OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

APRIL 2011

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 service documents consist of amongst other the following types of documents:

— *Service Specifications.* Procedual requirements.
— *Standards.* Technical requirements.
— *Recommended Practices.* Guidance.

The Standards and Recommended Practices 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
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems

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CHANGES

- **General**

This document supersedes DNV-OS-D201, October 2008.

Main changes in April 2011

General

— References to ship types have been removed.

Ch.2 Technical Provisions

— Sec.2: For clarification of design ideas for electric systems and to improve readability, some reorganization and improved grouping of related requirements have been made.
— Sec.2 A207 and Sec.3 C103: The limits for voltage harmonic distortion are increased.
— Sec.2 C104: The requirements to offshore units with two or more independent machinery spaces and no emergency generator are updated. Requirements for FMEA and test program for such systems have been introduced.
— Sec.2 F100: is re-written.
— Sec.2 F200: Requirements to lighting systems is modified.
— Sec.2 F300 and H101: Power supplies to control systems are re-written.
— Sec.2 G104: Continuity of supply and continuity of service has been introduced.
— Sec.2 G700: Requirements for harmonic filter protection is added.
— Sec.3 D301: Twist-on or clamp-on connections is accepted for lights and small power applications in dry accommodation.
— Sec.4 A105: Requirements for switchgear for isolating purposes is modified.
— Sec.6 A201: Requirements related to forced cooling of transformers is modified.
— Sec.7: Totally re-written. The update reflects current IEC standards, and does generally not impose specific class requirements to semiconductor converters.
— Sec.9: Requirements for cables rated 1.8/3 kV are moved to high voltage cables. References to IEC have been updated.
— Sec.10 B, Table B1 is modified.
— Sec.10: New items D409 and D410.

Ch.3 Certification and Classification

— Sec.1: Tables for documentation requirements have been included in Ch.3 Sec.1 and are updated and aligned the matrix approach in Rules for Ships Part 0 Chapter 3 and DNV-RP-A201.
— Sec.1: Semiconductor converters may be certified in a “two stage” process: This implies that the switchboard part is certified at the assembly manufacturer's site, while the power modules may be certified at the original manufacturer's site.

CONTENTS

CH. 1 INTRODUCTION **9**

Sec. 1 General **10**

A. Introduction **10**
A 100 Objectives 10

B. Normative References **10**
B 100 Standards 10
B 200 Reference documents 10

C. Informative References **11**
C 100 General 11

D. Definitions **11**
D 100 Verbal forms 11
D 200 Offshore units 11
D 300 Operational conditions 12
D 400 Services 12
D 500 Installation 13
D 600 Area definitions 13
D 700 Hazardous area 13
D 800 Sources of power, generating station and distribution 14
D 900 Switchboard definitions 16
D 1000 Components and related expressions 16

E. Abbreviations and Symbols **18**
E 100 Abbreviations 18

F. Documentation **18**
F 100 General 18

CH. 2 TECHNICAL PROVISIONS **19**

Sec. 1 General **20**

A. Introduction **20**
A 100 Application 20

Sec. 2 System Design **21**

A. General **21**
A 100 Design principle 21
A 200 System voltages and frequency 23

B. Main Electric Power Supply System **25**
B 100 General 25
B 200 System functionality 26

C. Emergency Power Supply System **27**
C 100 General 27
C 200 Transitional source 30
C 300 Emergency generators 30

D. Battery Systems **31**
D 100 General 31

E. Starting Arrangement for Engines with Electric Starter **32**
E 100 General 32

F. Electric Power Distribution **33**
F 100 Distribution in general 33
F 200 Lighting 34
F 300 Power supply to control and monitoring systems 35
F 400 Low voltage shore connections 36

G. Protection **36**
G 100 System protection 36
G 200 Circuit protection 37
G 300 Generator protection 39
G 400 Transformer protection 40
G 500 Motor protection 40

G 600 Battery protection 40
G 700 Harmonic Filter protection 40

H. Control of Electric Equipment 41
H 100 Control circuits 41
H 200 Control of generator sets and main power supply 41
H 300 Main and emergency switchboard control 42
H 400 Motor control 43
H 500 Emergency stop 44

I. Offshore unit Arrangement 45
I 100 General 45
I 200 Switchboard arrangement 45
I 300 Rotating machines 46
I 400 Battery installations 47
I 500 Cable routing 49
I 600 Lightning protection 49
I 700 Earthing of aluminium superstructures on steel offshore units 49

J. Cable Selection 50
J 100 General 50
J 200 Cable temperature 51
J 300 Choice of insulating materials 51
J 400 Rating of earth conductors 52
J 500 Correction factors 52
J 600 Parallel connection of cables 53
J 700 Additional requirements for AC installations, and special DC installations 53
J 800 Rating of cables 54

Sec. 3 Equipment in General 57

A. General Requirements 57
A 100 References 57

B. Environmental Requirements 57
B 100 Inclinations 57
B 200 Vibrations and accelerations 57
B 300 Temperature and humidity 58

C. Equipment Ratings 58
C 100 Electrical parameters 58
C 200 Maximum operating temperatures 59

D. Mechanical and Electrical Properties 59
D 100 Mechanical strength 59
D 200 Cooling and anti-condensation 60
D 300 Termination and cable entrances 61
D 400 Equipment protective earthing 61
D 500 Enclosures ingress protection 62
D 600 Clearance and creepage distances 62

E. Marking and Signboards 63
E 100 General 63

F. Insulation 64
F 100 Insulation materials 64

Sec. 4 Switchgear and Controlgear Assemblies 66

A. Construction 66
A 100 General 66

B. Power Circuits 68
B 100 Power components in assemblies 68
B 200 Additional requirements for high voltage assemblies 69

C. Control and Protection Circuits 71
C 100 Control and instrumentation 71

D. Inspection and Testing 72
D 100 General 72

Sec. 5 Rotating Machines **74**

A. General **74**
A 100 References 74
A 200 Requirements common to generators and motors 74
A 300 Instrumentation of machines 76

B. Additional Requirements for Generators **76**
B 100 General 76
B 200 Voltage and frequency regulation 77
B 300 Generator short circuit capabilities 77
B 400 Parallel operation 78

C. Inspection and Testing **78**
C 100 General 78

Sec. 6 Power Transformers **82**

A. General **82**
A 100 General 82
A 200 Design requirements for power transformers 82

B. Inspection and Testing **83**
B 100 General 83

Sec. 7 Semi-conductor Converters **85**

A. General Requirements **85**
A 100 General 85
A 200 Design and construction requirements 85

B. Inspection and Testing **88**
B 100 General 88

Sec. 8 Miscellaneous Equipment **91**

A. General **91**
A 100 Socket outlets and plugs 91
A 200 Lighting equipment 91
A 300 Heating equipment 91
A 400 Cooking and other galley equipment 93

Sec. 9 Cables **94**

A. Application **94**
A 100 General 94

B. General Cable Construction **94**
B 100 Conductors 94
B 200 Insulating materials 95
B 300 Wire braid and armour 95
B 400 Protective sheaths 95

C. High Voltage Cables **96**
C 100 Construction of cables rated 1.8/3 kV 96
C 200 Construction of high voltage cables rated above 1.8/3 kV 96

D. Low Voltage Power Cables **97**
D 100 Construction of cables rated 0.6/1 kV 97
D 200 Switchboard wires 97
D 300 Lightweight electrical cables 98

E. Control and Instrumentation Cables **98**
E 100 Construction of control and instrumentation cables rated 150/250 V 98

F. Data Communication Cables **98**
F 100 General 98

G. Fibre Optic Cables **98**
G 100 General 98

H. Inspection and Testing **98**
H 100 General 98

Sec. 10 Installation 100

A. General Requirements 100
A 100 General 100

B. Equipment 100
B 100 Equipment location and arrangement 100
B 200 Equipment enclosure, ingress protection 101
B 300 Batteries 104
B 400 Protective earthing and bonding of equipment 104
B 500 Equipment termination, disconnection, marking 105
B 600 Neon lighting 105

C. Cables 106
C 100 General 106
C 200 Routing of cables 106
C 300 Penetrations of bulkhead and decks 107
C 400 Fire protection measures 108
C 500 Support and fixing of cables and cable runs 108
C 600 Cable expansion 110
C 700 Cable pipes 111
C 800 Splicing of cables 111
C 900 Termination of cables 112
C 1000 Trace or surface heating installation requirements 113

D. Inspection and Testing 113
D 100 General 113
D 200 Equipment installation 113
D 300 Wiring and earthing 114
D 400 Electric distribution and power generation 114

Sec. 11 Hazardous Areas Installations 117

A. General 117
A 100 General 117

B. Documentation 117
B 100 General 117

C. Equipment Selection 117
C 100 General 117
C 200 Ex protection according to zones 118
C 300 Additional requirements for equipment and circuit design 119

D. Installation Requirements 120
D 100 General 120
D 200 Cable types, cabling and termination 121

Sec. 12 Electric Propulsion 123

A. General 123
A 100 General 123
A 200 System design 123
A 300 System capacity 123
A 400 Electric supply system 124
A 500 System protection 124
A 600 Control systems 124

B. Verification 126
B 100 Survey and testing upon completion 126

CH. 3 CERTIFICATION AND CLASSIFICATION 127

Sec. 1 Certification and Classification - Requirements 128

A. General 128
A 100 Introduction 128
A 200 Certification and classification principles 128
A 300 Assumptions 128
A 400 Documentation requirements 128

B. Documentation 128
B 100 General 128

C. Certification **130**
C 100 General 130
C 200 Certificate types 131
C 300 Type approval 131
C 400 Certification requirements for electrical equipment 131
C 500 Survey during construction 132

D. Onboard Survey **133**
D 100 General 133
D 200 Onboard inspections 133
D 300 Function tests 133
D 400 Available documentation 133

App. A List of alarms and monitoring parameters **134**

A. General **134**
A 100 General 134

OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

CHAPTER 1

INTRODUCTION

CONTENTS PAGE

Sec. 1 General 10

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.

SOLAS references are as quoted in MODU Code 1989 and fulfil class requirements. Note that for compliance with flag state requirements, later amendments may be applicable.

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.

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102 The publications listed in Table B1 and Table B2 includes 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-OSS-101, App.B	Appendix B: Plan Approval Documentation Types – Definitions
DNV-OS-D202	Automation, Safety, and Telecommunication Systems
DNV-RP-A201	Plan Approval Documentation Types – Definitions

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.

104 *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.

105 If the rules are used for a unit 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.

106 *Electrical installations:* The term electrical installations are an all-inclusive general expression that is not limited to the physical installations. For physical installations, the wording, "installation of…" is used.

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.

For the purpose of Ch.2 of this standard, ship-shaped units shall be regarded as offshore units, not as ships.

D 300 Operational conditions

301 *Normal operational and habitable condition:* Normal operational and habitable condition is a condition under which the unit, 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 and lighting necessary to perform normal operation and maintenance of the unit. 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.

302 *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 system.

303 *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 units 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 DNV-OS-D101.

304 *Blackout situation:* Blackout situation occurs when there is a sudden loss of electric power in the main distribution system and remains until the main source of power feeds the system. All means of starting by stored energy are available.

D 400 Services

401 *Essential services*

a) Essential (primary essential) services are those services that need to be in continuous operation for maintaining the unit's manoeuvrability in regard to propulsion and steering. The definition is extended for systems associated with the offshore unit/installation to cover systems which are needed to be available on demand to prevent development of, or to mitigate the effects of an undesirable event, and to safeguard the personnel, environment and the installation. The definition essential services may also apply to other services when these are defined as such in the DNV Offshore Standards.

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 units, and also for auxiliary boilers on units 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.
— fire pumps
— emergency shut down (ESD) system of an offshore unit.

402 *Important services*

a) Important (secondary essential) services are those services that need not necessarily be in continuous operation for maintaining for the unit's manoeuvrability, but which are necessary for maintaining the unit's functions. The definition is extended for systems associated with the offshore unit/installation to cover systems, which ensures reliable operation and which maintains plant operation within operational limitations. Important electrical consumers are electrical consumers serving important services. The definition important services may also apply to other services when these are defined as such in the DNV Offshore Standards.

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
— 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 and signals
— navigation equipment
— internal safety communication equipment
— fire and gas 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
— jacking motors
— water ingress detection and alarm system
— cargo pumping.

403 *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 Pt.4 Ch.10 of the Rules for Classification of Ships.

c) Further requirements for emergency services are given in Ch.2 Sec.2.

404 *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.

D 500 Installation

501 *Short circuit proof installation*

For low voltage installations, short circuit proof installation means one of the following methods:

— bare conductors mounted on isolating supports
— single core cables (i.e., conductors with both insulation and overall jacket) 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
— double insulated wires or conductors.

D 600 Area definitions

601 *Open deck*

Open deck is a deck that is completely exposed to the weather from above or from at least one side.

D 700 Hazardous area

701 *Area definitions*

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.

702 *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.

703 *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
— gas and equipment group, according to Table A1
— temperature class, according to Table A2.

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:

Comparison between the IEC based zone, NEC based divisions and ATEX equipment categories are given in Table A3.

Table A3 Divisions and zones

	Continuous hazard	*Intermittent hazard*	*Hazard under abnormal conditions*
NEC500-503	Division 1	Division 1	Division 2
IEC	Zone 0 (Zone 20 dust)	Zone 1 (Zone 21 dust)	Zone 2 (Zone 22 dust)
ATEX	Category 1	Category 2	Category 3

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D 800 Sources of power, generating station and distribution

801 *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 unit in normal operational and habitable conditions.

Guidance note:

A generator prime mover and associated equipment is called “generators' primary source of power”.

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802 *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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803 *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.

804 *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.

805 *Main generating station*

A main generating station is a space in which the main source of electrical power is situated.

806 *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.

807 *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.

808 *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 un-insulated 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.

809 *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.

810 *Batteries*

a) Vented batteries are of the type where individual cells have covers, which are provided with an opening, through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere. Normally, these types of battery have wet electrolyte with the possibility to check and refill electrolyte levels and to take the specific gravity of the electrolyte with a hydrometer.

b) Valve-regulated batteries are of the type in which the cells are closed, but have an arrangement (valve) that allows the escape of gas if the internal pressure exceeds a predetermined value. Normally, these are dry type or gel type batteries, with no refill or maintenance of electrolyte possible. Battery variants, characterised as “sealed” or “hermetically sealed” should be regarded as similar to the dry types, unless other properties are confirmed. With valve regulated batteries, the amount of escaping gas is normally very low. However, in the case where a battery, of this type, has been abnormally or excessively charged, then the volume of escaping gases can be comparable with the vented types.

811 *Voltage levels*

The terminology used in these rules are as follows:

Safety voltage: rated voltage not exceeding 50 V AC.
Low voltage: rated voltages of more than 50 V up to and inclusive 1 000 V with rated frequencies of 50 Hz or 60 Hz, or direct-current systems where the maximum voltage does not exceed 1 500 V.
High voltage: rated voltages of more than 1 kV and up to and inclusive 15 kV with rated frequencies of 50 Hz or 60 Hz, or direct-current systems with the maximum voltage under rated operating conditions above 1 500 V.

812 *Continuity of service*

Condition for protective system and discrimination; after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.

813 *Continuity of supply*

Condition for protective system and discrimination; during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.

D 900 Switchboard definitions

901 *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 unit'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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902 *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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903 *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.

D 1000 Components and related expressions

1001 *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) 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.

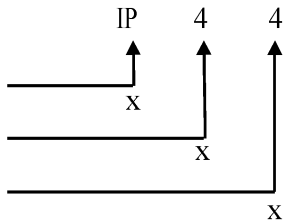
1002 *Ingress protection of enclosures*

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 15º
3	Protected against spraying water from above up to 60º 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:



Code letters (Ingress Protection)

First characteristic numeral

Second characteristic numeral

For further details see IEC 60529.

E. Abbreviations and Symbols

E 100 Abbreviations

101 Abbreviations used are given in Table E1.

Table E1 Abbreviations

Abbreviation	*Full text*
AC	Alternating current
ACB	Air circuit breaker
AVR	Automatic voltage regulator
DB	Distribution switchboard
DC	Direct current
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
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	Continuous 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

Sec. 1 General 20
Sec. 2 System Design 21
Sec. 3 Equipment in General 57
Sec. 4 Switchgear and Controlgear Assemblies 66
Sec. 5 Rotating Machines 74
Sec. 6 Power Transformers 82
Sec. 7 Semi-conductor Converters 85
Sec. 8 Miscellaneous Equipment 91
Sec. 9 Cables 94
Sec. 10 Installation 100
Sec. 11 Hazardous Areas Installations 117
Sec. 12 Electric Propulsion 123

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SECTION 1
GENERAL

A. Introduction

A 100 Application

101 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.

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

103 When the terms "offshore unit" is used, it shall be interpreted as "offshore unit" or "offshore installation".

104 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.

105 With respect to the definition of "essential services" in Ch.1, the inclusion of propulsion and steering is only applicable for offshore units dependent on manoeuvrability.

106 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.

107 The term "additional class notation" and similar shall be understood as a reference to the offshore 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. General

A 100 Design principle

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. Exceptions are given in C104.

c) Services required for normal operation of the offshore unit shall be operable with the emergency electrical power generation and distribution system being unavailable, unless such services are permitted to be powered by emergency electrical power supply only.

d) All consumers that support functions required to be available in normal operation, shall be supplied from distribution systems independent of the emergency electrical power supply system. Exemptions are made for one of redundant consumers required for dead ship recovery.

e) All consumers required to be available in emergency operation shall be supplied from distribution systems independent of the main electric power supply system.

f) Consumers required having both main and emergency supply shall be supplied as required by relevant rules applicable for these consumers. The primary supply shall be from the main system.

g) Offshore units without a dedicated emergency electric power supply system are accepted upon compliance with requirements in C104.

Guidance note:
Requirements to arrangements of main and emergency power supply systems with respect to fire, flooding or other casualty are given in I102.

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102 *Environmental conditions*

a) The electrical installations shall be suitable for operation in those environmental conditions given in Sec.3 B, and have an ingress protection rating as given in Sec.3 D500 and Sec.10 B200, except as stated in b) and c).

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

— the equipment is not for use for emergency services, and shall not be in operation after ESD has been activated
— temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature
— the equipment can be started in a 45°C ambient temperature and kept in operation until the lesser ambient temperature may be achieved
— the cooling equipment shall be rated for a 45°C ambient temperature
— malfunction of, or loss of a cooling unit shall be alarmed at a manned control station.

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

c) The equipment used for cooling and maintaining the lesser ambient temperature is an important service, in accordance with Ch.1 Sec.1 D402 and shall comply with the relevant rules.

(IACS UR E19)

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

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103 *System earthing*

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

b) Any earthing impedances shall be connected to the hull. The connection to the hull shall be so arranged that any circulating current in the earth connections do not interfere with radio, radar, communication and control equipment circuits. (IACS UR E11 2.1.4)

c) If the system neutral is connected to earth, suitable disconnecting links or terminals 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.

d) If the system neutral is connected to earth at several points, equalising currents in the neutral earthing exceeding 20% of the rated current of connected generators or transformers is not acceptable. Transformer neutrals and generator neutrals shall not be simultaneously earthed in the same distribution system at same voltage level. On distribution transformers with star connected primary side, the neutral point shall not be earthed.

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

f) Combined PE (protective earth) and N (system earth) is allowed between transformer /generator and N-busbar in first switchboard where the transformer secondary side/generator is terminated i.e. TN-C-S-system. There shall be no connection between the N- and PE-conductor after the PEN-conductor is separated.

g) In case of earth fault in high voltage systems with earthed neutral, the current shall not be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. Electrical equipment in directly earthed neutral or other neutral earthed systems shall withstand the current due to single phase fault against earth for the time necessary to trip the protection device. It shall be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. For divided systems, connection of the neutral to the earth shall be provided for each section.
(IACS UR E11 2.1.2 and 2.1.5)

h) For earthing of aluminium superstructures on steel offshore units see I700.

104 *Types of distribution systems*

a) AC power: The following distribution systems can be used (for exemptions see 105):

— 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 AC:

— three-phase four-wire with neutral earthed, but without hull return
— single-phase two-wire with insulated neutral
— single-phase two-wire with one phase earthed at the power source, but without hull return.

c) DC power: The following distribution systems can be used (for exemptions see 105):

— 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, except as stated in b) and c). IEC61892-2 Item 6.1.1

b) Provided that any possible resulting current does not flow directly through any gas hazardous spaces, the requirements of a) 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
— intrinsically safe circuits.

c) Where the hull return system is used for distribution of DC power, one of the busbars of the distribution board shall be connected to the hull. Outgoing final sub circuits i.e. all circuits fitted after the last protective device shall be with insulated two-wires or two-core cable.

106 *Special requirements for non-metallic offshore units*

a) All metal parts of a non-metallic offshore unit shall 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 shall 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 0.02 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 0.25 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 a 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 standard values are accepted in 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*

Except as stated in b) and c), the following maximum voltages in distribution systems apply:

— connected by permanent wiring: 15 000 V
— for portable appliances, which are not hand-held during operation, and with connection by flexible cable and socket outlet: 1 000 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. Phase voltage of a system with neutral earthed may be used for this purpose.

Where necessary for special application, higher voltages may be accepted by the Society.

(IACS UR E11 1.2)

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 1 000 V. However, control voltage to external equipment shall not exceed 500 V.

204 *Supply voltage variations*

a) Electric AC 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 AC system voltage

Transient state

from –15% to +20% of nominal AC voltage.

b) Electric DC battery powered systems shall be designed and installed so that the voltage variations on the main distribution board are maintained within these limits:

Voltage tolerance: -15% to +30% of nominal DC system voltage
Voltage cyclic variation: max. 5%
Voltage ripple: max. 10%.

c) The requirement for maximum transient voltage shall also be complied with in case of load shedding or tripping of consumers. The requirement for maximum transient voltage is not applicable to failure conditions.

d) After a transient condition has been initiated, the voltage in a main distribution AC 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.

e) In AC installations designed for variable system voltage, equipment and its protection devices shall be rated to operate within the design limits throughout the voltage range.

205 *Voltage drop in the distribution system*

a) An AC 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 DC 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) Specific 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 in AC 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) In AC installations designed for variable system frequency, equipment and its protection devices shall be rated to operate within the design limits throughout the frequency range

Guidance note:

See DNV-OS-D101 regarding the prime movers' speed governor characteristics.

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207 *Harmonic distortion*

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

b) In distribution systems the acceptance limits for voltage harmonic distortion shall correspond to IEC 61000-2-4 Class 2. (IEC 61000-2-4 Class 2 implies that the total voltage harmonic distortion shall not exceed 8%.) In addition no single order harmonic shall exceed 5%.

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 have been designed to withstand the actual levels. The system and components ability to withstand the actual levels shall be documented.

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 following effects should be considered when designing for higher harmonic distortion in c):

- 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 offshore unit 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
— normal operation of propulsion (not maximum load)
— starting the largest essential or important electric motor on board, except auxiliary 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

For "dead ship" recovery, see 204.

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
- 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 *Generator prime movers*

a) Each generator required according to 101 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 offshore unit speed is controlled only by varying propeller pitch, may be one of the required generators according to 101. 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 offshore unit, including stopped. This shall be possible without utilising any emergency power source.

e) Shaft generator installations which do not comply with the requirement given in d), may be fitted as additional source(s) of power provided that:

— on loss of the shaft generator(s) or upon frequency variations exceeding ±10%, a standby generating set is started automatically
— the capacity of the standby set is sufficient for the loads necessary for propulsion and safety of the offshore unit.

f) Generator prime movers shall comply with the requirements in DNV-OS-D101.

Guidance note:

Shaft generators and other generators based on variable speed drives will be evaluated in each case. As a minimum, the following should be evaluated:

- availability

- stability of output voltage and frequency
- short circuit capability and protection.

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B 200 System functionality

201 *Start of generator sets*

At least two generator sets, connected to separate main busbar sections, shall be arranged with systems for starting in a blackout situation. However, only one standby generator may be permitted if this generator is not intended to be used for normal operation of the offshore unit.

202 *Energy for starting*

a) The energy used for starting in a blackout situation shall be arranged as required in E100.

b) Control power supply to electronic governors, AVRs and necessary control power for auxiliary engines shall, if dependent on external power, be arranged as required for starting arrangement in E.

c) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems being available in a blackout situation, these auxiliaries shall be arranged with at least two independent sources of power. At least one of the sources of power shall be from stored energy located within the machinery space. The capacity of the power sources shall correspond to the required number of starting attempts and last for at least 30 minutes.

d) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems during standby mode in order to start in a blackout situation, auxiliaries for at least one generator shall be supplied from the main switchboard in order to comply with A101 c).

e) When a single, dedicated, standby generator is used, this generator set alone shall be arranged in accordance with this paragraph, i.e. two sources of energy for starting, control power and auxiliaries. As above, one of the sources for auxiliaries shall be from stored energy located within the machinery space.

Guidance note:

Example of auxiliary system that must be available in a blackout situation may be fuel oil booster pump, and lubrication oil pump if start blocking is activated within 30 minutes after blackout.

Example of auxiliary system that must be supplied in standby mode may be pre lubrication pump and jacket water heating.

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203 *Load shedding and automatic restoration of power*

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

— All generators shall be equipped with automatic load shedding or other automatic means to prevent sustained overload of any generator, ref. G101.
— Where the electrical power is normally supplied by one generator provision shall be made, upon loss of power, for automatic starting and connecting to the main switchboard of standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds, but in any case not more than 45 seconds, after loss of power.
— Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the society.
— 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. 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 standby generator.

204 *Start from "dead ship"*

a) The requirement for start from dead ship is given in DNV-OS-D101 Ch.2 Sec.1 B313.

b) 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, transformers and power converters 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:

On installations without a dedicated emergency generator in accordance with C104, only one engine room is considered to be in dead ship conditions, since there should be redundancy in starting arrangement for each engine room as required for emergency generator sets. However, necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy.

For offshore units with two or more independent engine rooms but not complying with C104, the requirements for dead ship starting still applies, i.e. dead ship condition in both/all engine rooms simultaneously. Necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy.

In cases where only electric starting is arranged for engines driving generators and the main propulsion engines, an additional battery for "dead ship" starting may be installed. This battery shall then be dedicated for this purpose and always kept fully charged and monitored.

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C. Emergency Power Supply System

C 100 General

101 *Emergency power source*

a) The emergency source of power, associated transforming equipment, emergency switchboard, emergency lighting switchboard and transitional source of emergency power shall be located above the worst damage waterline and be readily accessible. It shall not be located within the assumed extent of damage referred to in DNV-OS-C301 or forward of the collision bulkhead, if any.

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. If the power source is a generator, it shall be automatically started and within 45 s supply at least the services required to be supplied by emergency and 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 offshore unit. 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.

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 such services as may have to be operated simultaneously, 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.

Guidance note:

The emergency generator rating shall be based upon the consumed power for all consumers that may be in simultaneous operation. Non-emergency motors, which will not automatically start, are considered to be automatically disconnected.

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103 *Services to be supplied*

a) The list of services in Table C1 shall be supplied by the emergency source of power and the transitional source of power for the period listed. For additional class notations, additional requirements may apply.

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*	*Duration of emergency power, (h)*	*Duration of transitional power, (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 shall be launched.	18	0.5 1)
	In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks.	18	0.5 1)
	In the machinery spaces and main generating stations including their control positions.	18	0.5 1)
	In all control stations, machinery control rooms, locations where operation of safety equipment may be necessary to bring the installation to a safe stage, steering gear and at each main and emergency switchboard.	18	0.5 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	0.5 1)
	At all stowage positions for firemen's outfits.	18	0.5 1)
	At the fire pump referred to in this table and its starting position.	18	0.5 1)
	At the sprinkler pump and its starting position, if any.	18	0.5 1)
	At the emergency bilge pump and its starting position, if any.	18	0.5 1)
	Floodlight and perimeter lights on helicopter landing decks.	18	0.5 1)
	In all cargo pump-rooms	18	0.5 1)
Navigation lights	The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force.	18	
Structure marking	Any signalling lights or sound signals that may be required for marking of offshore structures.		96
Fire pumps	Fire pumps dependent upon the emergency generator	18	
Steering gear	The auxiliary steering gear or, if two identical units, one of the main steering gears	10 minutes	
Ballast valves	For column stabilised units: Ballast control and indicating system.	18	
Ballast pumps	For column stabilised units: 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 system	Permanently installed diving system, if dependent upon the offshore unit's electrical power.	24	
Life boat	Second means of launching of free fall life boat, ref. LSA Code.	5)	
Communication 3)	The VHF radio installation required by SOLAS Ch. IV/7.1.1 and IV/7.1.2.	18	0.5 1)
	If applicable: — the MF radio installation required by SOLAS Ch.s 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	0.5 1)
	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 positions fitted with facilities for operation of radio equipment.	18	0.5 1)

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*	*Duration of emergency power, (h)*	*Duration of transitional power, (h)*
Alarm systems	The fire detection and alarm systems.	18	0.5 1) 2)
	The gas detection and alarm systems 4)	18	0.5 1) 2)
	The general alarm system.	18	0.5 1) 2)
	Intermittent operation of the manual fire alarms and all internal signals that are required in an emergency	18	0.5 1)
ESD system	Emergency Shutdown (ESD) System	18	0.5
BOP control	The capability to close the blow-out preventer and of disconnecting the offshore unit from the well head arrangement, if electrically controlled.	18	2

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) Unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.
3) Means of communication according to DNV-OS-A101.
4) Only where continuous gas detection is required by other applicable rules.
5) Power for launching of the life boat shall be available on demand with duration of 10 minutes for each lifeboat.

104 *Independent installation of power sources*

If the applicable regulation for the offshore unit is the IMO MODU Code, or when alternative emergency power arrangement has been accepted by the authorities of the flag state the following may apply:

Where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces and such that a fire or other casualty in any one space will not affect the power distribution from the others, or to the services in Table C1, the requirements for self-contained emergency power source may be considered satisfied without an additional emergency source of electrical power, provided that:

— There are at least two generator sets meeting the inclination design requirements for emergency installations in Sec.3 B101
— Each set has capacity to meet the requirements in paragraph 102
— These generator sets are located in each of at least two spaces
— A casualty in any one space will not affect the control system for automatic start and connection of both/ all these generator sets.
— Power to all required emergency functions, as listed in Table C1, supplied from main switchboards and sub distributions are to be automatically available within 45 seconds when power is automatically restored after a black-out
— Load shedding/trip is arranged to prevent overload of these generator sets
— Transitional source of power is installed when required in 201
— The location of each of the spaces referred to in this paragraph is such that one of these generator sets remains operable and readily accessible in the final condition of damage. Further, the boundaries shall meet the provisions of I102, except that contiguous boundaries shall consist of an A-60 bulkhead and a cofferdam or a steel bulkhead insulated to class A-60 on both sides
— Bus tie breakers between the spaces have short circuit protection providing discrimination
— The arrangements of these generating sets comply with the requirements given in:

105 c), i.e. bus-tie breakers shall open automatically upon blackout

105 h)

301

303 (see guidance note).

Guidance note 1:

The second source of energy for starting may be located outside the machinery space. In case of a fire or other casualty in any one space a total of at least two sources of starting energy for the remaining generator(s) have to be available.

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Guidance note 2:

The system philosophy for the electrical power supply system should describe how this paragraph is complied with. In addition operating philosophy, it should include description of physical location of main components and cable routings. The test program for onboard testing should describe in detail how this functionality shall be tested.

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Guidance note 3:

An offshore unit built in accordance with this paragraph will not have any dedicated emergency power system, since the two (or more) independent main power systems are considered to ensure power supply to emergency consumers at all times. Compliance with 302 is not required.

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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 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 batteries, except the starting battery for the emergency generator prime mover and control and monitoring for the emergency system, shall be installed in the same space as the emergency switchboard.

i) Cables between equipment installed in the emergency generator room, shall be run inside the boundary of the room.

C 200 Transitional source

201 *Transitional source of emergency electrical power*

a) A transitional source of power is required

b) The transitional source of electrical power shall consist of an accumulator battery suitably located for use in an emergency as required for emergency power in 101, unless it supplies power to consumers within the same space as the transitional source itself.

c) The battery source shall be charged by the emergency power distribution system and 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 services required by Table C1, if they depend upon an electrical source for their operation. See notes to Table C1.

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 supply of fuel with a flashpoint (closed cup) of not less than 43°C and shall have auxiliary systems e.g. cooling system, ventilation and lubrication operating independently of the main electrical power system.

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

c) When the emergency source of power is not ready for immediate starting, an indication shall be given in 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 i.e. short circuit. For prime mover see DNV-OS-D101.

b) Other protective functions such as overcurrent, high temperature etc. shall, if installed, give alarm only. It is recommended that such alarms are given to the main alarm system.

If overcurrent protection release is integrated in the circuit breaker, the setting of this release shall be set at its maximum value.

c) For use as a harbour generator, see 304.

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 offshore unit 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 device 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 within this time. One starting motor is sufficient. The duration of each starting shall be minimum 10 s.

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 set 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 of emergency generating sets.

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 offshore unit 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 Systems

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

— a charging device supplied from the offshore unit'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.

b) Each battery required by these rules shall have its own dedicated charging device.

c) Each charging device is, at least, to have sufficient rating for recharging to 80% capacity within 10 hours, while the system has normal load.

d) The battery charger shall be suitable to keep the battery in full charged condition, (float charge), taking into account battery characteristics, temperature and load variations. If the battery requires special voltage regulation to obtain effective recharging, then this is to be automatic. If manual boost charge is provided, then the charger is to revert to normal charge automatically.

Guidance note:

When the charging dynamo is an AC generator (alternator), particular attention should be paid to ensure that no damage would occur if the connection with the battery is broken. Provisions shall be made for preventing reverse current from the battery through the charging dynamo.

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103 *Battery monitoring*

An alarm shall be given at a manned control station if the charging of a battery fails, alternatively an alarm shall be given if the battery is being discharged. Requirements for alarm if ventilation fails are given in I400.

Guidance note:

A single common alarm signal to a central alarm system may be accepted for the two alarms listed in this paragraph.

If other alarms are included in the common alarm signal, it must be ensured that an active alarm will not prevent initiation of any new alarm with its audible and visual indication.

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104 *Battery arrangement*

Battery installations shall comply with the requirements in I400.

Guidance note:

Trip of battery from the ESD system might be required according to DNV-OS-A101.

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E. Starting Arrangement for Engines with Electric Starter

E 100 General

101 *Starting arrangements for main engines*

a) When electric starting arrangement for main engines is used, 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 shall be sufficient for 3 starts per engine. However, the total capacity shall not be less than 12 starts and need not exceed 18 starts.

102 *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 101.

b) When the starting arrangement serves two or more auxiliary engines, there shall at least be two separate batteries, as specified for main engines in 101. The main engine batteries, when such are used, can also be used for this purpose.

c) 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.

F. Electric Power Distribution

F 100 Distribution in general

101 *General*

a) All switchboards and outgoing circuits shall be provided with switchgear so that isolation for maintenance is possible. See Sec.4 A105

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 have a separate supply circuit from different sections of the main switchboard(s) or shall be divided between at least two distribution switchboards, each having a separate supply circuit from different sections of the main switchboard(s). In instances where more than two units are used and the switchboard has only two sections, the circuits are to be evenly divided between the two sections.

d) When a component or system has two or more power supply circuits, an alarm shall be initiated upon loss of any of these power supplies.

e) For converters serving as AC power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

Guidance note:

Equipment suitable for isolation is defined in IEC 60947-1 clause 7.1.7. Contactors are therefore normally not accepted as suitable for isolation.

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102 *Consequence of single failure*

a) The failure of any single circuit or busbar section shall not endanger the services necessary for the offshore unit'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 When the secondary distribution is arranged as two separate systems each fed from one transformer or converter, duplicated essential or important consumers shall be divided between the two systems.

c) Each transformer required according to B101 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 *Division of main busbars*

a) Where the main source of electrical power is necessary for propulsion of the ship, or for high voltage distribution systems, the main busbar shall be subdivided into at least two parts which shall normally be connected by circuit breakers or other approved means; so far as is practicable, the connection of generating sets and other duplicated equipment shall be equally divided between the parts.

b) Where two separate switchboards are provided and interconnected with cables, a circuit breaker shall be provided at each end of the cable. See Sec.4 B106. (IACS UR E11 2.1.1)

Guidance note:

Other approved means can be achieved by:

Circuit breaker without tripping mechanism; or disconnecting link or switch by which busbars can be split easily and safely. Bolted links, for example bolted busbar sections, are not to be accepted.

Single failure means failure in any single circuit, feeder, transformer or part of switchboard within one bus tie section. Additional class notations may require that each part of the main busbars with its associated generators is arranged in separate compartments.

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104 *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, or can be connected to more than one busbar section, more than one generator breaker is acceptable. In such cases, additional requirements to protection of the circuits between the generator terminals and the generator circuit breakers are given in G301 f).

F 200 Lighting

201 *Lighting system arrangement*

a) The lighting system shall be based on the following separation of the system:

— main lighting system supplied from the main power supply system
— emergency lighting system supplied from the emergency power supply system
— escape (transitional) lighting system supplied from a battery backup (transitional) source of electrical power.

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

c) The emergency lighting system shall provide illumination throughout those parts of the offshore unit listed in table C1, and shall be supplied from the emergency source of electrical power. Upon loss of main source of power, all required emergency lighting shall be automatically supplied from the emergency source of power. Emergency exterior lighting may however be controlled by switch on the bridge.d)

d) The escape (transitional) lighting system shall provide illumination throughout those parts of the offshore unit listed in table C1, supplied by integrated or centralised batteries. These batteries shall have supply from an emergency distribution system. The escape lighting system shall be switched on automatically in the event of failure of the main and emergency power supply.

e) 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 offshore unit.

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

g) For offshore units meeting the requirements in C104, i.e. which does not have a dedicated emergency source of power, c) does not apply. However, sufficient lighting to carry out all functions necessary for the safe operation of the offshore unit and in all areas where emergency light is required according to Table C1, shall be divided between at least two circuits from the independent power sources.

Exception

The redundancy requirement in e) 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 offshore unit. The emergency switchboard may be used as one of the secondary distribution systems.

The lighting in all areas where emergency or escape lighting is required shall be divided between at least two circuits, one from the main and one from the emergency switchboard.

Guidance note:

At least 30% of the lighting installation in each space/area should be operable after loss of one of the lighting systems.

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202 *Navigation lights controllers*

The navigation lights shall be connected to a dedicated navigation light controller placed on the bridge or in the chart room or space. This navigation light controller shall not be used for other purposes, except that signal lights required by canal authorities can be supplied.

Guidance note:

According to IMO MSC253(83) navigation lights means the following lights:

- masthead light, sidelights, stern light, towing light, all-round light, flashing light as defined in Rule 21 of COLREG

- all-round flashing yellow light required for air-cushion vessels by Rule 23 of COLREGs; and
- manoeuvring light required by Rule 34(b) of COLREG.

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203 *Power supply to navigation lights*

a) The navigation light 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. Upon failure of either power supply, an alarm shall be given.

b) For offshore units without emergency power the navigation lighting shall have a battery backed up supply.

204 *Navigation light circuits*

a) A separate circuit shall be arranged for each light connected to this controller 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 when the light circuit is switched on, giving alarm in the event of failure of the light, and in the event of a short circuit.

d) According to IMO MSC.253(83) some of the navigation lights shall either be duplicated or have duplicated lamps. When duplication is required, each navigation light or lamp shall be fed by a separate circuit as required in this paragraph.

F 300 Power supply to control and monitoring systems

301 *General*

This part of the rules defines the principal requirements to power supply arrangement for control and monitoring systems. Where particular power supply requirements are valid it is specified in the applicable rules.

302 *Power supply*

The power supply shall in general be supplied from the same distribution board as the consumer or the system being served.

Guidance note:

The general principle is that the power supply to the control and monitoring systems shall reflect the general segregation in the power supply arrangement to the consumers or equipment under control.

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303 *Independent power supplies*

When independent power supplies are required, these supplies shall be from separate sections of the main switchboard or from distribution boards supplied from separate sections of the main switchboard.

For single control and monitoring systems where independent power supplies are required, an automatic change-over for the two power supplies shall be arranged as close as possible to the consumer.

Guidance note:

Two supplies from a common power distribution board are not considered to be independent, even if the distribution board itself is fed from independent supplies.

Single control and monitoring systems in this category shall be equipped with two terminals for connection of the external power supply cables. The change-over arrangement shall then be located on the consumer side of these terminals.

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304 *Additional emergency supply*

For control and monitoring systems where supply from both main and emergency source of power are required, but not requiring independent supplies, the power may be supplied by a single circuit from a power distribution board provided that this distribution board is supplied from both the main- and emergency distribution systems. Such a distribution board shall be located in the same space as the system being served.

Guidance note:

The emergency switchboards alone are not considered to comply with the above, even if supplied from main switchboard during normal operation.

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305 *Uninterruptible power supply (UPS)*

For control and monitoring systems where both un-interruptable and independent power supplies are required, at least one of the supplies shall be provided with stored energy.

Guidance note:

A UPS alone is not considered to provide the required independency, even if the UPS itself is fed by two independent supplies and equipped with static bypass. An electrically independent bypass is required.

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306 *Monitoring of power supplies*

Upon failure of the power supply to essential and important functions, an alarm shall be initiated unless loss of function will otherwise be alarmed. In case of duplicated or independent power supplies, both supplies shall be monitored.

F 400 Low voltage shore connections

401 *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 receiving switchboard. 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 receiving switchboard.

b) In the receiving switchboard, the circuit shall, at least, be provided with a switch-disconnector.

c) If the shore connection is supplying power via the emergency switchboard, the following applies:

— C105 d) shall be complied with.
— Undervoltage disconnection of the power supply from shore shall be arranged so that the shore connection supply is disconnected upon loss of power in order to enable automatic start and connection of the emergency generator.

d) For AC 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 may then have short circuit and overcurrent protection in the receiving switchboard only.

Guidance note:

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

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G. Protection

G 100 System protection

101 *Overload protection*

a) Load shedding or other equivalent automatic 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.

c) A load shedding, or load reduction system, if installed, shall be activated at a load level suitable below 100% of the overload or overcurrent protection setting.

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. For high voltage system the alarm shall be both audible and visual (IACS E11 2). However, audible or visual indication can be omitted provided automatic disconnection is arranged. The circulation current generated by each device for insulation monitoring shall not exceed 30 mA under the most unfavourable conditions.

b) The requirements in a) shall be applied on all galvanic isolated circuits, 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 systems with low-resistance 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.

e) Test lamps or similar without continuous monitoring is accepted for:

— battery systems not extending their circuits outside a single panel
— battery system for non-important systems below 50 V and
— battery systems serving one function only.

f) For direct-earthed system (TN) the three-phase overcurrent and short circuit protection is accepted as earth fault protection.

103 *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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104 *Discrimination*

All circuits in the electric distribution systems shall have protection against accidental overcurrents and short circuits as described in G200. The protective devices shall provide complete and co-ordinated protection through discriminative action in order to ensure:

— Continuity of supply to essential consumers and emergency consumers.
— Continuity of services to important consumers where supply to healthy circuits shall be automatically re-established.
— Elimination of the fault to reduce damage to the system and hazard of fire.

Guidance note:

Continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.

Continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.

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G 200 Circuit protection

201 *General*

a) Each separate circuit shall be protected against short circuit with the protection in the feeding end.

b) Each consumer shall be protected against overcurrent.

c) All consumers shall be separately protected.

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

e) A fuse, switch or breaker shall not be inserted in earthing connections or conductors. Earthed neutrals may be disconnected provided the circuit is disconnected at the same time by means of multipole switch or breaker.

f) The circuit breaker control shall be such that “pumping” (i.e. automatically repeated breaking and making) cannot occur.

g) Circuits for heating cables, tapes, pads, etc. should be equipped with earth fault breakers. See Sec.10 C1000.

Exceptions

— For special requirements for protection of steering gear circuits, see DNV-OS-D101.
— For emergency generator see C302.
— Circuit supplying multiple socket outlets, multiple lighting fittings or other multiple non-important consumers is accepted when rated maximum 16 A in 230 V systems, or 30 A in 110 V systems.
— Non-important motors rated less than 1 kW, and other non-important consumers, rated less than 16A, do not need separate protection.
— Separate short circuit protection may be omitted for consumers serving non-important services. Each motor shall have separate overcurrent protection and controlgear.
— Separate short circuit protection may be omitted at the battery or busbar end of short circuit proof installed cables.

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) 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 with sufficient breaking capacity protecting the circuit breaker and connected equipment from damage.

d) 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)

e) If the main switchboard is divided by a switch disconnector (IEC 60947-3) or a circuit breaker (IEC 60947-2) 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)

f) Provided that the main switchboard is divided by a bus tie circuit breaker 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)

g) 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)

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

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

c) 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 busbar 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 the single phase voltage transformers shall be protected. The protection may be 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 withstands 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 short circuit and overcurrent protection.

b) The overcurrent protection shall normally be set so that the generator breaker trips at 110% to 125% of nominal current, with a time delay of 20 s to 120 s. Other settings may be accepted after confirmation of discrimination.

c) 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.

d) Other forms for generator overload protection, for example winding over-temperature combined with power relays (watt metric relays), may substitute overcurrent protection provided the generator cables are sufficiently protected.

e) Generators having a capacity of 1 500 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.

f) 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-excited and all the generator's breakers opened, in case of short circuit between the generator's terminals and the generator's breakers.

g) When a generator is installed outside the space where the switchboard with the generator circuit breaker is installed, the generator cable shall have short circuit protection at both ends. Alternatively, the generator shall be de-excited and the switchboard generator breaker opened, in case of short circuit between the generator's terminals and the generator breaker. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the engine room, is not considered as separating the switchboard from the generator.

h) 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 shall not depart from the set point by more than 50% at voltage variations down to 60% of the rated voltage, and on AC installations at any power factor variation.

i) Generator circuit breakers shall be tripped at undervoltage. This undervoltage protection shall trip the breaker when the generator voltage drops within the range 70% to 35% of its rated voltage.

j) The undervoltage protection shall have a time delay allowing for correct operation of the short circuit protection (I.e. longer time delay than the short circuit protection.)

k) The undervoltage protection shall allow the breaker to be closed when the voltage and frequency are 85% to 110% of the nominal value.

l) 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.

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

n) 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) For liquid filled transformers see Sec.6 A202.

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 DC motors, overcurrent relay in one pole can be used, but this cannot then substitute overcurrent release at the switchboard
— for AC 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 DNV-OS-D101)
— 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.

G 600 Battery protection

601 *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, i.e. one of the methods described in Ch.1 Sec.1 D501 must be used.

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, and with a switch for isolating purposes. Auxiliary circuits, which are branched off from the starter motor circuit, shall be protected as required in a).

G 700 Harmonic Filter protection

701 *Harmonic filters*

Each harmonic filter shall be protected against overcurrent and short circuit.

Circuit protection in filter circuits shall be monitored and provided with alarm in a manned control station.

Guidance note:

Harmonic filters connected as network units (not as integrated parts of a converter) shall have isolating switchgear as required for important consumers in F101.

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H. Control of Electric Equipment

H 100 Control circuits

101 *General*

All consumers other than motors shall be controlled by, at least, multi-pole switchgear, except that single pole switches can be used for luminaries 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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102 *Power supply to control circuits*

a) Power supply to control circuits for steering gear shall be branched off from the motor power circuit.

b) All other essential and important consumers control circuits may be arranged as in a) or they may be supplied by a control distribution system as long as:

— Consumers serving duplicated essential or important services are supplied by independent power supplies in accordance with F303.
— Supplies to consumers serving non-duplicated essential services and where the rules require two independent power supplies (main and back-up), are arranged in accordance with F303.
— The control circuit to each consumer has separate short circuit protection.

c) Upon failure of the power supply to essential and important functions, an alarm shall be initiated. In case of duplicated supplies, both shall be monitored.

H 200 Control of generator sets and main power supply

201 *General*

a) Tachometer feedback to the starting system shall be arranged so that mechanical or electrical failures do not lead to stop of a running generator unit. Neither shall such faults inhibit automatic stop or alarm functions.

b) The following alarms shall be arranged at a manned control station:

— power failure to the control system
— high and low frequency on the main busbars
— high and low voltage on the main busbars.

202 *System for automatic start and stop of generator prime movers and automatic operation of breakers*

Where start, stop and load sharing between generators, is controlled by an automation system the following shall be arranged:

a) The following alarms shall be arranged at a manned control station:

— starting failure of prime mover
— 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.

b) Automatic starting attempts which fail shall be limited to restrict consumption of starting energy.

c) The generator circuit breaker shall be provided with automatic wind up of the closing spring of the breaker.

d) Simultaneous connection of generators on to the same bus shall not be possible.

e) Automatic connection of a generator during blackout shall only be possible when auxiliary contacts on all generator circuit breakers show directly that all generators are disconnected from the main switchboard and the bus is dead.

f) When a generator unit is standby, this shall be indicated on the control panel.

g) No more than one attempt of automatic connection per standby generator is permitted to a de-energised switchboard.

h) Systems with automatic start of the standby unit at heavy load on running units shall be arranged with adequate delay to prevent false start attempts, e.g. caused by short load peaks.

i) If the generator breaker has a "test" position, this shall be recognised by the control system as not available.

j) Automatic connection of generator shall not take effect before the voltage of the generator is stable and at normal level.

k) It shall be possible to select a minimum number of running generator sets or to deselect functions for automatic stop of generator sets at low load.

l) For requirements to system functionality, see B200.

H 300 Main and emergency switchboard control

301 *General*

a) Power supply for control circuits to generator breakers and generator protection shall generally be branched off from the main circuit (i.e. generator side for the generator breaker). For exception, see 302.

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 302.

c) Where the main switchboard is arranged for operation from an automation system, the switchboard shall in addition be arranged for local operation at the front of the switchboard or at a dedicated control position within the switchboard room. This local operation shall be independent of remote parts of the automation system.

   Exception:

   For production systems, power plants not used for propulsion and steering e.g. process plant, alternative arrangement may be accepted.

d) Any casualty within one compartment of the main or emergency switchboard should not render more than one generators circuit breakers, nor their instrumentation and signals, inoperative.

e) Requirements for automatic operation of generator breakers are given in 202.

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

302 *Battery supplied control power*

a) The power supply to the control circuits may be from a battery installation when arranged as required for starting batteries. Generator circuit breakers and other duplicated essential and important equipment shall be supplied from independent power supplies as described in F302.

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

c) Each auxiliary control power supply system shall 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.

303 *Generator instrumentation*

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

   — control and indication of breaker open and breaker close
   — generator power (kW)
   — 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. At an operating station one reading is sufficient.
   — generator voltage
   — generator frequency
   — busbar voltage
   — busbar frequency
   — adjustment device for speed of generator prime mover. (Not required at operator stations if load sharing is controlled by the automation system.)

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 busbar by a synchronising device independent of any other sections of the switchboard.

Alternatively one independent synchronising device for each generator will be accepted.

Exception:

Synchronisation of generators driven by propulsion engines may be achieved by adjusting the busbar frequency, i.e. by adjusting the speed/frequency set point(s) of the running generator(s).

304 *Auxiliary generators 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 and generator driver shall be equipped with remote control and alarms as required by class notation **E0**.

A generator installed in accordance with this will generally not be taken into account with respect to total generator capacity, see B.

305 *Sectioning of busbars*

a) Switchgear for sectioning of busbars 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 accepted as long as the switchgear has sufficient capacity for breaking the prospective fault current at the point of installation.

306 *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 non-synchronous systems, necessary interlocks shall be arranged to preclude parallel operation of the transformers when the primary sides are not connected.

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 to ensure 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 400 Motor control

401 *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 re-start after a blackout situation
— each motor rated less than 1 kW: a multipole switch.

For exemptions and additions regarding steering gear motors, see DNV-OS-D101.

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.

f) For requirements to emergency stop, see 500.

402 *Interlock for motor starting*

a) If the starting of a 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.

H 500 Emergency stop

501 *Arrangement of emergency stop circuits*

When emergency stop of a consumer is required by the rules, the following principles apply:

— The arrangement of the emergency stop system shall be such that no single failure will cause loss of duplicated essential or important equipment.
— The control circuits for emergency stop of duplicated equipment shall be arranged as two separate circuits with separate cables. A common stop button with several contacts (separate for each consumer) will be accepted.
— The emergency stop signal shall act independently of any software based control system for the same consumer.
— A computer based emergency stop systems shall be independent from other computer based systems with control functions for the same consumers. It shall have facilities to detect failures that will set the system inoperable, and give alarm to the main alarm system. See DNV-OS-D202.
— Alarm for loss of power shall be provided 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 systems having effect on propulsion motors and thruster should be based on NO circuits.

Circuit breakers and motor starters should be prepared for NE/NDE trip as required in DNV-OS-A101 Sec.5 and the ESD philosophy for the offshore unit.

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502 *Emergency stop of oil pumps and fans*

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 feed and booster pumps
— nozzles cooling pumps when fuel oil is used as coolant
— fuel and lubrication oil purifiers
— pumps for oil-burning installations
— fans for forced draught to boilers
— all ventilation fans
— all electrical driven lubrication oil pumps
— thermal oil circulating pumps
— hydraulic oil pumps in machinery space.

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.

Guidance note 1:

Emergency stop will not be required for the following:

- fans not capable of supplying outside air to the space such as fans in HVAC temperature control units, fans for heating coils, ventilation fans for cabinets and switchboards, etc.
- pumps for systems containing less than 500l of flammable oil.

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Guidance note 2:

As long as the functional requirements in this paragraph are met, the emergency stop of pumps and fans may be included in the offshore unit's ESD system required by DNV-OS-A101 Sec.5.

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I. Offshore unit 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) Where 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 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.

b) 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.

c) The integrity of the main electrical supply shall be affected only by fire, flood or other damage conditions, in one space. The main switchboard shall be located as close as is practicable to the main generating station.

d) 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.

e) 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.

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

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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I 200 Switchboard arrangement

201 *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. Ventilation and air conditioning systems shall be so arranged that possible water or condensation 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) 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 A108), are not accepted installed in machinery space category "A".

f) 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.

202 *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.

203 *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 as given in Table I1.

c) Where switchgear needs passage behind for installation and maintenance work the free passage behind the switchgear shall be as given in Table I1.

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.

Table I1

	Width of front passage		*Width of passage behind*	
System voltage	*Unobstructed*	*With doors open or switchgear drawn out*	*Minimum free passage*	*Minimum free passage at frames*
Below 500 V	0.8 m	0.4 m	0.6 m	0.5 m
500 V ≤ and ≤ 1 000 V	0.8 m	0.4 m	0.8 m	0.6 m
Above 1000 V	1.0 m	0.5 m	1.0 m	0.6 m

204 *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, shall comply with enclosure type IP 20 with exemption for fuses as specified in Sec.4 A103.

205 *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.

I 300 Rotating machines

301 *General*

a) On ship-shaped offshore units, generating sets with horizontal shaft shall generally be installed with the shaft in the fore-and-aft direction.

b) Where a large machine is installed on column-stabilised units, self-elevating units or athwartships on ship shaped units, it should be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in DNV-OS-D101 Ch.2 Sec.1 B. In such cases, the manufacturer should be informed when the machine is ordered.

c) Normally pipes shall not be installed above generators. If this is unavoidable, additional screening of flanges shall be required in order to protect the generator against splash, spray or leakage. Such screening shall be provided with drains, if necessary.

I 400 Battery installations

401 *Application*

These requirements are applicable to all types of rechargeable batteries.

Guidance note:

Installation of battery types which may not produce explosive gasses but which may require other safety precautions will be evaluated on a case-by-case basis. Installation and ventilation recommendations from the manufacturer should always be followed.

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402 *Hazardous area*

Requirements for installation of electrical equipment in battery rooms are given in Sec.11 C205.

Table I2 Location and ventilation of vented type (liquid electrolyte)

Total capacity of batteries	*Acceptable location*	*Acceptable ventilation*
> 20 kVAh	Dedicated battery room	Mechanical extract ventilation to open air. If the ventilation fails, an alarm shall be given
> 5 kVAh and ≤ 20 kVAh	Battery box with ventilation to open air	Natural ventilation or mechanical extract ventilation with alarm when the ventilation fails.
≤ 5 kVAh	Battery box with ventilation holes at upper part of box	Ventilated to the room as described in 404.

Table I3 Location and ventilation of valve regulated/dry types

Total capacity of batteries	*Acceptable location*	*Acceptable ventilation*
> 100 kVAh	Dedicated battery room	Mechanical extract ventilation to open air. If the ventilation fails, an alarm shall be given
>5 kVAh and ≤ 100 kVAh	Battery box or open battery stand providing mechanical protection and human safety against touching of live parts (IP 10).	Natural ventilation to room as described in 404. Dry and well ventilated room.
≤ 5 kVAh	Battery box or separate part of an electrical assembly	Ventilation holes at upper part of box. Also at lower part where found appropriate.
≤ 5 kVAh and > 0.2 kVAh	Inside an electrical assembly/enclosure	Mechanical ventilation
≤ 0.2 kVAh	Inside an electrical assembly/enclosure	Natural ventilated

403 *Arrangement*

a) Requirements for the location and ventilation of vented batteries are given in Table I2 and of valve regulated/dry batteries are given in Table I3.

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

— the batteries shall be so located that their ambient temperature remains within the manufacturer's specification at all times
— 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
— the space above cells shall be sufficient for maintenance and cooling
— normally, batteries shall not be located in sleeping quarters.

c) Normally batteries shall not be located in a battery box at open deck exposed to sun and frost. Batteries may exceptionally be accepted located at open deck on the following conditions:

— the box shall be white in colour, and be provided with ventilation and heating.
— the charger must be provided with temperature compensation capability.

d) Additional requirements for GMDSS batteries installed in accordance with c):

— the battery box shall be situated above the main muster stations.

Guidance note:

Required capacity for GMDSS battery to be calculated according to the formula (for 1 hour and 6 hours of operation respectively, depending on provision of approved an emergency generator):

$$C_1 = 1.5\left[\frac{1}{2}(T_1 + T_2 + \ldots + T_M) + R_1 + R_2 + \ldots + R_M + L_{em}\right]$$

$$C_6 = 1.5\left[\frac{1}{2}(T_1 + T_2 + \ldots + T_M) + R_1 + R_2 + \ldots + R_M + L_{em}\right] 6$$

Where:

T = power consumption of GMDSS transmitter 1 to M

R = power consumption of GMDSS receiver 1 to M

L = power consumption of emergency lighting

M = number of GMDSS transceivers.

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404 *Ventilation*

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.

b) Ventilation openings from rooms where batteries are installed shall be of a non-closable type suitable for all weather conditions.

Guidance note:

Openings located lower than 4.5 m above the freeboard deck are subject to approval. See Rules for Classification of Ships Pt.3 Ch.3 Sec.6 H303. For small vessels other suitable arrangement may be accepted.

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c) Natural ventilation to open air shall be through an unobstructed duct not inclined more than 45 degrees from the vertical. The natural escape of air shall not be reduced by the room ventilation system; i.e. the room shall not have negative air pressure.

d) Ventilation rate, (m^3/hour), for battery rooms and lockers with mechanical extract ventilation to open air shall comply with the following:

— for vented batteries, 10 × sum of battery kVAh
— for dry batteries, 2 × sum of battery kVAh.

e) Rooms into which battery lockers or boxes are ventilated shall have an extract ventilation duct at ceiling level. The area of the room (m2) shall be at least 0.3 times battery kVAh. Ventilation rate of the room shall be at least 6 air changes per hour.

Guidance note:

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

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405 *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.11) 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 404. 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 500 Cable routing

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

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

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

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

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

d) 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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503 *Separation of main generators or main power converters cabling*

a) Cables for generators, transformers and converters required according to Sec.2, shall be divided between two or more cable runs. As far as practicable, these cable runs shall be routed away from each other and away from areas protected by Fixed Water-Based Local Application Fire-Fighting Systems, i.e. boiler fronts, purifiers for heated fuel oil, the fire hazard portions of internal combustion machinery and incinerators.

b) 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) and mechanical damage.

I 600 Lightning protection

601 *General*

a) All offshore units 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 70 mm^2 in copper or equivalent surge carrying capacity in aluminium.

d) The conductor shall be fastened to a copper spike of minimum diameter 12 mm reaching a minimum of 300 mm above the mast. The conductor shall terminate to a copper plate with a minimum area of 0.25 m^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.

I 700 Earthing of aluminium superstructures on steel offshore units

701 *General*

Aluminium superstructures that are provided with insulating material between aluminium and steel in order to prevent galvanic action, shall be earthed to the hull. For this purpose, corrosion-resistant metal wires or bands shall be used. The distance between each such connection shall be maximum 10 m. The sum of conductivities of all connections for one superstructure shall not be less than 50 mm^2 copper, and the conductivity of each

connection shall not be less than 16 mm^2 copper.

Provisions shall be made for preventing galvanic action at the terminals of these connections (e.g. by using "Cupal" terminals when copper wires or bands are connected to the aluminium constructions).

Guidance note:

With regard to radio interference, it may be necessary to use shorter spacing between the connections than the 10 m specified above.

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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 offshore unit.

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

— I500- 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*

a) Cables for services, required to be operable under fire conditions shall be of fire resistant type complying with the requirements of IEC 60331-, where they pass through machinery spaces of category A and other high fire risk areas other than those which they serve. this requirement also applies for cables passing through fire zones. (IACS UR E15)

b) Systems that are self-monitoring, fail safe or duplicated with runs as widely as is practicable may be exempted.

c) The following electrical services are required to be operable under fire conditions:

— fire and general alarm system
— fire extinguishing systems and fire extinguishing medium alarms
— control and power systems to power operated fire doors and status indication for all fire doors
— control and power systems to power operated watertight doors and their status indication
— emergency lighting
— public address system
— low location lighting
— emergency fire pump (IACS UI SC 165)
— remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and or explosion (IACS UR E 15)
— ESD/PSD, fire and gas detection systems.

Guidance note:

"High fire risk areas" in the context of above Rules are:

- machinery spaces of category A
- galleys and pantries containing cooking appliances
- laundries containing drying equipment
- saunas
- sale shops, barber shops and beauty parlours
- paint lockers and other store-rooms for flammable liquids.

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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.

Guidance note:

It is recommended that cables used for semiconductor converters for motor drives are selected with increased voltage rating in order to withstand voltage transients. Maker's recommendations should be followed.

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b) Cables designed in accordance with Sec.9 E100 are only accepted for use in control and instrumentation systems up to 250 V.

c) In power distribution systems, with system voltage up to 250 V, 0.6/1 kV power cables in accordance with Sec.9 D100 shall be used.

Guidance note:

Cables designed in accordance with IEC 60092-376 is not accepted as power cable, and can therefore not be used for light circuits etc., only instrumentation and control circuits

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d) In systems with high-resistance earthed neutral 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	-

e) In systems with insulated neutral (IT-systems), the rated phase to earth voltage (U_0) of the cables shall be as for systems with high-resistance earthed neutral without automatic disconnection upon earth fault.

Guidance note:

- 0.6/1 kV cables may be accepted in 690 V distribution system
- 3.6/6 kV cables may be accepted in 6.6 kV distribution system with automatic disconnection upon earth fault if accepted by manufacturer.

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104 *Colour code on earthing cable*

Colour code is not required on earthing cables. However if yellow/green colour code is used, it shall be used for protective earthing only.

105 *Cable separation and protection*

Separate cables shall be used for circuits provided with separate short circuit or over current protection except for:

— control circuits branched off from a main circuit may be carried in the same cable as the main circuit
— multicore cables used intrinsically safe circuits see Sec.11 D206
— special cables such as umbilicals to be considered in each case.

J 200 Cable temperature

201 *Cable temperature class*

The temperature class of power cables shall be at least 10°C above the ambient temperature.

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. The conductor temperature classes are given in IEC 60092-351.

302 *PVC insulated conductors and switchboard wires*

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.

PVC-insulated conductors may be used for internal wiring of switchboards and other enclosures, and for control wiring installed in closed piping system. Other types of flame retardant switchboard wires may be accepted for the same purpose. See Sec.9.

303 *PVC insulated cables*

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

304 *Silicon 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 Rating of earth conductors

401 *Earthing connections and conductors*

a) All earthing connections of copper shall have sufficient cross-section to prevent the current density exceeding 150 A/mm^2 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) (mm^2)*	*Minimum cross-section of earth conductor*
1	i) Insulated earth conductor in cable for fixed installation. 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.10 B.	Q ≤ 16	Q
		16 < Q	1/2 of the current-carrying conductor, but not less than 16 mm^2
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 mm^2
		2.5 < Q ≤ 6	1.5 mm^2
		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 mm^2 for stranded earthing connection or 2.5 mm^2 for unstranded earthing connection
		2.5 < Q ≤ 120	1/2 of current-carrying conductor, but not less than 4 mm^2
		120 < Q	70 mm^2
4	Insulated earth conductor in flexible cable.	Q ≤ 16	Same as current-carrying conductor
		16 < Q	1/2 but minimum 16 mm^2

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 single-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 J8 apply.

504 *Bunching*

The current ratings specified in the Tables J3 to J7 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:

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

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:

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

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, cross-section and construction. 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 AC installations, and special DC installations

701 *General*

a) Generally, multi-core cables shall be used on AC 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 shall not be used as the neutral conductor.

c) The neutral conductor shall normally be a part of the power supply cable. Separate neutral cable may be accepted for cross section above 16 mm^2, if the power cable not is provided with magnetic braiding.

702 *Single-core cables*

a) Single-core cables shall not have steel-wire braid or armour when used in AC systems and DC systems with a high “ripple” content.

b) See Sec.10 C204 and C506 for fixing of single core cables.

J 800 Rating of cables

801 *Conductor current rating*

The highest continuous load carried by a cable shall not exceed the current rating specified in Tables J3 to J7, with consideration given to the correction factors given in 500.

Guidance note:

Cables used in circuits with non-sinusoidal currents should be de-rated in order to compensate for the additional heat losses. Maker's recommendations should be followed.

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Table J3 Rating of cables with temperature class 60°C

Nominal cross-section (mm²)	*Current rating (A) (Based on ambient temperature 45°C)*					
	Single-core		*2-core*		*3 or 4-core*	
1	8		7		6	
1.5	10		9		7	
2.5	17		14		12	
4	23		20		16	
6	29		25		20	
10	40		34		28	
16	54		46		38	
25	71		60		50	
35	88		75		62	
50	110		94		77	
70	135		115		95	
95	164		139		115	
120	189		161		132	
150	218		185		153	
185	248		211		174	
240	292		248		204	
300	336		286		235	
	DC	AC	DC	AC	DC	AC
400	390	380	332	323	273	266
500	450	430	383	366	315	301
630	520	470	442	400	364	329

Table J4 Rating of cables with temperature class 70°C

Nominal cross-section (mm2)	*Current rating (A) (Based on ambient temperature 45°C)*					
	Single-core		*2-core*		*3 or 4-core*	
1.5	15		13		11	
2.5	21		18		15	
4	29		25		20	
6	37		31		26	
10	51		43		36	
16	68		58		48	
25	90		77		63	
35	111		94		78	
50	138		117		97	
70	171		145		120	
95	207		176		145	
120	239		203		167	
150	275		234		193	
185	313		266		219	
240	369		314		258	
300	424		360		297	
	DC	AC	DC	AC	DC	AC
400	500	490	425	417	350	343
500	580	550	493	468	406	385
630	670	610	570	519	469	427

Table J5 Rating of cables with temperature class 85°C

Nominal cross-section (mm^2)	*Current rating (A) (Based on ambient temperature 45°C)*					
	Single-core		*2-core*		*3 or 4-core*	
1	16		14		11	
1.5	21		18		15	
2.5	28		24		20	
4	38		32		27	
6	49		42		34	
10	67		57		47	
16	91		77		64	
25	120		102		84	
35	148		126		104	
50	184		156		129	
70	228		194		160	
95	276		235		193	
120	319		271		223	
150	367		312		257	
185	418		355		293	
240	492		418		344	
300	565		480		396	
	DC	AC	DC	AC	DC	AC
400	650	630	553	536	445	441
500	740	680	629	578	518	476
630	840	740	714	629	588	518

Table J6 Rating of cables with temperature class 90°C

Nominal cross-section (mm^2)	*Current rating (A) (Based on ambient temperature 45°C)*					
	Single-core		*2-core*		*3 or 4-core*	
1	18		15		13	
1.5	23		20		16	
2.5	30		26		21	
4	40		34		28	
6	52		44		36	
10	72		61		50	
16	96		82		67	
25	127		108		89	
35	157		133		110	
50	196		167		137	
70	242		206		169	
95	293		249		205	
120	339		288		237	
150	389		331		272	
185	444		377		311	
240	522		444		365	
300	601		511		421	
	DC	AC	DC	AC	DC	AC
400	690	670	587	570	483	469
500	780	720	663	612	546	504
630	890	780	757	663	623	546

Table J7 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	26		22		18	
2.5	32		27		22	
4	43		37		30	
6	55		47		39	
10	76		65		53	
16	102		87		71	
25	135		115		95	
35	166		141		116	
50	208		177		146	
70	256		218		179	
95	310		264		217	
120	359		305		251	
150	412		350		288	
185	470		400		329	
240	553		470		387	
300	636		541		445	
	DC	AC	DC	AC	DC	AC
400	760	725	646	616	532	508
500	875	810	744	689	612	567
630	1010	900	859	765	707	630

Table J8 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	-	-	-	-	-	-	-
70	1.18	1.10	1.00	0.89	0.77	0.63					
85	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.50	-	-
90	1.10	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47	-
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 offshore unit 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 ship-shaped units shall be designed to operate satisfactorily under the following inclinations of the offshore unit:

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

b) Emergency installations on ship-shaped units shall be designed to operate satisfactorily under the following inclinations of the offshore unit:

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

c) For column-stabilised and self-elevating 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 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 offshore units of length exceeding 90 m (duration 5 to 10 s)
— peak accelerations ±1 g for offshore units 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 offshore units 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 offshore units 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 system's nominal frequency and voltage, voltage drop in distribution and the 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/delay time of 1.2 μs/50 μs, respectively.

c) Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits given in Sec.2 A200 should not be supplied directly from the system but by alternative means, e.g. through stabilized supply.

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 8% of voltage root mean square value
— no single harmonic being greater than 5% of voltage root mean square value.

For distribution systems with harmonic distortion, see Sec.2 A207.

104 *Electromagnetic compatibility (EMC)*

Equipment producing transient voltage, frequency and current variations shall not 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 exterior parts shall not be so high that fire risk, damage to the equipment, adjacent materials or danger to personnel occurs. The temperature rise shall not exceed 50°C. Exemptions may be considered for equipment that is especially protected against touching or splashing of oil.

b) For enclosures installed in contact with flammable materials such as wooden bulkheads, the temperature rise limit is 40°C.

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

d) Maximum temperature for operating handles is:

— handles and grips made of metal: 55°C
— handles and grips made of insulating material (porcelain, moulded material, rubber or wood): 65°C.

Guidance note:

Higher temperatures may be accepted for parts which normally will not be handled with unprotected hands.

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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 1 000 N applied by a flat surface 70 × 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 luminaries, 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 Flammability test in accordance with UL94 5VA, 5VB, V0 and V1 can also be accepted.

For minor equipment or non metallic parts of electrical components a glow wire test in accordance with IEC 60695-2-11 may be accepted. Parts of insulation material necessary to retain current-carrying parts should conform to a test temperature of 960 ºC.

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104 *Material deterioration 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 on additional 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.

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, DNV-OS-D101

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 dismantling and connection of external incoming cables. Twist-on or clamp-on connections inside connection boxes for lighting and small power consumers are accepted inside dry accommodation.

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 1 000 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 entrances shall be fit for the outer diameter of the cable in question.

Guidance note:

Cable entries from the top on equipment installed on open deck should be avoided unless other alternatives prove impracticable.

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D 400 Equipment protective earthing

401 *General*

a) Exposed parts of electrical installations, other than current carrying parts which are liable, under fault conditions to become live, shall be earthed. Fixing devices between a high voltage enclosure and steel hull parts shall not be relied upon as the sole earthing connection of the enclosure.

b) Switchgear and controlgear assemblies shall be fitted with earth connection(s) to ensure earthing of all metallic non-current carrying parts. In main and emergency switchboards a continuous earth-bar is required for this purpose.

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) Hinged 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 DC or AC 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.

(Interpretation of SOLAS Ch. II-1/45.1.1)

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 1 000 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 busbars 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 A108 may apply.

For frequency converters, see Sec.7.

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

Rated insulation voltage, AC root mean square or DC (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 1 000 V)	25	35

603 *Clearance and creepage distances for high voltage equipment*

a) The minimum clearance distance in high voltage equipment shall be suitable for the rated voltage having regard to the nature of the insulating material and the transient over voltages developed by switching and fault conditions. This requirement may be fulfilled by subjecting each assembly type to an impulse voltage type test according to Table D3. Alternatively, maintaining the minimum distances given in Table D2.

b) Minimum creepage distances for main switchboards and generators are given in Table D4, and for other equipment in D5.

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

d) Within the busbar section of a switchgear assembly the minimum creepage distance shall be at least 25 mm/kV for non standardised parts. Behind current limiting devices the creepage distance shall be at least 16 mm/kV. (IACS E11 2.3.2)

Table D2 Clearances for high voltage equipment 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*
1 000 - 1 100	25	25
3 000 - 3 300	55	55
6 000 - 6 600	90	90
10 000 - 11 000	120	120
Above 11 000 - maximum 15 000	160	160
1) Intermediate values with corresponding distances are accepted.		

Table D3 Alternative impulse voltage type test		
Rated voltage [kV]	*Highest voltage for equipment [kV]*	*Rated lightning impulse withstand voltage [kV]*
3.0 3.3	3.6	40
6.0 6.6	7.2	60
10.0 11.0	12.0	75
15.0	17.5	95

Table D4 Minimum creepage distances for high voltage main switchboards and generators				
Nominal voltage of the system, (V) [1]	*Minimum creepage distance (for tracking index 300) (mm)*			
	300 V	*375 V*	*500 V*	*> 600 V*
1 000 - 1 100	26 [2]	24 [2]	22 [2]	20 [2]
3 000 - 3 300	63	59	53	48
6 000 - 6 600	113	108	99	90
10 000 - 11 000	183	175	162	150
1) Intermediate values with corresponding distances are accepted. 2) Minimum 35 mm is required for busbars and other bare conductors in main switchboards.				

Table D5 Minimum creepage distances for other high voltage equipment				
Nominal voltage of the system, (V) [1]	*Minimum creepage distance (for tracking index 300) (mm)*			
	300 V	*375 V*	*500 V*	*> 600 V*
1 000 - 1 100	18	17	15	14
3 000 - 3 300	42	41	38	36
6 000 - 6 600	83	80	75	70
10 000 - 11 000	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 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 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, cables*

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 shall be marked.

f) External instrumentation and control cables shall be marked for identification inside the cabinet. Each core in a cable shall be marked in accordance with Sec.9 B103. The identification marking used shall be reflected in the wiring diagram or schematics.

Guidance note:

It is expected that the owner and the shipyard agree a mutually acceptable method of providing permanent identification marking.

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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. For cables see requirements in Sec.9.

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 and Ch.1 Sec.1 regarding tracking index.

Table F1 General insulation classes

Insulation class (thermal class)	*Maximum temperature °C*
A	105
B	130
E	75
F	155
H	180
220	220

SECTION 4
SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

A. Construction

A 100 General

101 *Applicable standards*

a) Switchgear and controlgear assemblies shall generally comply with IEC 61439-1 and IEC 60092-302 for low voltage equipment, and IEC 62271-200 for high voltage equipment.

b) Electronic equipment used in switchgear shall comply with environmental requirements given in DNV-OS-D202.

102 *General*

a) All switchboards and assemblies shall be safe against accidental touching of live conductors during normal operation of the switchboard or assemblies. (Interpretation of SOLAS Ch. II-1/45.2)

b) A low voltage 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. For high voltage equipment or assemblies, see B201.

c) For switchgear constructed and type tested in accordance with IEC 60439-1 sections can be designed to withstand the short-circuit stress occurring on the load side of the respective short-circuit protective device as stated in IEC 60439-1 item 7.5.5.1.2. However, this reduced short-circuit level shall not be less than 60% of the short circuit rating of the main busbars.

103 *Accessibility*

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

b) All other parts that might require operation shall be accessible. If placed behind doors, the interior front shall 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, shall be hinged.

d) Hinged doors, which shall be opened for operation of equipment, shall 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 shall be accessible for maintenance work.

Guidance note:

Normally, all connections of conductors, busbar joints and mechanical fastening of components and busbars 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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104 *Materials*

Framework, panels and doors are normally to be of steel or aluminium alloy, and shall 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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105 *Circuit separation*

a) There shall 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 shall 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. Alternatively, an arrangement without flame retardant partitions

may be accepted, provided the busbar is divided with a circuit breaker with short circuit protection, located in a separate 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 shall be placed in cubicles separated from all other parts of the switchboard by partitions of flame retardant material.

e) Equipment for different distribution systems shall be placed in separate switchboards (panels), or shall 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.

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

(IACS UR E11.2)

i) Each outgoing circuit from a switchboard shall be provided with a switch for isolating purposes in accordance with B105. If remote from the consumer, the switchgear shall be lockable in the "off" position. For isolating purposes, a group of non-important consumers may be fed from one common switchgear.

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

Guidance note:

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 when front door is opened.

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106 *Handrails*

Main and emergency switchboards and other switchboards requiring operation shall have handrails with an insulating surface.

107 *Nameplates and marking*

a) Switchgear and controlgear assemblies shall be marked in accordance with general requirements given in Sec.3 E.

b) Protection devices shall be permanently marked with voltage, current and breaking capabilities.

c) Protection devices with adjustable settings shall have means that readily identify the actual setting of the protective device.

d) Circuit designation for outgoing circuits and incoming feeders shall be marked for identification.

e) The appropriate setting of overload protective device for each circuit shall be permanently indicated at the location of the protective device. (Interpretation of SOLAS Reg. II-1/45.6.2)

Guidance note:

A document placed inside that assembly with the data required in d) and e) will be accepted.

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108 "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 61439-1) 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 61439-1
— maximum operating temperature of busbars 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".

b) For busbar trunking systems where the conductors are fixed for the whole length with an insulating rail or similar, distances in accordance with IEC 61439-1 Table 14 and 16, pollution degree 3, inhomogeneous field, may be accepted.

B. Power Circuits

B 100 Power components in assemblies

101 *Main busbar sectioning*

See Sec.2 for requirements regarding main busbar division arrangement.

102 *Busbar materials*

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

b) Copper coated aluminium or pure aluminium busbar 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 busbars*

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

b) Busbars and other conductors with their supports shall 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 busbars for neutral connection on an AC three-phase, four-wire system, and for equaliser connection on a DC system, shall be at least 50% of the cross-section for the corresponding phases (poles).

d) For maximum temperatures of busbars in type tested and partially type tested assemblies the requirement in A108 applies.

e) The maximum permissible load for copper busbars with ambient temperature 45°C is given in Table B1.

f) Rating of aluminium busbar to be documented by type test report.

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 be rated as required by Sec.2 G202, and comply with:

   — IEC 60947 for low voltage equipment
   — IEC 60470, IEC 62271-100, IEC 62271-102 for high voltage equipment.

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

c) All load switches and contactors shall 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 element as making and breaking contacts are not accepted in place of switches, where such are required. Fuse switches may be accepted as isolating switches.

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

f) Undervoltage and closing coils, including contactor coils, shall allow closing of the switchgear and controlgear when the voltage and frequency are 85 to 110% of nominal value. The undervoltage protection shall release if the voltage is below 70% or absolutely below 35% of nominal voltage.

g) Each circuit-breaker rated more than 16 A shall be of trip-free type, i.e. the breaking action initiated by short-circuit and overcurrent relays, or by undervoltage coil, when fitted, shall be fulfilled independently of the position or operation of manual handle or of other closing devices.

Table B1 Rating of copper busbars								
With x thickness (mm)	*Maximum permissible loading [A] with 50/60 Hz*							
	Painted (matt-black)				*Bare*			
	Numbers of bars				*Numbers of bars*			
	1 |	2 ||	3 |||	4 || ||	1 |	2 ||	3 |||	4 || ||
15 × 3	230	390	470	-	200	350	445	-
20 × 3	290	485	560	-	250	430	535	
20 × 5	395	690	900	-	340	620	855	-
20 × 10	615	1 145	1 635	-	530	1 020	1 460	-
25 × 3	355	580	650	-	300	510	615	-
25 × 5	475	820	1 040	-	405	725	985	-
30 × 3	415	670	735	-	350	590	700	-
30 × 5	555	940	1 170	-	470	830	1 110	-
30 × 10	835	1 485	2 070	-	710	1 310	1 835	-
40 × 5	710	1 180	1 410	-	595	1 035	1 350	-
40 × 10	1 050	1 820	2 480	3 195	885	1 600	2 195	2 825
50 × 5	860	1 410	1 645	2 490	720	1 230	1 560	2 380
50 × 10	1 260	2 130	2 875	3 655	1 055	1 870	2 530	3 220
60 × 5	1 020	1 645	1 870	2 860	850	1 425	1 785	2 740
60 × 10	1 460	2 430	3 235	4 075	1 220	2 130	2 850	3 595
80 × 5	1 320	2 080	2 265	3 505	1 095	1 795	2 170	3 370
80 × 10	1 860	2 985	3 930	4 870	1 535	2 615	3 460	4 275
100 × 10	2 240	3 530	4 610	5 615	1 845	3 075	4 040	4 935
120 × 10	2 615	4 060	5 290	6 360	2 155	3 545	4 635	5 580
Note: The current rating is based on 45°C ambient air temperature. Sufficient ventilation must be ensured, or the loading values shall be reduced.								

106 *Internal wiring*

a) Connections to/from busbars to the short circuit protection shall be installed short-circuit proof, as defined in Ch.1 Sec.1. This requirement also applies to branching off for control power and measuring signals from busbars and generator terminals.

b) Interconnection between busbars shall be short circuit protected according to Sec.2 G201 if the length of the cable/wire/flexible busbar exceeds 3 m.

c) Switchboard wires shall as a minimum be insulated single core wires unless used in a short circuit proof installation requiring double insulating wires or conductors.

Guidance note:

In distributions boards where the connections mentioned in a) are sufficiently protected by upstream short circuit protection devices, the required short circuit proof installation may be exempted.

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107 *Screening of horizontally installed busbars*

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

108 *Clearance and creepage distances*

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

B 200 Additional requirements for high voltage assemblies

201 *General design and construction*

a) High voltage switchgear and controlgear assemblies shall be metal-clad in accordance with IEC 62271-200, 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 A of IEC 62271-200 Type A, Accessibility A with arcing time 1 s unless pressure relief flaps have been proven effective. Then arcing time as low as 0.1 s is accepted).

Guidance note:

Accessibility A implies access only by instructed personnel, and that safe operation only is in front of the switchboard.

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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 busbars).

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.

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

e) Means shall 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.

202 *Mechanical interlocks*

a) The arrangement in high voltage enclosures shall 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) shall 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, shall 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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203 *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, shall be accessible without exposing high voltage parts.

c) An alarm shall be arranged 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 shall be arranged. However, manual closing of the circuit breakers shall not 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.

204 *Safety earthing of high voltage circuits*

Each circuit shall 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, shall be kept on board.

C. Control and Protection Circuits

C 100 Control and instrumentation

101 *General*

a) Requirements for power supply and distribution of control circuits are given in Sec.2 H200.

b) For short circuit proof installation of control cables, see B108.

102 *Control of duplicated consumers*

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

b) Controlgear for duplicated essential or important equipment shall be mutually independent and shall 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*

Incandescent signal lamps shall 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 shall be at least 130% of the rated full load of the circuit. For generators arranged for parallel operation, the scale shall 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 shall be at least 120% of the nominal voltage.

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

d) Frequency meters shall be able to indicate values within a ranging at least 8% below and above the nominal frequency.

105 *Generator instrumentation and control*

a) Each generator cubicle shall as far as possible function independently as required in Sec.2 H300. The wiring of each generator circuit breaker's control and release circuits (e.g. undervoltage circuit) is generally to be kept within its cubicle. Exemption: shunt-operated circuits for closing/opening of the circuit-breaker may be carried out e.g. to a common control panel.

b) Each AC generator shall be provided with instrumentation as listed in Sec.2 H303. Instrumentation for current, voltage and frequency shall be arranged for simultaneous and continuous reading.

c) When generators are arranged for parallel operation, they shall in addition be provided with synchronising devices as required by Sec.2 H303.

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

Alternatives

Single voltmeters and ampere meters 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 busbars. A "double frequency meter" may be used for this purpose.

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

Each secondary distribution system shall be equipped with a voltmeter.

107 *Instrumentation for shore connections*

The shore connection circuit shall be equipped with:

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

D. Inspection and Testing

D 100 General

101 *Factory testing*

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, shall be tested
— insulation resistance test
— high voltage test.

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.

Guidance note:

Factory testing of switchgear or control gear assemblies at full power is normally not required.

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104 *Onboard testing*

Switchgear or controlgear assemblies shall be subject to complete function tests after installation onboard. See Sec.10 D.

105 *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 1 000 V with a minimum of 1 500 V. The test voltage shall 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) As an alternative to the voltage test in a), impulse voltage test in accordance with IEC 61439-1 Section 8.3.2 can be carried out for type tested (TT) and partly type tested (PTT) low voltage assemblies

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. The insulation level shall be at least 1 MOhm.

Guidance note:

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

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

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106 *Power frequency test for high voltage assemblies*

a) Each high voltage assembly shall 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 shall be subjected to a 1 minute voltage test between the circuits and the enclosure

according to 105.

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 1 013 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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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*

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

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

202 *Insulation*

a) All windings for machines shall 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 temperature rise in windings is given in Table A1, with the following exceptions:

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. Maximum acceptable increase is 20°C.

b) If the ambient temperatures clearly exceed the maximum upper limits, then the temperature rises shall 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 offshore units 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 shall 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 13°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 13°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 13°C and may be further increased by an amount not exceeding the amount by which the cooling temperature is less than 32°C.

h) For machines with insulating class 220 the temperature rise will be evaluated in each case.

Table A1 Limits of temperature rise of machines for offshore units for unrestricted service 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 (ºC) Insulation class*				
			A	*E*	*B*	*F*	*H*
1.	a) AC winding of machine having output of 5 000 kVA or more	ETD R	60 55	-[3] -	80 75	105 100	125 120
	b) AC winding of machine having output of less than 5 000 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 AC and DC 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 DC excitation	R			85	105	130
	b) Stationary field windings of DC 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 AC and DC machines and compensating windings of DC machines having more than one layer	R, T	55	70	75	95	120
	d) Single-layer windings of AC and DC machines with exposed bare surfaces or varnished metal surfaces and single compensating windings of DC machines	R, T	60	75	85	105	130

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 5 000 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 5 000 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 5ºC.

204 *Machine short time overloads*

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

— AC induction motors and DC 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
— AC 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
— AC 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 9.3.

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

— AC 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
— AC 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 shall 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 shall comply with the requirements in DNV-OS-D101 both with regard to strength, bearings and balancing.
b) Means shall 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 shall be capable of withstanding 1.2 times the rated maximum speed for a period of 2 minutes.

209 *Nameplate*

Each machine shall be provided with nameplate of durable 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 AC 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*

Low voltage machines having a rated output above 5 000 kW (or kVA), and all high voltage machines shall 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:

See DNV-OS-D101 regarding the prime movers' speed governor characteristics and DNV-OS-D202 regarding instrumentation equipment.

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102 *Automatic voltage regulator*

The AVR shall be capable of keeping the voltage within the values specified for stationary and dynamic variations.

103 *Available neutral point*

Generators with rating exceeding 1 500 kVA, and all high voltage generators, shall be prepared for installation of equipment for short circuit protection of the generator windings.

104 *De-excitation*

Generators with rating exceeding 1 500 kVA, and all high voltage generators, shall be prepared for external signal for initiation of de-excitation of the generator.

105 *Voltage waveform*

For AC generators, the voltage shall 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 external source is arranged as required for starting arrangement.

202 *Stationary voltage regulation*

a) The voltage regulation shall 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 shall 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.

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 shall not be more than 15% of the generators nominal voltage.

  The generator voltage shall 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 shall not be more than 20% of the rated voltage.

  The generator voltage shall 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) 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.

e) See DNV-OS-D101 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 AVRs, 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*

AC 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) shall not 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 DNV-OS-D101.

Guidance note:
The sharing of power is mainly determined by the prime movers' governor characteristics, to which further requirements are given in DNV-OS-D101). 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 shall be ensured that the equalising current resulting from harmonics does not exceed 20% of the rated current of each generator.

C. Inspection and Testing

C 100 General

101 *Factory testing*

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 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: 60034-14	TT, RT	TT, RT
5	Overspeed test: 20% in excess of the rated r.p.m. for 2 minutes.	TT	TT[4)]
6	Withstand 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	Overload or overcurrent test[3)] (IEC 60034-1/9.3 and 9.4).	TT	TT
12	AC generator: Measuring of voltage regulation during steady and transient loading and unloading, see B202 and B203.	TT, RT2)	
13	AC generator: Measuring of open circuit voltage characteristics (no load curve).	TT, RT	
14	AC generator: Measuring of short circuit characteristics (short circuit curve).	TT, RT	

Table C1 Testing and inspection of electrical machines (Continued)			
No.	*Task*	*Required test for generators*	*Required test for motors*
15	AC synchronous motor or generator: Measuring of excitation current at rated voltage, current and power factor.	TT, RT	TT, RT
16	AC Synchronous generator: Measuring of steady short circuit condition.	TT	
17	For high voltage machines a steep fronted impulse test, or equivalent, of the coil interturn insulation shall 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) Only functional test of voltage regulator system. 3) Overload test for generators. Test of momentary excess torque for motors. 4) Except for squirrel cage motors			

Guidance note 1:

Overspeed test (5)

Dielectric test to be performed on rotors after overspeed test IEC 60034-1-9.7.

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Guidance note 2:

High voltage tests (6)

a) A 1 minute high voltage test should be applied to a new and completed machine with all its parts in place under conditions equivalent to normal working conditions. The test should be in accordance with IEC 60034-1-9.2 "Withstand voltage test", and should be carried out at the maker's works at the conclusion of the temperature-rise test.

b) For voltage levels to be used, see IEC 60034-1 Table 16, normally (for ac windings of machines between 1 kW and 10 000 kW) the test voltage is 1 000 V + twice the rated voltage with a minimum of 1 500 V.

c) After rewinding or other extensive repair of a machine, it should be subjected to a high voltage test with a test voltage of at least 75% of that specified in IEC 60034-1-9.2.

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 3:

Temperature rise measurement and testing (8)

a) The temperature rise of a machine should be measured at the rated output, voltage and frequency, and the temperature test should 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 should be continued until thermal equilibrium has been reached, that is when the temperature 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, see Table A1. See Guidance note 4 regarding the variety of temperature measurement methods.

d) The measurement of final winding temperature at end of the test should be performed within the time limits given in Table C2.

e) If measurements of final winding temperature should be carried out by resistance measurements according to Table C2, the temperature shall be measured as a function of time after shutdown, and correct temperature being determined by extrapolation back to the initial switch off time point.

f) The initial reading shall not be delayed by more than twice the time limits given in Table C2. (See IEC 60034-1 8.6.2 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 ≤ 50	30
50 < P ≤ 200	90
200 < P ≤ 5 000	120
5 000 < 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 should 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 should be at least six detectors suitably distributed throughout the machine windings. They should 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 should be used to determine compliance with requirements for temperature limits.

i) When there is two or more coil-sides per slot, the ETD elements should 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 should 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 4:

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
- "Equivalent loading and super-position techniques - Indirect testing to determine temperature rice.", according to IEC 61986.

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Guidance note 5:

Insulation resistance test (9)

a) The insulation resistance of a new, clean dry machine, should 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 should 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 to 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
$250 < U_n \leq 1\,000$	500	1
$1\,000 < U_n \leq 7\,200$	1 000	$(U_n / 1\,000) + 1$
$7\,200 < U_n \leq 15\,000$	5 000	$(U_n / 1\,000) + 1$

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Guidance note 6:

Overload testing (11)

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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Guidance note 7:

Alternative methods for measuring excitation current at rated voltage, current and power factor (15)

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:

— load excitation, according to IEEE Std. 115-1983, 6.2.2.

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102 *Onboard testing*

All machines shall be tested onboard, after installation, so that acceptable starting and running performance are verified with full capacity of driven equipment, alternatively full generator load. See Sec.10.

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 and relevant parts of IEC 60076.

A 200 Design requirements for power transformers

201 *General*

a) Transformers shall be double wound. Starting transformers and transformers feeding single consumers, as long as the secondary consumer has the same insulation level as the primary side, may be of autotransformer type.
b) Normally, transformers shall be of the dry air-cooled type. Where forced cooling is used, it shall be possible to operate at reduced power on failure of a pump or a fan. Power transformers with forced cooling shall be equipped with monitoring and alarm as required by Sec.3 D200.
c) All windings for air-cooled transformers shall be treated to resist moisture, sea air, and oil vapours.
d) For the general requirements for insulation materials and terminations, see Sec.3 D.
e) For requirements for busbar material see Sec.4 B100.

202 Liquid immersed transformers

a) Liquid immersed transformers, filled with liquid with flashpoint above 60°C, may be accepted in engine rooms or similar spaces if provisions have been made, when installed, for containing or safe draining of a total liquid leakage.
b) Normally, liquid immersed transformers shall 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: 55°C
— insulation class E: 70°C
— insulation class B: 75°C
— insulation class F: 95°C
— insulation class H: 120°C
— insulation class 220: 145°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 shall 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 shall be constructed to withstand a primary or secondary terminal short circuit with a duration of minimum 1 s, with rated primary voltage and frequency, without damage to internal parts or enclosure.

207 *Nameplate*

Each power transformer shall be provided with nameplate of durable material, giving the following information:

— make, type, serial no.
— performance standard
— rated values for: output apparent power, voltage(s), frequency, current(s)
— duty type, if other than S1
— thermal classification of insulation
— IP code of enclosure and termination box
— vector group of windings
— maximum permissible cooling medium temperature
— short circuit impedance value
— liquid type (if applicable)
— total mass.

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) 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.

c) 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.

d) Required inspection and tests for distribution transformers are given in Table B1.

Table B1 Testing and inspection of transformers

No.	*Task*	*Type of test*	*IEC reference*
1	Inspection of enclosure, terminations, instrumentation or protection	RT	
2	Measuring of insulation resistance	RT	
3	Measuring of voltage ratio at no load and check of phase displacement	RT	IEC 60076-11.16
4	Measuring of winding resistance	RT	IEC 60076-11.15
5	Short circuit impedance and load losses	RT	IEC 60076-11.17
6	Measuring of no-load loss and current	RT	IEC 60076-11.18
7	Separate-source AC withstand voltage test	RT	IEC 60076-11.19
8	Inducted AC withstand voltage test	RT	IEC 60076-11.20
9	Temperature rise test	TT	IEC 60076-11.23
10	Partial discharge measurement on transformer windings above $U_m \geq 3.6$ kV. Maximum level of partial discharge shall be 10 pC.	RT	IEC 60076-11.22

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 may be accepted:

— back to back method, according to IEC 60076-11 23.2.2
— simulated load method, according to IEC 60076-11 23.2.1.

103 *Separate-source AC withstand voltage test/ high voltage test*

a) A high voltage test shall be applied to a new and completed transformers.
b) The test shall be carried out immediately after the temperature rise test, when such is required.
c) The test shall be applied between each winding and the other windings, frame and enclosure all connected together. The full test voltage shall be maintained for 1 minute. For test levels, see Table B2.
d) Single phase transformers for use in a polyphase group shall be tested in accordance with the requirements for the transformers as connected together in the system.
e) After rewinding or other extensive repair the transformer shall be subjected to a high voltage test with a test voltage of at least 75% of that specified in c) above.

104 *Insulation resistance testing*

The insulation resistance of a new, clean dry transformer shall 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 B3. The test shall be carried out between:

— all current carrying parts, connected together, and earth
— all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

Table B2 Test voltages

Highest voltage for equipment U_m (kV r.m.s.)	*Rated short duration power frequency withstand voltage (kV r.m.s)*
≤ 1	3
3.6	10
7.2	20
12	28
17.5	38

Table B3 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
$250 < U_n \leq 1\,000$	500	1
$1\,000 < U_n \leq 7\,200$	1 000	$(U_n / 1\,000) + 1$
$7\,200 < U_n \leq 15\,000$	5 000	$(U_n / 1\,000) + 1$

105 *Site testing*

All transformers shall be subject to function tests with intended loading, after installation onboard.

SECTION 7
SEMI-CONDUCTOR CONVERTERS

A. General Requirements

A 100 General

101 *References*

a) The design and construction of semi-conductor converters shall comply with relevant requirements of Sec.3 and Sec.4. For control and monitoring equipment the requirements are given in DNV-OS-D202.

b) Voltage and frequency characteristics of supply networks are given in Sec.2 A200.

c) The design of semi-conductor converters shall comply with the requirements of IEC 60146-1-1 with applicable requirements modified to suit marine installations like e.g. environmental requirements stated in Section3.

d) The design of semi-conductor converters for power supply shall in addition to a), b) and c) comply with the requirements of IEC 62040 series.

e) The design of semi-conductor converters for motor drives shall in addition to a), b) and c) comply with the requirements of IEC 61800 series.

Guidance note:

Semi-conductor converters for power supply covers systems with converters with and without means for energy storage. UPS, battery chargers, clean power units etc.

References to specific clauses in IEC standards are based on valid editions per 2010

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102 *Technical integration*

Unless otherwise stated, it is the responsibility of the Yard to ensure technical integration of transformers, converters, motors and generators with respect to:

— Rating and cooling (with respect to increased losses)
— Torque/speed characteristics
— Acceleration/breaking
— Bearing currents
— Harmonic filters
— Operating philosophies
— Installation instructions.

103 *Functionality*

A converter shall be described in a functional description. This description shall at least cover the following items:

— Intended use and operational modes
— Control system
— Integration versus higher level control system
— Redundancy for cooling
— Manual operation
— Protection functions, trips and shut downs
— Redundancy
— Alarms
— Specific functional requirements given in applicable rules, e.g. Sec.12 for electric propulsion.

A 200 Design and construction requirements

201 *Electrical rating and duty*

a) The specified capacity shall at least include a 100% continuous load, and a specified overload capacity given by a current of maximum duration of time.

b) Converters for motor drives (including soft starters), shall as a minimum withstand two consecutive start attempts immediately followed after stopping, or starting up from cold without being overheated.

c) For battery chargers and UPS, requirements for charger capacity are given in Sec.2 D102.

202 *Creepage and clearance distances*

Unless an impulse voltage test has been carried out as a type test with impulse voltages as given in relevant

product standard, the creepage and clearance distances shall be in accordance with relevant product standard, suitable for pollution degree 3 and overvoltage category III. The clearance and creepage distances given in the relevant IEC standards are reproduced in Table A1 to A3. The impulse voltage test voltages are reproduced in table B3.

Guidance note:

For semi-conductor converters for power supply the requirements are given in IEC 60950-1. For semi-conductor converters for motor drives the requirements are given in IEC 61800-5-1

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Table A1 Minimum clearance distances for low voltage semi-conductor converters[1)]

Nominal voltage of the system, (line voltage); (V)[2)]	*Minimum clearance distance, (mm)*
120	0,80
220, 230, 240	1,5
380, 400, 415, 440	3,0
600, 630, 660, 690	5,5

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2. Applicable for three phase systems. If single phase supply, the distance shall be increased one step.

2) Interpolation is not permitted.

Table A2 Minimum clearance distances for high voltage semi-conductor converters[1)]

Nominal voltage of the system (maximum line voltage); (V)[2)]	*Minimum clearance distance, (mm)*
1732	8,0
6235	25
12470	60
20785	90

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2.

2) Interpolation is permitted.

Table A3 Minimum creepage distances, semi-conductor converters[1)]

Working voltage (V)[2) 3)] (rms)	*Minimum creepage distance[4)], (mm)*
100	2,2
160	2,5
200	3,2
250	4,0
320	5,0
400	6,3
500	8,0
630	10,0
800	12,5
1000	16
1250	20
1600	25
2000	32
2500	40
3200	50
4000	63
5000	80

Table A3 Minimum creepage distances, semi-conductor converters[1] (Continued)	
Working voltage (V)[2] [3] (rms)	*Minimum creepage distance[4], (mm)*
6300	100
8000	125
10000	160

1) Extract from IEC 61800-5-1, Table 10, and IEC 60950-1, Table 2N.
2) The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use.
3) Interpolation is permitted.
4) Based on insulating material group IIIa/b. If the material group is not known, group IIIa/b shall be assumed.

203 *Capacitor discharge*

Capacitors within a converter shall be discharged to less than 60 Volt in less than 5 s (or a residual charge of less than 50 μC) after removal of the power. If this requirement not is achievable, warning signboards shall be fitted.

204 *Accessibility*

Semi-conductor elements, fuses or other parts likely to be changed out, shall be so arranged that they can be removed from equipment without dismantling the complete unit.

205 *Access conditions for high voltage converters*

High voltage sections of converters shall have enclosures as required for high voltage switchgear in Section 4.

Doors shall be automatically locked unless the main circuit breaker is open and the circuit is earthed.

206 *Cooling*

a) 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. See also Sec.3 D200.
b) Piping shall be arranged to prevent harmful effects due to leakage or condensation, and be installed preferably in the lower part of the assembly.
c) Requirements for cooling of converters used for propulsion are given in Sec.12.

207 *Output voltage and frequency*

The output voltage and frequency of the power supply units shall comply with the requirements for power supply systems given in Sec.2 A.

208 *Short circuit current capabilities*

Converters 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. Such selective tripping may be achieved by the utilisation of an automatic bypass. Current limiting power supplies, or power supplies limited by internal temperature may be used for single consumers.

209 *By-pass arrangement*

For converters serving as power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

210 *Location of batteries*

Requirements for location of batteries inside electrical assemblies are given in Sec.2 I400.

211 *Protection and monitoring*

a) Alarm shall be given for power supply failure and trip of unit
b) For IT distribution, alarm shall be given for secondary side earth fault (except in dedicated supply system for single consumers).
c) For liquid cooled converters where the cooling liquid is in direct contact with live parts, the conductivity shall be monitored, and high conductivity shall give alarm.
d) When harmonic filters are integrated in a converter, protection and monitoring as required in Sec.2 G701 is required.
e) Additional requirements for monitoring of converters used in electrical propulsion systems are given in Sec.12.
f) For power supply units with batteries included, the following additional alarms shall be provided:
   — when the charging of a battery fails, alternatively if the battery is being discharged

— when the automatic bypass is in operation for on-line units.
— operation of battery protective device.

g) Alarms shall be given to a manned control station.

h) Requirements for protection of batteries and distribution circuits are given in Sec.2 G.

212 *Emergency stop, shutdown*

a) In drives used for applications where emergency stop is required, the emergency stop circuit shall comply with Sec.2 H501. I.e. the emergency stop signal shall be directly connected to trip the main power supply to the drive unit, either directly or through the control power circuit for the circuit breaker. Alternative arrangements independent of the software based control system may be accepted (e.g. pulse blocking, disconnection of control voltage to pulse amplifiers.)

b) Requirements for limited shutdown functions for steering and propulsion are given in DNV-OS-D101

213 *Restart*

It shall be possible to restart the converter in a normal manner after a blackout. Local resetting/restarting of the unit shall not be necessary.

B. Inspection and Testing

B 100 General

101 *Factory testing*

a) Converters 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., 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 routine tests.

d) The type tests and routine tests that semi-conductor converters shall undergo are listed in Table D B1.

Table B1 Testing and inspection of semi-conductor converters for power supply / UPS

No.	*Task*	*Required test converter for power supply/UPS*	*IEC test reference*	*DNV Rule requirement reference*
1	Visual inspection[1)]	TT, RT		Pt.4 Ch.8 Sec.3/4/7
2	Function test (UPS switch test)[2)]	TT, RT	62040-3 pt. 6.2.3	Pt.4 Ch.8 Sec.7 A103
3	Input voltage and frequency tolerance test	TT	62040-3 pt. 6.3.2	Pt.4 Ch.8 Sec.2 A200
4	Stored energy and restored energy tests	TT	62040-3 pt. 6.3.9	Pt.4 Ch.8 Sec.2 D102c)
5	Insulation tests (High voltage test)	TT, RT	61800-5-1 pt. 5.2.3.2 60146-1-1 pt 7.2	Pt.4 Ch.8 Sec.7 B102
6	Insulation resistance test[3)]	TT, RT	60146-1-1 pt 7.2.3.1	Pt.4 Ch.8 Sec.10 D303
7	Rated current test/Full load test[4)]	TT	62040-3 pt 6.7.5	Pt.4 Ch.8 Sec.7 A200
8	Temperature rise test	TT	60146-1-1 pt 7.4.2	Pt.4 Ch.8 Sec.3 B300
9	Control and monitoring system (ref also function test)	TT, RT	62040-3 pt. 6.2.4	Pt.4 Ch.9, Pt.4 Ch.8 Sec.7 A211
10	Short circuit test	TT	62040-3 pt 6.6.19	Pt.4 Ch.8 Sec.7 A208
11	Cooling failure tests	TT, RT	61800-5-1 pt.5.2.4.5	Pt.4 Ch.8 Sec.7 A206 & A211
12	Capacitor discharge	TT		Pt.4 Ch.8 Sec.7 A203
13	Pressure test of coolant piping/ hoses.	RT		Pt.4 Ch.6 Sec.6 D

1) Verification of separation, labelling, IP-rating, creepage and clearance distances.

2) Including check of auxiliary devices, properties of control equipment and protective devices.(IEC 60146-1-1 pt 7.5.1-3) In accordance with functional description and test program. The light load and function test may be performed with power modules identically to the ones that shall be installed onboard. The correct power modules may be tested separately.

3) Insulation resistance test shall be done in accordance with Sec.10 Table D1.

4) Full load current and over current test according to rating as required in B101 a) and C101 a).

Table B2 Testing and inspection of semi-conductor converters for motor drives

No.	*Task*	*Required test converter for motor drives*	*IEC test reference*	*DNV Rule requirement reference*
1	Visual inspection[1)]	TT, RT	61800-5-1 pt. 5.2.1	Pt.4 Ch.8 Sec.3/4/7
2	Input voltage and frequency tolerance test	TT	62040-3 pt. 6.3.2	Pt.4 Ch.8 Sec.2 A200
3	Light load and function test[2)]	TT, RT	60146-1-1 pt 7.3.1 and 7.5	Pt.4 Ch.8 Sec.7 A103
4	Impulse voltage test[3)]	TT	61800-5-1 pt. 5.2.3.1	61800-5-1 pt. 5.2.3.1
5	Insulation tests (High voltage test)	TT, RT	61800-5-1 pt. 5.2.3.2 60146-1-1 pt 7.2	Pt.4 Ch.8 Sec.7 B102
6	Insulation resistance test[4)]	TT, RT	60146-1-1 pt 7.2.3.1	Pt.4 Ch.8 Sec.10 D303
7	Rated current test/Full load test[5)]	TT	60146-1-1 pt 7.3.2	Pt.4 Ch.8 Sec.7 A200
8	Temperature rise test	TT	61800-5-1 pt. 5.2.3.9 60146-1-1 pt 7.4.2	Pt.4 Ch.8 Sec.3 B300
9	Control and monitoring system (ref also function test)	TT, RT		Pt.4 Ch.9, Pt.4 Ch.8 Sec.7 A211
10	Cooling failure tests	TT, RT	61800-5-1 pt.5.2.4.5	Pt.4 Ch.8 Sec.7 A206 & A211
11	Capacitor discharge	TT	61800-5-1 pt.5.2.3.7	Pt.4 Ch.8 Sec.7 A203
12	Pressure test of coolant piping/ hoses.	RT		Pt.4 Ch.6 Sec.6 D
13	Breakdown of components test [6)]	TT	61800-5-1 pt. 5.2.3.6.4	Pt.4 Ch.8 Sec.2 A101 a), Sec.4 A102 b)

1) Verification of separation, labelling, IP-rating, creepage and clearance distances.
2) Including check of auxiliary devices, properties of control equipment and protective devices.(IEC 60146-1-1 pt 7.5.1-3) In accordance with functional description and test program. The light load and function test may be performed with power modules identically to the ones that shall be installed onboard. The correct power modules may be tested separately.
3) To be performed if clearance and /or creepage distances are less than specified in Table A1, A2 and A3
4) Insulation resistance test shall be done in accordance with Sec.10 Table D1.
5) Full load current and over current test according to rating as required in B101 a) and C101 a).
6) Only applicable for variable speed drives larger than 1 MW.

102 *High-voltage testing*

High-voltage testing shall be carried out with test voltages as given in relevant product standard. These voltages given in IEC 60146-1-1 are reproduced in Table D2.

The test voltage shall be applied for 1 minute at 50/ 60 Hz for Type Tests, and minimum 1 s for Routine Tests. If the circuit contains capacitors the test may be performed with a DC voltage.

Table B3 High voltage test

Nominal voltage of the system	*Test voltages*		
	Power frequency withstand voltage		*Impulse voltage level*
	AC r.m.s (V)	*DC (V)*	U_{imp} *(kV)*
<50	1250	1770	0,8
100	1 300	1840	1,5
150	1 350	1910	2,5
300	1 500	2120	4
600	1 800	2550	6
1000	2200	3110	8
>1000	3000	4250	8
3600	10000	14150	20

Table B3 High voltage test (Continued)			
Nominal voltage of the system	*Test voltages*		
	Power frequency withstand voltage		*Impulse voltage level*
	AC r.m.s (V)	*DC (V)*	U_{imp} *(kV)*
7200	20000	28300	40
12000	28000	39600	60
17500	38000	53700	75
Interpolation is permitted			

103 *Onboard testing*

Semi-conductor converters for power supply and semi-conductor converters for motor drives shall be tested according to Sec.10 D after installation onboard.

SECTION 8
MISCELLANEOUS EQUIPMENT

A. General

A 100 Socket outlets and plugs

101 *General*

a) Socket outlets and plugs with a rated current not exceeding 63 A in AC installations and 16 A in DC 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 AC or 16 A DC shall be provided with interlocks so that the plug can only be inserted and withdrawn when the switch is in the "off" position.

c) Socket outlets for portable appliances, which are not hand-held during operation (e.g. welding transformers, refrigerated containers), shall be interlocked with a switch regardless of rating, maximum 1 000 V can be accepted. At each such socket outlet, a warning sign shall be fitted, with text: DANGER (maximum voltage) V AC ONLY FOR CONNECTION OF.... (type of equipment)....

d) Higher voltage socket outlets can only be used for special applications.

e) 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 AC or DC
— socket outlets with double insulated transformers for handheld equipment
— for distribution systems with insulated neutral; socket outlets in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material. The resistance of the insulating material shall be at least 50 kOhm. Earth potential shall not be brought into the space, for instance through earth conductors, piping etc.

f) Precautions shall be taken so that a plug for one voltage cannot be inserted in a socket outlet for a different voltage. Alternatively, warning signboards shall be fitted.

A 200 Lighting equipment

201 *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 rise 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 offshore units, will be accepted.

e) Normally, gas discharge lighting equipment shall not be used.

202 *Starting devices*

Starting devices which develop higher voltages than the supply voltage are generally to be placed within the luminaries.

203 *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 300 Heating equipment

301 *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.

302 *Temperature rises for heaters*

The temperature rises in Table A1 are accepted.

Table A1 Temperature rises for heaters	
Part	*Temperature °C*
Enclosure parts against the bulkhead	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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303 *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 shall not be built into casings of woodwork or other combustible material.

304 *Heating batteries for ventilation systems*

Heating batteries in centralised ventilation systems shall be equipped with the following safety / control functions:

— heating elements shall be interlocked with respect to the air flow either directly controlled by the power to the fan or by measuring the airflow locally at the heating element
— heating elements shall be equipped with over temperature switch that can be reset manually only
— heating elements shall be equipped with thermostat control gear.

305 *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 302 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.

306 *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 in Table A2 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 DNV-OS-D101 apply.

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307 *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 in Table A2 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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A 400 Cooking and other galley equipment

401 *General*

a) Cooking equipment is generally to have insulated heating elements. Special equipment, such as for example high frequency ovens or electrode pots, shall 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 307 apply

d) The temperature rises in Table A2 are accepted.

Table A2 Temperature rises for cooking and other galley equipment

Part	*Temperature °C*
Enclosure parts against the bulkhead and decks	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) 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.

c) All electrical cables and wiring external to equipment shall be at least of a flame-retardant type. (This requirement is intended to cover SOLAS Ch. II-1/45.5.2)

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:

Permanently installed cables for power, control and instrumentation shall normally comply with the specifications of International Electrotechnical Commission's (IEC):

1) Publication No. 60092-350 Third Edition 2008-02 “Electrical installations in ships - Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications”
2) Publication No. 60092-353 Second edition 1995-01. “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” for lighting and power cables.
3) Publication No. 60092-354 Second edition 2003-06. “Electrical installations in ships, Part 354: Single and three-core power cables with extruded solid insulation for rated voltages 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV) for High Voltage cables”.
4) Publication No. 60092-376 Second edition 2003-05. “Electrical installations in ships, Part 376: Cables for control and instrumentation circuit 150/250 V (300 V)”.

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B. General Cable Construction

B 100 Conductors

101 *Conductors*

All conductors shall consist of plain or metal-coated annealed copper according to IEC 60092-350 and shall be stranded according to IEC 60228 class 2 or class 5.

Guidance note:

The use of other conductor metals may be considered in applications where copper cannot be used for chemical reasons. See Sec.10 B401.

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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 communication cables
— 0.5 mm^2 for 60 V cables and 250 V control and instrumentation cables and control and instrumentation

switchboard wires
— 1.0 mm^2 for power circuit switchboard wires
— 1.0 mm^2 for 250 V and 0.6/1 kV power 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.

103 *Core marking*

Cores for control and instrumentation cables shall be marked in accordance with relevant IEC standard.

B 200 Insulating materials

201 *General requirements for insulating materials*

a) The temperature classes and materials given in Table B1 may be used.

b) Electrical and mechanical characteristics shall comply with the specifications of table 2, 3 and 4, respectively of IEC 60092-351.

Table B1 Temperature classes for insulating materials

Material	*Temperature °C*
Polyvinyl chloride or (PVC)	70
Ethylene propylene rubber (EPR)	90
Halogen free ethylene propylene rubber (HF EPR)	90
Hard grade ethylene propylene rubber (HEPR)	90
Halogen free hard grade ethylene propylene rubber (HF HEPR)	90
Cross linked polyethylene (XLPE)	90
Halogen free cross linked polyethylene (HF XLPE)	90
Halogen free cross linked polyolefin (HF 85)	90
Silicone rubber, (S 95)[1)]	95
Halogen free silicone rubber (HF S 95)[1)]	95

1) Silicon rubber only to be used together with a varnished glass braid

B 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 3.8 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 B2.

Table B2 Nominal diameter of braided wire

Diameter of core assembly under braid [1)] (mm)	*Minimum diameter of threads in braid [2)] (mm)*
$D \leq 10$	0.2
$10 < D < 30$	0.3
$D \geq 30$	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 sub-clause 7.2 of IEC 60092-350 (2001-06).

B 400 Protective sheaths

401 *General*

a) Mechanical and particular characteristics of sheath materials shall comply with the specifications of table II and III respectively of IEC 60092-359.

b) Thickness of sheaths shall comply with sub-clause 3.7.3 of IEC 60092-353.

c) 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.)

402 *Temperature classes for protective sheaths*

The temperature classes and materials shall be used in accordance with Table B3.

Table B3 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

C. High Voltage Cables

C 100 Construction of cables rated 1.8/3 kV

101 *General*

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353 second edition 1995-01. "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".

102 *Minimum thickness of insulating walls*

The minimum average thickness of insulating walls shall be used in accordance with Table C1.

Table C1 Minimum average thickness of insulating walls for power cables with rated voltage 1.8/3kV

Nominal cross section of conductor (mm²)	*Designation of the insulating compound*	
	EPR *HF EPR* *(mm)*	*XLPE* *HF XLPE* *HEPR* *HF HEPR* *(mm)*
10 - 70	2.2	2.0
95 - 300	2.4	2.0
400	2.6	2.0
500	2.8	2.2
630	2.8	2.4
Table C1 is according to IEC 60092-353 for 1.8/3 kV cables.		

C 200 Construction of high voltage cables rated above 1.8/3 kV

201 *General*

a) The construction and testing of cables for permanent installations shall normally comply with the recommendations of IEC 60092-354 second edition 2003-06, "Electrical installations in ships, Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV)".

Guidance note:

Other constructions and materials may 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 characteristics of such cables make it difficult to apply screening as specified above.

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202 *Minimum thickness of insulating walls*

The minimum average thickness of insulating walls shall be used in accordance with Table C1.

Table C1 Minimum average thickness of insulating walls for high voltage cables					
Nominal cross-sectional area of conductor mm²	*Nominal thickness of insulation at rated voltage U_0 /U (U_m)*				
	3.6/6 (7.2) kV mm	*6/10 (12) kV mm*	*8.7/15 (17.5) kV mm*	*12/20 (24) kV mm*	*18/30 (36) kV mm*
10	2.5	-	-	-	-
16	2.5	3.4	-	-	-
25	2.5	3.4	4.5	-	-
35	2.5	3.4	4.5	5.5	-
50 to 185	2.5	3.4	4.5	5.5	8.0
240	2.6	3.4	4.5	5.5	8.0
300	2.8	3.4	4.5	5.5	8.0
400	3.0	3.4	4.5	5.5	8.0
500 to 1000	3.2	3.4	4.5	5.5	8.0

D. Low Voltage Power Cables

D 100 Construction of cables rated 0.6/1 kV

101 *General*

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353 second edition 1995-01. “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”.

102 *Minimum thickness of insulating walls*

The minimum average thickness of insulating walls shall be used in accordance with Table D1.

Table D1 Minimum average thickness of insulating walls for power cables with rated voltage 0.6/1.0 kV			
Nominal cross section of conductor (mm²)	*Designation of the insulating compound*		
	PVC/A (mm)	EPR HF EPR S 95 (mm)	XLPE HF XLPE HF 85 HEPR HF HEPR (mm)
1.5	0.8	1.0	0.7
2.5	0.8	1.0	0.7
4 to 16	1.0	1.0	0.7
25 to 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
400	2.6	2.6	2.0
500	2.8	2.8	2.2
630	2.8	2.8	2.4
— For smaller cross sections than 1.5 mm², the insulation thickness shall not be less than specified for 1.5 mm². — Table D1 is according to IEC 60092-353 for 0.6/1.0 kV cables.			

D 200 Switchboard wires

201 *General*

a) 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, HF HEPR, HF XLPE, XLPE or HF85.

b) The minimum thickness of insulation walls shall be in accordance with Table D1.

D 300 Lightweight electrical cables

301 *General*

Lightweight electrical 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 ships/high speed, light craft and naval surface craft", are accepted.

E. Control and Instrumentation Cables

E 100 Construction of control and instrumentation cables rated 150/250 V

101 *General*

The construction of cables for permanent installations shall normally comply with the requirements of IEC Publication No. 60092-376 Second edition 2003-05. "Electrical installations in ships, Part 376: Cables for control and instrumentation circuit 150/250 V (300 V)".

102 *Minimum thickness of insulating walls*

The minimum average thickness of insulating walls shall be used in accordance with Table E1.

Table E1 Minimum average thickness of insulating walls for control and instrumentation cables

Nominal cross section of conductor (mm^2)	*Designation of the insulating compound*		
	PVC/A EPR HF EPR (mm)	*XLPE HF XLPE HEPR HF EPR (mm)*	*HF 85 S 95 HF S 95 (mm)*
	Rated voltage 0.15/0.25 kV		
0.50	0.6	0.4	0.6
0.75	0.6	0.5	0.6
1.0	0.6	0.5	0.6
1.5	0.7	0.6	0.7
2.5	0.7	0.6	0.7

Table E1 is according to IEC 60092-376 second edition 2003-06

F. Data Communication Cables

F 100 General

101 *General*

Data communication cables approved in accordance with the DNV type approval programme "Standards for Certification No. 2.9, Type Approval Programme No. 6-827.50-2: Type Approval Programme for Data Communication cables" are accepted".

G. Fibre Optic Cables

G 100 General

101 Fibre optic cables approved in accordance with the DNV type approval programme "Standards for Certification No. 2.9, Type Approval Programme No. 6-827.50-1: Type Approval Programme for Fibre Optic cables" are accepted".

H. Inspection and Testing

H 100 General

101 *Factory testing*

a) Cables shall be tested at the manufactures works with the test specified in this part of the rules. Tests noted as Routine Test (RT) shall be carried out on all cables. Tests noted as Product Sample tests (PST) shall be performed as random test at suitable intervals in order to ensure that products from subsequent production confirm to result of type tests, ensuring "equal production".

b) The following inspection and tests shall be carried out according to IEC 60092-350 (2008-02):

— checking of cable construction (4.1.2.2)
— measurement of electrical resistance of conductor (5.2.2)
— voltage test (5.2.3)
— insulation resistance test (5.2.4)
— mechanical/particular characteristics of insulating compounds (8.3)
— mechanical/particular characteristics of sheathing compounds (8.4)
— hot set test for EPR and XLPE insulation and for SE1 and SHF 2 sheath (6.8).

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.

B. Equipment

B 100 Equipment location and arrangement

101 *General*

a) All electrical equipment shall be permanently installed and "electrically safe". This shall prevent injury to personnel, when the equipment is handled or touched in the normal manner. (Interpretation of SOLAS Ch. II-1/45.1.3)

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. (Interpretation of SOLAS Ch. II-1/45.7)

e) Equipment shall be installed in such a manner that the circulation of air to and from the associated equipment or enclosures is not obstructed. The temperature of the cooling inlet air shall not exceed the ambient temperature for which the equipment is specified.

f) All equipment of smaller type (luminaries, 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) Requirements for installation of switchboards given in Sec.2 I201 shall also be applied to installation of transformers.

h) Requirements for rotating machinery arrangement are given in Sec.2 I300.

i) See Sec.2 I for additional requirements for offshore unit 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 authorised and 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 oil resistant insulating material, when the deck is made of a conducting material.

Guidance note:
Mats complying with IEC 61111 or equivalent standard will be accepted.

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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 possible 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 and for high voltage equipment, see Sec.3 D.

Table B1 Enclosure types in relation to location

Location		*Switchgear and transformers*	*Luminaries*	*Rotating machines*	*Heating appliances*	*Socket outlets*	*Miscellaneous such as switches and connection boxes*	*Instrumentation components*
Engine and boiler rooms [15]	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 20	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, columns below main deck and pontoons 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 welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard [7]		EX[12]	EX [12]	EX [12]	EX [12]	EX[12]	EX [12]	EX [12]
Dry accommodation spaces		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20 [8]	IP 20
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, regardless if IP rating. 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 Sec.3 D100. For truck battery charging arrangements, see Sec.2 I.
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, welding 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. Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes.
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 in accordance with the minimum requirements in Sec.11 or minimum requirements in this table, whichever is the strictest. Minimum explosion group and temperature class shall be one of those specified in Sec.11 (some national regulations may limit the choice of type of protection).
13) Luminaries 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 switchgear and starting transformers for thrusters shall be equipped with heating elements for standstill heating. Provided the space will not be used as pump room for ballast, fuel oil etc., the thrusters motor may be accepted with IP22 enclosure type.
15) Electrical and electronic equipment and components located in areas or in the vicinity of areas protected by Fixed Water-Based Local Application Fire-Fighting Systems as required by SOLAS Ch. II-2/10 5.6 using fresh water shall be to a degree of protection not less than IP22.
16) When salt water is used, electrical and electronic equipment and components located in areas, or in the vicinity of areas, protected shall be to a degree of protection not less than IP44, unless the manufacturer of the electrical and electronic equipment or components submits evidence of suitability using a lower degree of protection (e.g. IP23, IP22, etc.) restricted to:
   — For the natural air cooled static power equipment (e.g. starter, distribution panel, transformer, lighting etc.) at least IP23 is required.
   — For the natural air cooled electronic equipment mounted or located on the protected system (e.g. sensors, actuators, etc.), at least IP44 is required.
   — For the rotating machinery and mechanically air cooled type equipment (e.g., rotating machinery, air cooled SCR panel, etc.) which needs the forced cooling air from outside the equipment, the lower degree than IP44 may be accepted if measures are taken, in addition to ingress, to prevent the ingest of water. The terminal boxes shall be of at least IP44.

   Generators with a lower degree of protection as IP44 may be used if they are separated to each other in a way that the water used for the FWBLAFFS (e.g. watermist, waterdrops) will harm only the set concerned.

B 300 Batteries

301 *General*

Battery installations shall 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 offshore unit'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 502 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 J401.

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) Portable equipment shall always be earthed by an earth conductor contained in the flexible supply cable.

g) 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.

h) 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.

i) 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.

j) 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 i) 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 may be omitted:

— equipment supplied at a voltage not exceeding 50 V DC or AC 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 *Signboards for equipment*

a) Labels (nameplates) of durable 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, unless colour coding of cables has been used.

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. See Table B1, note 6.

f) At each socket outlet for portable appliances where 1 000 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 AC 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 durable 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”.

j) Emergency lighting fixtures shall be marked for easy identification.

B 600 Neon lighting

601 *General*

a) Neon tubes for voltage above 1 000 V, 50 Hz, shall be installed at least 2.5 m above the floor.

b) Each circuit shall have circuit protection rated at maximum 16 A.

c) The on and off switch shall be clearly marked. The switch is not accepted on the secondary side of the transformer.

d) Cables and wires shall have braiding, armour or be fitted in an earthed pipe.

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.

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 braid/armour*

Cables with braid or armour without outer sheath for corrosion protection is accepted with the following exceptions:

— when installed in hazardous areas (see Sec.11 D201)
— when the braiding is used for protective earthing.

104 *Corrosion protection*

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*

General requirements for routing of cables are given in Sec.2 I500.

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) Cables for control or monitoring circuits below 50 V shall not be run in the same bunch or pipe as cables for circuits emitting a high degree of electromagnetic disturbance, unless means to avoid interference has been provided.

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 or parallel connection of conductors of multicore cables is necessary for AC circuits with nominal current exceeding 20 A the following apply:

a) Armour or braiding on single core cables shall be of non-magnetic type.
b) If provided, the non-magnetic armour or braiding shall be earthed at one end, only.
c) Single core cables belonging to the same circuit shall be contained within the same pipe, conduit or trunk. 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 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.
h) For fixing of single core cables, see 506.
i) For DC-installations with a high “ripple” content (e.g. thyristor (SCR) units), the requirements above are applicable.

205 *Accessible cable runs*

a) Cable runs shall be accessible for later inspection, except cables carried in pipes.
b) 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.
c) 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 shall meet the fire and watertight integrity of the bulkhead or deck. The penetrations 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. The installation shall be in accordance with the manufacturers' installation instructions.
b) Fire rated penetrations shall be documented as required by DNV-OS-D301.

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 ≤ 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. (Interpretation of SOLAS Ch. II-1/45.5.5)

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. (Interpretation of SOLAS Ch. II-1/45.5.2)

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.

Guidance note:

A cable bunch in this context 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.

Additional fire stops need not be fitted inside totally enclosed cable trunks.

b) In enclosed and semi-enclosed spaces, cable runs not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least B-0 penetrations:

— at every second deck or approximately 6 metres for vertical runs
— at every 14 metres for horizontal.

Alternatively, to 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.

Alternatively, type approved fire protective coating or mats installed as described in the type approval certificate can be accepted.

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.

Guidance note:

Cable transits in “A”, “B” or “F” class divisions should not have more than 40% of the inside cross sectional area of the transit occupied by cables. The installation should be in accordance with the transit manufacturer's instructions.

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406 *Fire resistant cables*

For requirements for fire resistant cable, see Sec.2 J102.

C 500 Support and fixing of cables and cable runs

501 *General*

Cable ladders, trays and cable pipes shall not be used for carrying water, oil or steam pipes. Hydraulic pipes for valve control are exempted. Other exemptions may be considered in each case.

502 *Cable ladder or tray material and mechanical requirements*

a) Cable ladders and trays with their fixing devices shall be made of steel adequately protected against corrosion 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) Cable trays or protective casings made of plastic materials shall be supplemented by metallic fixing and straps such that in event of a fire they, and the cable affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

The load on the cable trays or protective casings shall be within the Safe Working Load (SWL). The support spacing shall not be greater than manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing shall not exceed 2 m. (IACS UR E 16).

Guidance note:

The term "cable ladder" includes support brackets. The term "cable tray" means constructions being formed by continuous tray plates or structural steel.

Adequate protection against corrosion may be stainless steel, hot dipped galvanised steel or black steel adequately coated in accordance with a marine coating standard.

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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) All cables that may be exposed to mechanical damage, shall be protected by covers of steel plates, steel grids or profiles, or by being carried in steel pipes, e.g. on weather decks in cargo hold areas, and through cargo holds.

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, except when carried in pipes.

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, metallic 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.

b) Flame retardant polymer material may be used for cable fixing if the material is resistant to heat and light radiation, affecting the material during the lifetime of the offshore unit.

c) The spacing between supports or fixing shall be suitably chosen according to the type of cable and the probability of offshore unit movement and vibration at the actual point of installation, as given in Table C3.

d) 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.

e) When cables are installed on top of 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.

f) 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.

Table C3 Spacing of fixing points for cables

External diameter of cables		*Non-armoured or unbraided cables (mm)*	*Armoured or 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 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 should 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 offshore unit'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 offshore unit 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. The pipes shall be fitted with drain holes.

c) 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. g. sandfilling.

d) 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*

The wall thickness of cable pipes shall be in accordance with requirements for seawater pipes given in Rules for Classification of Ships Pt.4 Ch.6 Sec.6 Table A1, A2 and A3.

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, shall not 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 *Termination of data communication cables*

Twisted pair data cables (as IBM Cat 5) 0.22 mm^2 shall be installed such that the strands and insulation of each conductor are kept as part of the termination, as for coaxial cables.

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.

All termination of conductors and braiding shall be made inside enclosures. Where space does not permit this arrangement, then cable braids/sheaths may be bonded to earth in a protected none corrosive area below the enclosure. Cable braids/sheaths although bonded to earth below the enclosure should still be left long enough to be stopped within the enclosure and thereby reduce EMC effect.

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 offshore unit at both ends of the cable, except for short circuit proof installation where the braiding shall be insulated with crimp-on sleeve. 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. For earthing of cables in hazardous areas, see Sec.11 D200.

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) Special DC cables with a high ripple content (e.g. for thyristor equipment) and single core cables for AC shall be earthed at one end only.

e) 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.

f) The braiding or armour shall be connected directly from the cable to dedicated earth terminal or bar. 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.

g) 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.

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 (metal to metal without paint or coating), 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.

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 heat tracing cables shall not be spliced.

d) Heat tracing 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) Heat tracing cables shall be installed in such a way as to allow dismantling of joints and valves, instruments etc. without cutting or damaging the cable. Heat tracing 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 shall 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 offshore unit. This also applies after modifications and alterations.

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.

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 I.

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 *Electrical test of high voltage cable after installation*

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:

a) When a DC voltage withstand test is carried out, the voltage shall be not less than:

— $1.6 \cdot (2.5 \cdot U_0 + 2)$ kV for cables with U_0 not exceeding 3.6 kV
— $4.2 \cdot U_0$ kV for cables with U_0 in excess of 3.6 kV.

The test voltage shall be maintained for a minimum of 15 minutes.

b) A power frequency test at the normal operating voltage of the system, applied for 24 hours.

c) A power frequency test with the phase-to-phase voltage of the system applied between the conductor and the metallic screen or earth for 5 minutes.

(IACS UR E11 7.2.6)

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 onboard.)

The insulation resistance tests (megger tests) shall be carried out by means of a suitable instrument applying a DC voltage according to Table D1.

Table D1 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
$250 < U_n \leq 1\,000$	500	1
$1\,000 < U_n \leq 7\,200$	1 000	$(U_n/1\,000) + 1$
$7\,200 < U_n \leq 15\,000$	5 000	$(U_n/1\,000) + 1$

D 400 Electric distribution and power generation

401 *Testing of consumers*

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 purpose.

c) Setting of protective functions shall be verified.

d) Consumers having their protective function (e.g. overload, short circuit and 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 shall 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*

a) All generating sets together with their switchboard equipment (switchgear or protection and cabling) shall be run at the rated load until the exhaust temperature and cooling water temperature has stabilised and at least for the time specified in DNV-OS-D101. The following has to be verified:

— electrical characteristics in general and control of the generator itself
— engine room ventilation/air flow.

b) Dynamic tests such as voltage regulation, speed governing and load sharing shall be carried out to verify that voltage and speed regulation under normal and transient conditions is within the limits given in DNV-OS-D101.

c) The following tests shall be carried out:

— testing of overload protection
— reverse power protection
— overcurrent and short circuit protection
— other protection like: earth fault, differential, undervoltage, overvoltage (if applicable)
— synchronising systems.

Guidance note:

Testing of overcurrent and short circuit protection: Secondary current injection is accepted as a method for verification of correct operation. For off the shelf moulded case circuit breakers and smaller MCBs with integrated protection units routine tested at the breaker manufacturer, testing of the protection functionality is generally not required. For other circuit breakers where testing at the switchboard manufacturer has been witnessed by DNV, and the circuit has not been wired up onboard, a verification of protection settings on board may be accepted.

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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. See Sec.2 J601 d).

406 *Testing of battery supplies*

a) UPS systems and regular DC 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.

407 *Testing of harmonic distortion*

Tests may be required to verify that the level of harmonic distortion does not exceed the limits given in Sec.3.

408 *Testing of independency between main and emergency system*

It shall be verified that the main electrical power supply system is independent of the emergency electrical power supply systems. Before testing the main system, the emergency system including emergency switchboard and all battery systems powered from the emergency system shall be disconnected. The tests shall be performed under as realistic conditions as practicable.

The following shall be verified:

— black out start
— normal operation.

409 *Testing of dead ship recovery*

Dead ship recovery, as required by Sec.2 B204, shall be verified by testing. The tests shall be performed under as realistic conditions as practicable.

410 *Redundancy tests*

— If separate emergency source of power is omitted in accordance with Sec.2 C104 a selection of tests within

each system analysed in the FMEA shall be carried out. Specific conclusions of the FMEA for the different systems shall be verified by tests when redundancy or independence is required. The test procedure for redundancy shall be based on the simulation of failures and shall be performed under as realistic conditions as practicable

411 *Testing of semi-conductor converters*

a) Semi-conductor converters for power supply shall be subject to complete function tests with intended loading onboard.

b) Functional tests of semi-conductor converters for motor drives shall be performed with all relevant ship systems simultaneously in operation, and in all characteristic load conditions.

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 Ch.1 Sec.1.

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.

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 should be listed so that correspondence with IP rating required according to the requirements in D102 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) Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes and when permitted by the relevant rules.

d) Gas group and temperature class of electrical equipment shall be in accordance with the requirements relevant for the gas or vapour that can be present (IEC 60092-502, 6.2.3, 6.2.4).

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) 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.

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, shall be suitable for installation in Zone 2. Arrangements shall be provided to facilitate disconnection of equipment in those areas not suitable for installation in Zone 2. See DNV-OS-A101 Sec.5 F.

205 *Battery rooms, paint stores, and welding gas bottle stores*

a) Electrical equipment installed in battery rooms lockers or boxes, paint stores or welding 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
— welding 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) 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.

d) Enclosed spaces giving access to 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.

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

f) The fan mounted inside extract ventilation ducts shall be of non-sparking type.

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.

Guidance note:

Ex-e equipment, 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.

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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 offshore unit, 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.

c) Both the safety barrier in the safe area, and the equipment installed in hazardous area shall be certified safe unless it is “simple apparatus”.

Guidance note:

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 should 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”.

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305 *Ex-d equipment*

a) Exd 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. 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, with the addition that the 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.

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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	Dust tight	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 drip proof	52	Dustproof and resistant to dripping water (not rain)
13	Oil tight and dust tight. (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)

D 200 Cable types, cabling and termination

201 *Cable types*

a) All cables installed in hazardous areas shall have an outer non-metallic impervious sheath.

b) Power and signal cables shall have a metallic braiding or armour between conductors and the non-metallic impervious sheath in the following zones and areas:

— zone 0
— zone 1.

c) Cables for intrinsically safe circuits shall have a common metallic screen or braiding. Multicore cables for Ex-i circuits shall have individual screened pairs unless all of the following is complied with:

— the cable shall be installed as fixed installation i.e. mechanically protected
— the circuit voltage shall be less than 60 V
— the cable shall be type approved or case by case.

202 *Fixed cable installations*

a) In zone 0 only cabling for Ex-ia circuits are allowed.

b) In zone 1 trough runs of cables other than the ones intended for Ex-equipment, shall be limited.

c) In zone 2, through runs of cables are accepted.

d) All metallic protective coverings of power and lighting cables passing through a hazardous zone, or connected to apparatus in such a zone, shall be earthed at least at their ends. The metallic covering of all other cables shall be earthed at least at one end.

203 *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.

204 *Penetrations of bulkheads and decks*

Cable penetrations through bulkheads and decks shall be gas tight, and of a recognised type, if used as sealing between zones or between hazardous areas and non-hazardous areas.

205 *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.

206 *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.

207 *Intrinsically safe circuit wiring and termination*

a) The braid, armour or collective screen provided in intrinsically safe circuits shall be connected to the local earth at both ends, and might also be earthed at intermediate junction boxes or panels where relevant.

Where the bonding of the braiding, armour or screen at the field end is not practical, it may be earthed at the safe end only.

b) The individual screen, when provided, of single pair or multi pair cable, shall be connected to earth in safe area at the barrier end only. In hazardous area, the inner screen shall be properly insulated or terminated. If there is special reason to connect the inner screen to earth at both ends, then this might be accepted based on the explanation in IEC 60079-14 sec. 12.2.2.3

c) Where the installation has separate earth bars for protective earth, instrument earth and intrinsically safe earth, these bars shall be used accordingly.

d) Terminals for intrinsically safe circuits and terminals for non-intrinsically safe circuits shall be separated by a physical distance of 50 mm or a by an earthed metallic partition. Terminals for intrinsically safe circuits shall be marked as such.

e) Category Ex-ia- circuits intended for zone 0, and category Ex-ib-circuits shall not be run in the same cable.

f) Intrinsically safe circuits and non-intrinsically safe circuits shall not be carried 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.

208 *Special conditions in EX certificates*

Verification and inspection of Ex certified equipment shall include checking that special conditions for safe use given in the certificates are compiled with.

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 offshore unit 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 offshore unit 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 offshore unit, except for fire and flooding, which are accepted as common mode failures.

b) Offshore units 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) Offshore units 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) Offshore units 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 and cooling*

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/thrust available at the propeller shaft shall be adequate for the offshore unit to be manoeuvred, stopped, or reversed when the offshore unit 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 offshore unit.

Guidance note:
For thrusters, a gear oil temperature of 0°C should be considered.

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302 *Overload capacity*

The system shall have sufficient overload capacity to provide the necessary torque, power, and for AC 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 offshore unit, 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 busbar 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 shall not 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.

f) In case remote control of a propulsion drive is arranged for selecting other than the normal speed control mode (e.g. torque or power) the propeller thrust shall not change significantly as a consequence of selecting an alternative operating mode.

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. Verification

B 100 Survey and testing upon completion

101 *Onboard testing*

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 shall include tests of the propulsion plant in normal and abnormal conditions as well as crash stop manoeuvres.

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.

OFFSHORE STANDARD
DNV-OS-D201

ELECTRICAL INSTALLATIONS

CHAPTER 3

CERTIFICATION AND CLASSIFICATION

CONTENTS PAGE

Sec. 1 Certification and Classification - Requirements 128
App. A List of alarms and monitoring parameters 134

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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, Storage and loading 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 requirements shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

B. Documentation

B 100 General

101 For general requirements to documentation and definition of the documentation types, see DNV-RP-A201.

102 Documentation related to system design for main class shall be submitted as required by Table B1.

Guidance note:
Additional class notations may imply additional documentation requirements.

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Table B1 System design, documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI) On request (R)*
Electric power systems	E010 – Overall single line diagram		AP
	E050 – Single line diagrams/ consumer list for switchboards	For: AC power systems DC battery systems UPS systems	AP
	E040 – Electrical power consumption balance	For: AC power systems DC battery systems UPS systems	AP
	E220 – Electrical system philosophy	System philosophy may not be required if the "overall single line diagram" is sufficient to give necessary understanding of the operation and relevant operation modes of the system.	FI
	E200 – Short circuit calculations		FI
	E210 – Harmonic distortion calculations	Required when more than 20% of connected load is by semi-conductor assemblies, in relation to connected generating capacity.	FI
	E100 – Voltage drop calculations	Upon request and when a motor rated above 30% of the feeding generator(s) or transformer(s) rated power is started direct on line.	FI, R
	E080 – Discrimination analysis	The document shall cover: generator protection main switchboard circuits (Ch.1 Sec.1 D901) emergency switchboard circuits (Ch.1 Sec.1 D902) battery and UPS systems	AP
	Z030 – System arrangement plan	Including locations of power sources, switchboards and distribution boards for main and emergency power, UPSs and batteries. Arrangement of access doors, fire divisions and high fire risk areas related to the above.	FI
	Z071 – Failure mode and effect analysis	Required if separate emergency source of power is omitted in accordance with Ch.2 Sec.2 C104. Upon request for other systems.	AP
	Z140 – Test procedure for quay and sea trial	Redundancy and failure modes based on FMEA. Required if separate emergency source of power is omitted in accordance with Sec.2 C104. Upon request for other systems.	AP
Motor starters	E170 – Electrical schematic drawing	Starters for essential services.	AP
Cables	E030 – Cable selection philosophy		AP
Emergency stop system	E170 – Electrical schematic drawing	Emergency stop of electrical propulsion motors, pumps and fans, showing fail to safe functionality.	AP
Installation in hazardous areas	E090 – Table of Ex-installation	Based on approved area classification drawing and ESD philosophy (if relevant).	AP
Installation in hazardous areas	G080 – Hazardous area classification drawing	An approved Area classification drawing where location of electric equipment in hazardous area is added (Except battery room, paint stores and gas bottle store).	FI
Lighting systems	E190 – Lighting description		AP
	C030 – System arrangement plan	Emergency lighting arrangement	AP

103 Electrical equipment required to be delivered with DNV Product Certificate, see Table C1, shall be documented as described in Table B2.

Table B2 Component certification, documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Cables	E110 – Cable data sheet and design drawing	For cables not having a DNV type approval.	AP
Electric propulsion motors	Shafting documentation as required in Rules for Classification of Ships Pt.4 Ch.4 Sec.1 A200	Shafting for electric propulsion motors in mechanical propulsion line.	AP
Shaft generators	Shafting documentation as required in Rules for Classification of Ships Pt.4 Ch.4 Sec.1 A200	Shafting for electric generators in mechanical propulsion line.	AP
Main and emergency switchboards	E120 – Electrical data sheet, general		FI
	E140 – Assembly schedules and technical data		AP
	E150 – Strength calculation with respect to short circuit	When designed sub-transient short circuit strength exceeds 50 kA r.m.s.	FI
	E160 – Internal arc withstanding report	High voltage switchboards only.	FI
	E170 – Electrical schematic drawing		AP
	E180 – Layout of electrical assembly		FI
	E240 – Functional description for electrical assemblies		FI
Semi-conductor assemblies	E120 – Electrical data sheet, general		AP
	E130 – Electrical data sheet, semiconductor assemblies		FI
	E140 – Assembly schedules and technical data		AP
	E180 – Layout of electrical assembly		FI
	E240 – Functional description for electrical assemblies		FI
	Z120 – Test procedure at manufacturer		AP
Distribution switchboards, motor starters, motor control centres, harmonic filters etc.	E120 – Electrical data sheet, general		AP
	E140 – Assembly schedules and technical data		AP
	E150 – Strength calculation with respect to short circuit	When designed sub-transient short circuit strength exceeds 50 kA r.m.s.	FI
	E160 – Internal arc withstanding report	High voltage switchboards only.	FI
	E170 – Electrical schematic drawing		AP
	E180 – Layout of electrical assembly		FI
Systems for automatic start and stop of generator drivers and for automatic operation of breakers.	I020 – Control system functional description		AP
	I030 – Block diagram		AP
	I050 – Power supply arrangement		AP
	I080 – Data sheet with environmental specifications		AP
	Z120 – Test procedure at manufacturer		AP

C. Certification

C 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.

C 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.

C 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.

C 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 C1.

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 C1 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	≥ 50 kVA	X		
	< 50 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 B.

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.

C 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 non-conformities 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 NPS DocReq and DNV-RP-A201. 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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D. Onboard Survey

D 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 NPS DocReq and DNV-RP-A201, 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.

D 200 Onboard 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.

D 300 Function tests

301 Function tests are part of the Society's verification of the installation's compliance with the requirements in the Rules and approved documentation.

D 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 G080
— for the emergency shutdown system, 'Design philosophy', see DNV-RP-A201 standard documentation type Z050
— 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.

APPENDIX A
LIST OF ALARMS AND MONITORING PARAMETERS

A. General

A 100 General

101 The alarms and monitoring requirements in the Rule text are listed in Table A1 which can be use as guidance. Switchboard instrumentation is not listed.

In case of any deviation between Table A1 and the Rule text, the Rule text shall apply.

Table A1 List of alarms and monitoring parameters of miscellaneous electrical equipment

System	*Item*	*Indication Alarm Trip*	*Location indicated in the rules*	*Reference*	*Comment*
1.0 Design principles	Failure in one of the power supplies for consumers with dual supply	A	MAS	Ch.2 Sec.2 F101 c)	
	Failure in cooling unit in environmentally controlled spaces	A	MAS	Ch.2 Sec.2 A102 b)	Note 1) IACS URE 19
1.1 Automatic operation of CB and start /stop diesel engines/ PMS	Control system power failure	A	MAS	Ch.2 Sec.2 H201 b)	
	Starting failure of prime mover	A	MAS	Ch.2 Sec.2 H202 a)	
	Frequency	LA / HA	MAS	Ch.2 Sec.2 H201 b)	
	Voltage	LA / HA	MAS	Ch.2 Sec.2 H201 b)	
	Excessive percentage difference in loads	HA	MAS	Ch.2 Sec.2 H202 a)	
	Generator standby	IR		Ch.2 Sec.2 H202 f)	
1.2 Emergency generator / ESB	Prime mover for emergency generator not ready for start	IR		Ch.2 Sec.2 C301 c)	
	When used in port: Monitoring and safety requirements of prime mover		MAS	Ch.2 Sec.2 C304 c)	See Pt.4 Ch.3 Sec.1
	When used in port: Fuel oil supply tank level	LA	MAS	Ch.2 Sec.2 C304 d)	
1.3 Battery / UPS systems	Charging fail (Alternatively: battery being discharged)	A	MCS/ MAS	Ch.2 Sec.2 D103 Ch.2 Sec.7 A211 f)	
	Ventilation fail	A	MCS	Ch.2 Sec.2 D103 Ch.2 Sec.2 Table I2 Ch.2 Sec.2 Table I3	
	Automatic bypass in operation	A	MCS	Ch.2 Sec.7 A211 f)	
	Operation of battery protection device	A	MCS	Ch.2 Sec.7 A211 f)	
1.4 Navigation light	Failure in power supply	A	NB	Ch.2 Sec.2 F203 a)	Note 2)
	Short-circuit	A	NB	Ch.2 Sec.2 F204 c)	Note 2)
	Bulb failure	A	NB	Ch.2 Sec.2 F204 c)	Note 2)

Table A1 List of alarms and monitoring parameters of miscellaneous electrical equipment (Continued)

System	*Item*	*Indication Alarm Trip*	*Location indicated in the rules*	*Reference*	*Comment*
1.5 Protection	Insulation fault in distribution system	IL		Ch.2 Sec.2 G102 a)	Note 3)
	Insulation fault in high voltage system without automatic disconnection by insulation fault	LA	MAS	Ch.2 Sec.2 G102 a) and c)	Note 3)
	Loss of control voltage to protective functions	A	MAS	Ch.2 Sec.2 G201 c)	
	Overload alarm for motors without overcurrent trip	A	MAS	Ch.2 Sec.2 G501 d)	
	Activation of circuit protection in filter circuits	A	MCS	Ch.2 Sec.2 G701	
1.6 Control Power distribution	Failure power supply to essential and important control and monitoring systems	A	MAS	Ch.2 Sec.2 H102 c) Ch.2 Sec.2 F306	
	Loss of voltage in the auxiliary power system in high voltage switchboards	A	MAS	Ch.2 Sec.4 B203 c)	
1.7 Emergency stop	Failure in control power supply when arranged NO	A	MAS	Ch.2 Sec.2 H501	
	Computer based system: System failure	A	MAS	Ch.2 Sec.2 H501	
2.0 Cooling and anti-condensation	Failure in mechanical cooling of electrical systems	A	MAS	Ch.2 Sec.3 D201a)	Fail or Low flow
	Winding temperature in the cooled equipment for essential services	HA, IR	MAS	Ch.2 Sec.3 D201 a)	
	Winding temperature in the cooled equipment for important services	HA	MAS	Ch.2 Sec.3 D201 a)	
	Leakage alarm for water cooled heat exchangers	A		Ch.2 Sec.3 D202 a) and b)	
4.0 Rotating machines	Temperature detectors embedded in stator winding	HA		Ch.2 Sec.5 A301	Note 4)
5.0 Power transformers	Immersed transformers: Liquid level low	LA	A	Ch.2 Sec.6 A202	
	Immersed transformers: Liquid temperature high	HA	A	Ch.2 Sec.6 A202	
	Immersed transformers: Gas pressure high	SH		Ch.2 Sec.6 A202	
	Immersed transformers: Interturn short circuit	SH		Ch.2 Sec.6 A202	
6.0 Semi-conductor Converters	Power supply failure	A	MAS	Ch.2 Sec.7 A211 a)	
	Secondary side earth fault (IT distributions)	AL		Ch.2 Sec.7 A211 b)	
	High conductivity of cooling liquid	AH		Ch.2 Sec.7 A211 c)	Cooling liquid in contact with live parts
	Trip of units	A	MAS	Ch.2 Sec.7 A211 a)	
7.0 Pressurised spaces and Ex-p	Loss of pressure to Ex-p (zone 2)	A	MCS	Ch.2 Sec.11 C303 c)	

Table A1 List of alarms and monitoring parameters of miscellaneous electrical equipment (Continued)

System	*Item*	*Indication Alarm Trip*	*Location indicated in the rules*	*Reference*	*Comment*
8.0 Electric propulsion	AVR-failure	A	NB & ECR (MAS)	Ch.2 Sec.12 A501	
	Insufficient power for propulsion	A	NB	Ch.2 Sec.12 A603 b)	
	Shut down pre warning alarm	A	NB	Ch.2 Sec.12 A604 c)	
	Cooling medium temperature	HA	NB	Ch.2 Sec.12 A604 f)	Note 5)
	Winding temperature of all propulsion generators and motors	HA	NB	Ch.2 Sec.12 A604 f)	Note 5)
	Loss of flow of primary and secondary coolants	LA/A	NB	Ch.2 Sec.12 A604 f)	Note 5) & Note 7)
	Lubricating oil pressure	LA	NB	Ch.2 Sec.12 A604 f)	Note 5)
	Water-air heat exchanger leakage	A	NB	Ch.2 Sec.12 A604 f)	Note 5)
	Earth fault for main propulsion circuits	A	NB	Ch.2 Sec.12 A604 f)	Note 5)
	Earth fault for excitation circuits	A	NB	Ch.2 Sec.12 A604 f)	Note 5) & Note 6)
	Miscellaneous components	A		Ch.2 Sec.12 A604 f)	Note 5) & Note 8)

IL = Local indication (presentation of values), in vicinity of the monitored engine component or system
IR = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console
A = Alarm activated for logical value
LA = Alarm for low value
HA = Alarm for high value
SH = Shut down with corresponding alarm. May be manually (request for shut down) or automatically executed if not explicitly stated above.
NB = Navigation bridge
MAS = Main alarm system
MCS = Main control station

Notes:

1) Applicable for cooling equipment in environmentally controlled spaces, where equipment with reduced ambient temperature tolerance is installed
2) Alarms/indication required in WH only
3) Insulated or high resistance earthed systems
4) Applicable if rated output > 5000 kW and all high voltage motors
5) Critical alarms shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms
6) This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
7) For machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself
8) Fuses for filter units or for other components where fuse failure is not evident.