certified safe, into zone 0.
- Category 2 equipment is allowed, if certified safe, into zone 1.
- Category 3 equipment is suitable for zone 2 only.

The letter G indicates the equipment suitability for gas atmospheres.

The letter D indicates the equipment suitability for dust atmospheres.

Marking of protection methods, gas grouping, temperature class, etc., corresponds to the IEC 60079 standard system (or equivalent to the CENELEC 50014-39 standard series) as given in 603.

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604 *T_E-time*

The T_E –time is the time it takes for the motor, starting from normal operating temperature, to reach the temperature given by the temperature class of the Ex certification if the rotor is locked. The T_E-time is stated in the Ex-certificate for the motor.

605 *Simple apparatus*

a) A simple (non-energy storing) apparatus is an electrical component of simple construction with no, or low energy consumption or storage capacity, and which is not capable of igniting an explosive atmosphere. Normal maximal electrical parameters are 1.5 V, 100 mA and 25 mW. The component shall not contain inductance or capacitance. Components such as thermocouples or passive switches are typical examples of simple, non-energy storing, apparatus.

b) Simple (non-energy storing) apparatus, when used in an intrinsically safe circuit, generally does not need to be certified safe, provided that such apparatus is constructed in accordance with IEC 60079-14, Part 14: "Electrical apparatus for explosive gas atmospheres".

A 700 Sources of power, generating station and distribution

701 *Main source of electrical power*

A main source of electrical power is a source intended to supply electrical power to the main switchboard(s) for distribution to all services necessary for maintaining the vessel in normal operational and habitable conditions.

Guidance note:

Main source of electrical power may be generators and/or batteries.

A generator prime mover and associated equipment is called "generators' primary source of power".

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702 *Emergency source of electrical power*

An emergency source of electrical power is a source intended to supply the emergency switchboard and/or equipment for emergency services in the event of failure of the supply from the main source of electrical power.

Guidance note:

Emergency source of electrical power may be generator(s) or battery(ies).

A generator prime mover and associated equipment is called "emergency generators' primary source of power".

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703 *Main electric power supply system*

a) A main electric power supply system consists of the main source of electric power and associated electrical distribution. This includes the main electrical generators, batteries, associated transforming equipment if any, the main switchboards (MSB), distribution boards (DB) and all cables from generators to the final consumer.

b) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

704 *Emergency electric power supply system*

a) An emergency electric power supply system consists of the emergency source of electric power and associated electrical distribution. This includes emergency generators, batteries, associated transforming equipment if any, the transitional source of emergency power, the emergency switchboards (ESB), emergency distribution boards (EDB) and all cables from the emergency generator to the final consumer.

b) A transitional source of power is considered to be part of the emergency electric power supply system.

c) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

705 *Main generating station*

A main generating station is a space in which the main source of electrical power is situated.

706 *System with high resistance earthed neutral*

A system with high resistance earthed neutral is a system where the neutral is earthed through a resistance with numerical value equal to, or somewhat less than, 1/3 of the capacitive reactance between one phase and earth.

707 *System with low resistance earthed neutral*

A system with low resistance earthed neutral is a system where the neutral is earthed through a resistance which limits the earth fault current to a value of minimum 20% and maximum 100% of the rated full load current of the largest generator.

708 *Conductor, core, wire, cable*

a) A conductor is a part of a construction or circuit designed for transmission of electric current.

b) A core is an assembly consisting of a conductor and its own insulation.

c) A wire is an assembly consisting of one core where the insulation is at least flame retardant.

d) In electrical terms, a cable is an assembly consisting of:

— one or more cores
— assembly protection
— individual covering(s) (if any)
— common braiding (if any)
— protective covering(s) (if any)
— inner and/or outer sheath.

Additional uninsulated conductors may be included in the cable.

e) A cable may be either Class 2 or Class 5 as defined in IEC 60228. In a Class 2 cable the conductor is made up by a minimum number of strands. In a Class 5 cable the conductor is made up by many small strands with a maximum size according to IEC 60288.

709 *Neutral conductor*

A neutral conductor is a conductor connected to the neutral point of a system, and capable of contributing to the transmission of electric energy.

A 800 Switchboard definitions

801 *Main switchboard (MSB)*

a) A main switchboard is a switchboard directly supplied by the main source of electrical power or power transformer and intended to distribute electrical energy to the vessel's services.

b) Switchboards not being directly supplied by the main source of power will be considered as main switchboards when this is found relevant from a system and operational point of view.

Guidance note:

Normally, all switchboards between the main source of electrical power and (inclusive) the first level of switchboards for power distribution, to small power consumers, will be considered to be

main switchboards (MSBs) (i.e. at least first level of switchboards for each voltage level used).

Cubicles for other system voltages attached to a main switchboard are considered part of the main switchboard.

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802 *Emergency switchboard (ESB)*

a) An emergency switchboard is a switchboard, which in the event of failure of the main electrical power supply system, is directly supplied by the emergency source of electrical power and/or the transitional source of emergency power and is intended to distribute electrical energy to the emergency power consumers.

b) Switchboards not being directly supplied by the emergency source of power may be considered as emergency switchboards when this is found relevant from a system and operational point of view.

Guidance note:

Normally all switchboards between the emergency source of electrical power and (inclusive) the first level of switchboards, for power distribution to small power consumers, will be considered to be emergency switchboards (ESBs) (i.e. at least one level of switchboards for each voltage level used).

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803 *Distribution board (DB) and emergency distribution board (EDB)*

A distribution board or an emergency distribution board is any switchboard utilised for distribution to electrical consumers, but which is not considered as a main or emergency switchboard.

A 900 Components and related expressions

901 *Definitions of words used in relation to electrical components and equipment*

a) For definitions of terms related to switchgear and controlgear, see IEC 60947-1 for low voltage, and IEC 60470 and IEC 60056 for high voltage equipment.

b) For assemblies, the following definitions are used in the rules:

- Controlgear: A general term for devices used for controlling consumer equipment, e.g. by switching on and off, starting and stopping a motor, controlling a motor's speed.
- Electrical components: electrical units for use in electrical equipment. A component is ready made by a component manufacturer, for use by an equipment manufacturer. The term component is also used for smaller free-standing equipment like connection boxes, sensors, switches etc.
- Electrical equipment: A common term for electrical machines, transformers, switchboards, panels, assemblies, control units and other units made by components.
- Semi-conductor assembly: Electrical equipment that uses semi-conductors as the main active elements, for switching or conducting the main flow of power.
- Switchgear: A common term for devices used for making and breaking circuits, including auxiliary components such as for example short circuit and overcurrent relays, coils, etc.

c) Proof tracking index is the numerical value of the proof voltage, in volts, at which a material withstands 50 drops without tracking, in accordance with IEC 60112 (i.e. a voltage value describing the isolating materials surface property to withstand tracking when wet.) Determination of the tracking index shall be done in accordance with the requirements in IEC 60112, and is normally done by type testing of the material by the manufacturer, before the material is available in the market.

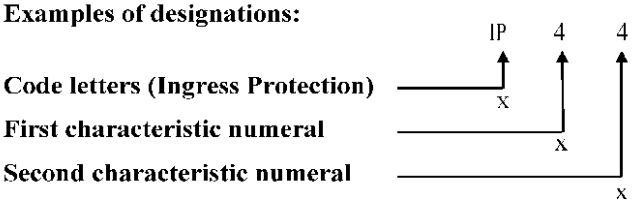
902 *Ingress protection of enclosures*

Ingress protection of enclosures in regard to intrusion of particles and water, normally called IP rating, is defined as follows:

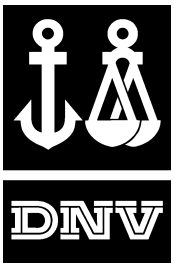
Table A3 Ingress protection of enclosures

First characteristic numeral	*Protection against intrusion of particles and against accidental touching of live parts*
0	Non-protected
1	Protected against solid objects greater than 50 mm
2	Protected against solid objects greater than 12.5 mm
3	Protected against solid objects greater than 2.5 mm
4	Protected against solid objects greater than 1.0 mm
5	Dust protected
6	Dust tight
Second characteristic numeral	*Protection against intrusion of water*
0	Non-protected
1	Protected against dripping water
2	Protected against dripping water when tilted up to 15°
3	Protected against spraying water from above up to 60° from vertical
4	Protected against splashing water
5	Protected against water jets
6	Protected against heavy seas
7	Protected against the effects of immersion
8	Protected against submersion (water depth to be given)

Examples of designations:



For further details see IEC 60529.



OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

CHAPTER 3

CERTIFICATION AND CLASSIFICATION

CONTENTS PAGE

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SECTION 1
CERTIFICATION AND CLASSIFICATION - REQUIREMENTS

A. General

A 100 Introduction

101 As well as representing DNV's recommendations on safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV classification, certification and verification services.

102 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the DNV offshore service specifications for classification, see Table A1.

Table A1 DNV Offshore Service Specifications

No.	*Title*
DNV-OSS-101	Rules for Classification of Offshore Drilling and Support Units
DNV OSS-102	Rules for Classification of Floating Production and Storage Units

A 200 Certification and classification principles

201 Electrical systems and equipment will be certified or classified based on the following main activities:

— design verification
— equipment certification
— survey during construction and installation
— survey during commissioning and start-up.

A 300 Assumptions

301 Any deviations, exceptions and modifications to the design codes and standards given as recognised reference codes shall be documented and approved by DNV.

302 Aspects of the design and construction provisions of this standard which shall be specially considered, agreed upon, or may be accepted are subject to DNV approval when the standard is used for classification purposes.

303 DNV may accept alternative solutions found to represent an overall safety level equivalent to that stated in the requirements of this standard.

A 400 Documentation requirements

401 Documentation for classification shall be in accordance with DNV-RP-A201 and 202. DNV-RP-A202 lists detailed document requirements for classification projects, while DNV-RP-A201 describes applicable standard document types.

402 All documentation requirements listed in DNV-RP-A202 under CIBS code 33, 'Electrical power' are applicable. For other CIBS codes, document related to discipline E - Electrical are applicable.

B. Certification of Products

B 100 General

101 The product certification is a conformity assessment normally including both design and production assessment.

The production assessment includes inspection and testing during production and/or of the final product.

102 Components shall be certified consistent with its functions and importance for safety. The principles of categorisation of component certification are given in the relevant offshore service specifications, see Table A1.

B 200 Certificate types

201 DNV defines two levels of documentation depending on importance of equipment and experience gained in service:

Works certificate (W) is a document signed by the manufacturer stating:

— conformity with the rule or standard requirements
— that the tests are carried out on the certified product itself
— that the tests are made on samples taken from the certified product itself
— that the tests are witnessed and signed by a qualified department.

The manufacturer shall have a quality system that is suitable for the kind of certified product. The surveyor shall check that the most important elements of this quality system are implemented and may carry out random inspections at any time. The component shall be marked to be traceable to the work certificate.

DNV certificate (NV) is a document signed by a surveyor of the Society stating:

— conformity with the rule or standard requirements
— that the tests are carried out on the certified product itself
— that the tests are made on samples taken from the certified product itself
— that the tests are made in the presence of a surveyor from the Society or in accordance with special agreements.

The product shall be stamped with a special NV-stamp traceable to the certificate.

B 300 Type approval

301 Type approval is a procedure for design assessment. Type approval can be applied to a:

— product
— group of products
— system.

This procedure should be used for design assessment of standard designs.

302 The type approval procedure will normally consist of the following elements:

— design approval
— type testing
— issuance of type approval certificate.

The type approval procedure used by the DNV is described in standard for certification No. 1.2.

303 For certain products, equipment and systems as defined in applicable DNV offshore standards, type approval is sufficient as the assessment needed for conforming product quality, i.e. production assessment is not required.

304 For certain products, equipment and systems as defined in the applicable DNV offshore standards, type approval is a mandatory procedure for design assessment.

305 For products, equipment and systems manufactured for stock, type approval shall be the normal procedure for assessment of design.

B 400 Certification requirements for electrical equipment

401 *Required Certificates*

a) Electrical equipment serving essential or important functions and cables shall be delivered with certificates as required by Table B1.

b) Additional requirements to certification may be given by other relevant parts of the DNV offshore standards.

c) Equipment covered by a valid type approval certificate is generally accepted without further design verification , unless otherwise stated in the certificate. A reference to the type approval certificate shall substitute the required documentation for DNV design assessment.

d) A product certificate may be issued based on the type approval certificate and a product survey, unless otherwise stated in the type approval certificate.

Table B1 Required certificates

Equipment	*Rating*	*DNV certificate (NV)*	*Works certificate (W)*	*DNV type approval certificate (TA)*
Main and emergency switchboards	all ratings	X		
Distribution switchboards, motor starters, motor control centres, etc.	≥ 100 kW/kVA	X		
	≥ 10 kW/kVA and < 100 kW/kVA		X	
Generators [4] and transformers	≥ 300 kVA	X		
	≥ 100 kVA and < 300 kVA [1]		X	X
	≥ 10 kVA and < 100 kVA		X	
Motors [4]	≥ 300 kW	X		
	≥ 100 kW and < 300 kW [1]		X	X
	≥ 10 kW and < 100 kW		X	
Semiconductor assemblies for motor drives	≥ 100 kW	X		
	≥ 10 kW and < 100 kW		X	
Semiconductor assemblies for UPSs or battery chargers	≥ 100 kVA	X		
	< 100 kVA		X	
Cables [1], [2]	all ratings			X
Electrical equipment installed in hazardous areas [3]	all ratings	-	-	-

1) As an alternative to the acceptance based on a type approval certificate (TA) and a works certificate (W), the electrical equipment will also be accepted on the basis of a DNV product certificate (NV).

2) All cables – except cables for internal use in electrical assemblies or short lengths on mechanical packages.

3) All electrical installations in hazardous areas, and areas that may be become hazardous by accidental release of explosive gas, are to comply with the requirements for certification and documentation given in Ch.2 Sec.11.

4) Material certificates for shafts shall be issued as required by DNV-OS-D101.

Note:

Heat exchangers used in conjunction with certified electrical equipment, shall be certified as required for pressure vessels, see DNV-OS-D101.

B 500 Survey during construction

501 General requirements for survey during construction are stated in the relevant DNV offshore service specification for classification, see Table A1.

502 The contractors shall operate a quality management system applicable to the scope of their work. The system shall be documented and contain descriptions and procedures for quality critical aspects.

503 Contractors which do not meet the requirement in 502 will be subject to special consideration in order to verify that products satisfy the relevant requirements.

504 The contractors shall maintain a traceable record of nonconformities and corrective actions and make this available to the DNV surveyor on request.

Guidance note:

Contractors are encouraged to obtain ISO 9000 quality system certification through DNV accredited quality system certification services.

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505 *Product survey*

a) A product survey shall be performed as part of the certification process. The survey shall normally include:

- review of the manufacturers documentation
- visual inspection
- testing.

b) Visual inspection shall verify that:

- manufacturing and installation is in accordance with the approved design information
- the product manufacturing is in accordance with the requirements in the relevant equipment section of this standard
- general craftsmanship is acceptable.

c) The extent of the manufacturer's testing shall be as required by applicable sections of this standard. The testing shall be performed in accordance with approved test program when required by DNV-RP-A202. Test results shall be recorded and filed.

Guidance note:

With respect to visual inspection, a generic description of items normally emphasised, and guidelines to manufacturing survey, are found in the DNV standards for certification.

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C. Survey During Installation and Commissioning

C 100 General

101 Commissioning shall be performed as part of the classification process, and shall focus on the installation on board as well as on the functioning of the total electrical system and parts thereof.

102 When required by DNV-RP-A202, commissioning shall be performed in accordance with submitted procedures reviewed and approved by DNV prior to the commissioning.

103 Commissioning shall be witnessed by a surveyor and is considered complete when all systems and equipment, including their control and monitoring systems are operating satisfactorily.

C 200 Site inspections

201 The site inspections shall be performed in order to evaluate that:

- the electrical installation is in accordance with the accepted or approved documentation
- the electrical installation is in accordance with the requirements in this standard
- the craftsmanship is acceptable.

C 300 Function tests

301 Function tests are part of the Society's verification of the installation's compliance with the requirements in the Rules. Tests as required by the Rules shall be performed in order to demonstrate that:

- the electrical system functions in accordance with approved information
- the electrical system functions in accordance with the requirements in the Rules.

C 400 Available documentation

401 At the site survey, the following documentation shall be available for the DNV's surveyor:

- design documentation as required by A400
- DNV certificates for equipment required certified
- approved 'Hazardous area classification drawing', see DNV-RP-A201 standard documentation type G090
- for the emergency shutdown system, 'System design philosophy', see DNV-RP-A201 standard documentation type Z060
- Ex certificates
- manufacturer's declaration for non-certified equipment that is installed in a hazardous area
- additional documentation where deemed necessary to assess the installations' compliance with this standard.