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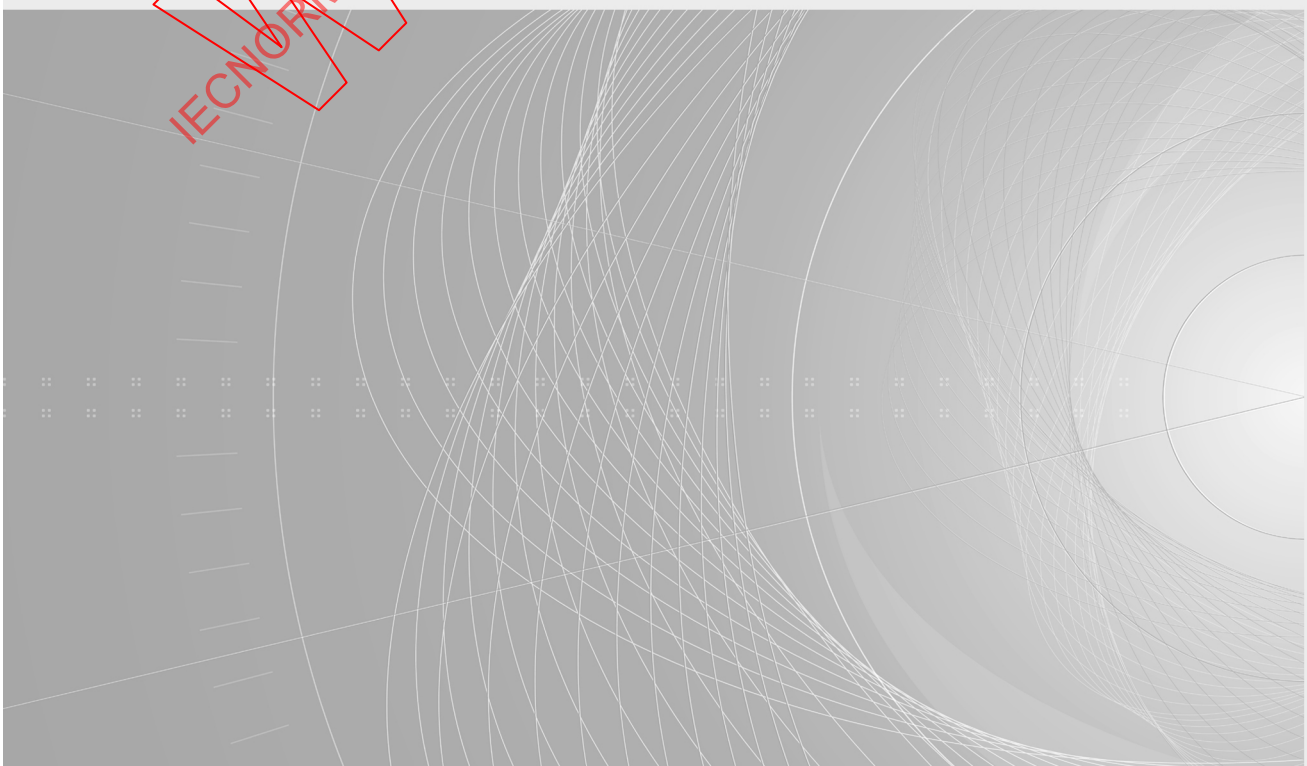
Edition 2.0 2007-11

INTERNATIONAL STANDARD

Mobile and fixed offshore units – Electrical installations – Part 3: Equipment



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Mobile and fixed offshore units – Electrical installations – Part 3: Equipment

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

Part 3: Equipment

FOREWORD

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International Standard IEC 61892-3 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This second edition cancels and replaces the first edition published in 1999. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the requirement to d.c. generators has been deleted;
b) detailed requirements to testing of machines have been deleted. Reference is made to the IEC 60034 series;
c) requirement to switchgear and controlgear has been rewritten, based on updated IEC 60439 and the IEC 62271 series;
d) requirement to Control and instrumentation has been rewritten, based on updated IEC 60092-504.

The text of this standard is based on the following documents:

FDIS	Report on voting
18/1064/FDIS	18/1070/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61892 series, under the general title *Mobile and fixed offshore units – Electrical installations*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 61892 forms a series of International Standards intended to enable safety in the design, selection, installation, maintenance and use of electrical equipment for the generation, storage, distribution and utilisation of electrical energy for all purposes in offshore units which are being used for the purpose of exploration or exploitation of petroleum resources.

This part of IEC 61892 also incorporates and co-ordinates, as far as possible, existing rules and forms a code of interpretation, where applicable, of the requirements of the International Maritime Organisation, a guide for future regulations which may be prepared and a statement of practice for offshore unit owners, constructors and appropriate organisations.

This standard is based on equipment and practices which are in current use but it is not intended in any way to impede development of new or improved techniques.

The ultimate aim has been to produce a set of International Standards exclusively for the offshore petroleum industry.

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

Part 3: Equipment

1 Scope

This part of IEC 61892 contains provisions for electrical equipment in mobile and fixed offshore units including pipeline, pumping or 'pigging' stations, compressor stations and exposed location single buoy moorings, used in the offshore petroleum industry for drilling, processing and for storage purposes.

This standard applies to equipment in all installations, whether permanent, temporary, transportable or hand-held, to a.c. installations up to and including 35 000 V and d.c. installations up to and including 750 V (a.c. and d.c. voltages are nominal values).

This standard gives requirements to equipment, which is additional to the requirement given in the product standard for the relevant equipment.

This standard does not apply to the electrical installations in rooms used for medical purposes or in tankers.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 16 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*

IEC 60034 (all parts), *Rotating electrical machines*

IEC 60044-1:1996, *Instrument transformers – Part 1: Current transformers*

IEC 60044-2:1997, *Instrument transformers – Part 2: Inductive voltage transformers*

IEC 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068 (all parts) *Environmental testing*

IEC 60076 (all parts), *Power transformers*

IEC 60076-1:2000, *Power transformers – Part 1: General*

IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-11:2004, *Power transformers – Part 11: Dry-type transformers*

IEC 60092 (all parts), *Electrical installations in ships*

IEC 60146-1-1:1991, *Semiconductor converters – General requirements and line commutated convertors – Part 1-1: Specifications of basic requirements*

IEC 60146-1-2:1991, *Semiconductor converters – General requirements and line commutated convertors – Part 1-2: Application guide*

IEC 60146-1-3:1991, *Semiconductor converters – General requirements and line commutated convertors – Part 1-3: Transformers and reactors*

IEC 60146-2:1999, *Semiconductor converters – Part 2: Self-commutated semicondutor converters including direct d.c. converters*

IEC 60282 (all parts), *High-voltage fuses*

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60331 (all parts), *Tests for electric cables under fire conditions – Circuit integrity*

IEC 60332-1-2:2004, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW premixed flame*

IEC 60439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEC 60439-1:2004, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

IEC 60533:1999, *Electromagnetic compatibility – Electrical and electronic installations in ships*

IEC 60865-1:1993, *Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods*

IEC 60884 (all parts), *Plugs and socket-outlets for household and similar purposes*

IEC 60896-11:2002, *Stationary lead-acid batteries – Part 11: Vented types – General requirements and methods of tests*

IEC 60896-21:2004, *Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test*

IEC 60896-22:2004, *Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements*

IEC 60906 (all parts), *IEC system of plugs and socket-outlets for household and similar purposes*

IEC 60945:2002, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 60947-3:1999, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*[1]

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*[2]

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunuty tests*

IEC 61097 (all parts), *Global maritime distress and safety system (GMDSS)*

IEC 61131 (all parts), *Programmable controllers*

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1 A consolidated edition (1.2), published in 2001, exists including IEC 61000-4-2 (1995), its Amendment 1 (1998) and its Amendment 2 (2000).

2 A consolidated edition (2.2), published in 2006, exists including IEC 61000-4-2 (2003), its Amendment 1 (2004) and its Amendment 2 (2005).

IEC 61800 (all parts), *Adjustable speed electrical power drive systems*

IEC 61892-1, *Mobile and fixed offshore units – Electrical installations – Part 1: General requirements and conditions*

IEC 61892-2, *Mobile and fixed offshore units – Electrical installations – Part 2: System design*

IEC 61892-4, *Mobile and fixed offshore units – Electrical installations – Part 4: Cables*

IEC 61892-5, *Mobile and fixed offshore units – Electrical installations – Part 5: Mobile units*

IEC 61892-6, *Mobile and fixed offshore units – Electrical installations – Part 6: Installation*

IEC 61892-7, *Mobile and fixed offshore units – Electrical installations – Part 7: Hazardous areas*

IEC 62040 (all parts), *Uninterruptible power systems (UPS)*

IEC 62271 (all parts), *High-voltage switchgear and controlgear*

IEC 62271-100:2001, *High-voltage switchgear and controlgear – Part 100: High-voltage alternating-current circuit-breakers*

IEC 62271-102:2005, *High-voltage switchgear and controlgear – Part 102: Alternating-current disconnectors and earthing switches*

IEC 62271-200:2003, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-201, *High-voltage switchgear and controlgear – Part 201: AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

ISO 6592:2000, *Information technology – Guidelines for the documentation of computer-based application systems*

IMO *Code of Safety for Diving Systems*

3 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 61892-1 through IEC 61892-7 and the following apply:

3.1
appropriate authority
governmental body and/or classification society with whose rules a unit is required to comply

3.2
computer-based system
system that consists of one or more programmable electronic devices with the connections, peripherals and software necessary to automatically carry out specified functions

NOTE The following types of programmable devices could form part of a computer system: mainframe, mini-computer, micro-computer, programmable logic controller.

3.3
convertor
a set of equipment, static or rotating, to convert one type of electric current to another type, different in nature, voltage and/or frequency

3.4
distribution board
switchgear or controlgear assembly for the control and distribution of electrical power to final subcircuits

3.5
double insulation
insulation comprising both basic insulation and supplementary insulation

3.6
electric surface heating
heat generated in the surface layer of a body to be heated by electrical means in order to raise or maintain its temperature

3.7
electric surface heating device
resistive or skin effect device designed to produce a defined output at a declared voltage and temperature, and terminated in a manner suitable for connection to the electricity supply

3.8
electric surface heating systems
system of electric surface heating devices together with any controls, thermal insulation and protective cladding designed to meet a specified electric surface heating requirement

3.9
electromagnetic compatibility EMC
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

3.10
emergency switchboard
switchgear and controlgear assembly which is normally supplied by the main switchboard but which, in the event of failure of the main electrical power supply system, is directly supplied by the emergency source of electrical power or the transitional source of emergency power and is intended to distribute and control electrical energy to the emergency services for all electrical consumers essential to the safety of the crew, contractors, visitors and the unit under emergency conditions

3.11
expert system
intelligent knowledge-based system that is designed to solve a problem using information that has been compiled from some form of human expertise

3.12
extra-low voltage ELV
voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as safety isolating transformers, or convertors with separate windings; a voltage which does not exceed 50 V d.c. between conductors, or between any conductor and earth, in a circuit which is isolated from higher voltage circuits.

NOTE 1 Consideration should be given to the reduction of the limit of 50 V under certain conditions, such as wet surroundings, exposure to heavy seas or powerful water jets where direct contact with live parts is involved.

NOTE 2 The voltage limit should not be exceeded, either at full load or no load, but it is assumed, for the purpose of this definition, that any transformer or convertor is operated at its rated supply voltage.

NOTE 3 Information about protection by extra-low voltage is given in IEC 60364-4-41.

3.13
heating cable
cable, with or without a shield or a metallic sheath, intended to give off heat for heating purposes

3.14
invertor
convertor for conversion from d.c. to a.c.

3.15
low-voltage switchgear and controlgear assemblies
combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulation equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical inter-connections and structural parts

3.16
main switchboard
switchgear and controlgear assembly which is directly supplied by the main source of electrical power and is intended to distribute and control electrical energy to the unit's services

3.17
non-type-tested low-voltage switchgear and controlgear assemblies NTTA
low-voltage switchgear and controlgear assembly which does not belong to 3.18 or 3.27

3.18
partially type-tested low-voltage switchgear and controlgear assemblies PTTA
low-voltage switchgear and controlgear assembly, containing both type-tested and non-type-tested arrangements provided that the latter are derived (e.g. by calculation) from type-tested arrangements which have complied with the relevant tests

3.19
rectifier
convertor for conversion of a.c. to d.c.

3.20
reinforced insulation
single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant IEC standard

NOTE The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation

3.21
resistive device
electric surface heating device of either the trace heating unit type or the surface heating unit type

3.22
(secondary) cell *(Syn.* (rechargeable) cell)
an assembly of electrodes and electrolyte which constitutes the basic unit of a secondary battery

3.23
section boards
switchgear and controlgear assembly for controlling and distributing the supply of electrical power to other section boards, distribution boards or final subcircuits

3.24
semiconductor device
device whose essential characteristics are due to the flow of charge carriers within a semi-conductor

3.25
skin effect device
electric surface heating device of the skin effect heater type

3.26
software
program, procedures and associated documentation pertaining to the operation of a computer system and including both the application (user) program and the operating system (firmware) program

3.27
type-tested low-voltage switchgear and controlgear assembly TTA
low-voltage switchgear and controlgear assembly conforming to an established type or system without deviations likely to significantly influence the performance from the typical assembly verified to be in accordance with this standard

3.28
valve-regulated battery cell
a secondary cell which is closed under normal conditions but which has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell cannot normally receive addition to the electrolyte

3.29
vented (secondary) battery cell (*Syn.* open (secondary) cell)
a secondary cell having a cover provided with an opening through which gaseous products may escape

NOTE The opening may be fitted with a venting system.

3.30
gastight sealed (secondary) cell
a secondary cell which remains closed and does not release either gas or liquid when operated within the limits and temperature specified by the manufacturer. The cell may be equipped with a safety device to prevent dangerously high internal pressure. The cell does not require addition to the electrolyte and is designed to operate during its life in its original sealed state

4 General requirements

4.1 Degree of protection

Degree of protection for electrical equipment shall be as specified in IEC 61892-2.

4.2 Service conditions

The normal environmental conditions shall be as stated in IEC 61892-1. Other environmental conditions shall be agreed between the manufacturer and the user if required, for example for use in arctic or tropical climates.

4.3 Temperature rise

Temperature rise shall be in accordance with the relevant product standard, taking into consideration the ambient temperatures referred to in IEC 61892-1.

NOTE When a rotating machine is connected to a supply system with harmonic distortion, the rating of the machine must allow for the increased heating effect of the harmonic loading.

4.4 Nameplates and labels

Each unit and main subassembly shall have nameplates clearly and indelibly marked with the data specified in the appropriate IEC standard.

Warning labels shall be provided in all location where necessary to warn personal of potentially dangerous situations.

All nameplates and labels shall be engraved on plastic-laminated material and secured with non-corrodible screws or rivets. Adhesive or self-tapping screws are unacceptable.

5 Generators and motors

5.1 General

The provisions of this clause are applicable to all rotating machines rated at 750 W or more for use in offshore units. It also applies to excitation machines and includes relevant requirements for prime-mover driving generators. Requirements particular to electrical propulsion machines are given in IEC 61892-5.

All electrical machines shall comply with the relevant requirements of IEC 60034-1 and also with the additional requirements included in this standard.

The duty types shall be in accordance with 60034-1.

When the duty is not declared, the manufacturer shall assume that duty shall be type S1 (continuous running duty) for generators and motors.

5.2 Voltage regulation of generators

5.2.1 General

The inherent voltage regulation of a general service generator shall be designed in relation to the speed regulation and governing of the prime movers as outlined below.

NOTE "General service" means that supplying motors and other consumers are a part of the normal distribution system of the unit. Consumers such as propulsion motors and other special consumers, for which other governing characteristics can be accepted or are required, are not considered part of the general service.

5.2.2 DC generators

The use of standard pattern of DC generators in mobile and fixed offshore unit is very limited, general reference is made to the 60092 series.

5.2.3 AC generators

The excitation system of a.c. generators rated 50 kW and above, and complying with 5.5, shall also comply with the requirements given below.

5.2.3.1 Steady conditions: tolerance of voltage and waveform

Each a.c. generator for general service driven by its prime-mover, whose governor characteristics comply with 5.8.2, shall be provided with an excitation system capable of maintaining the voltage under steady conditions within ±2,5 % of the rated voltage for all loads between zero and rated load at the rated power factor. These limits may be increased to ±3,5 % for emergency sets (see 5.2.3.4).

When the generator is driven at rated speed, giving its rated voltage and rated symmetrical load, the tolerance of waveform shall not exceed the values listed below:

- total harmonic distortion: 5 %
- single harmonic: 3 %

NOTE Attention is drawn to the possibility that under certain operating conditions the power factor may be less than the rated value, and that this can affect the voltage regulation.

5.2.3.2 Transient conditions

When the generator is driven at rated speed, giving its rated voltage, and is subject to a sudden change of symmetrical load within the limits of a specified current and power factor, the voltage shall not fall below 80 % nor exceed 120 % of the rated voltage.

The voltage of the generator shall then be restored to within ±3 % of the rated voltage, for the main generator set in not more than 1,5 s. For emergency sets these values may be increased to ±4 % in not more than 5 s respectively (see 5.2.3.4).

In the absence of precise information concerning the maximum values of the sudden loads, the following conditions shall be assumed: 60 % of the rated current with a power factor of between 0,4 lagging and 0 to be thrown on with the generator running at no load, and then withdrawn after steady-state conditions have been reached.

NOTE 1 Voltage regulation under transient conditions should be verified with all components as in normal operation (e.g. prime mover, generator and voltage regulator).

NOTE 2 To achieve satisfactory performance on board a unit, the governor of the prime-mover must restore the speed to a steady state within the limits specified in 5.8.2 in not more than 3 s.

5.2.3.3 Steady short-circuit conditions

Under short circuit conditions on the generator, it may be necessary to sustain a minimum value of current (after the transient disturbance has ceased) for a sufficient time to ensure operation of the system's protecting devices. Sustained short circuit current is attained by an excitation system designed to provide a specific value of short circuit current. The value of sustained short circuit current shall be decided in agreement between purchaser and manufacturer.

NOTE 1 For instance a current of at least three times its rated value for a duration of up to 2 s, unless protection selectivity conditions exist which allow a shorter duration and provided that, in any case, the safety of the installation is ensured, is acceptable.

NOTE 2 Sustained short circuit current is not necessary in cases where special relaying or other designs or means are employed to otherwise achieve selective protection.

5.2.3.4 Emergency generators

Emergency generator sets which are required to meet the same general requirements as in 5.2.3.2 need only maintain the steady-state voltage within 3,5 %, and during transient conditions to recover their voltage within 4 % in not more than 5 s.

5.3 Generators for special purposes

5.3.1 DC generators

Special purpose d.c. generators, together with their excitation system, shall have such voltage characteristics as are required.

5.3.2 AC generators

Special purpose a.c. generators and general service generators rated less than 50 kVA, together with their excitation system, shall have the voltage characteristics agreed upon between manufacturer and purchaser.

5.4 Parallel operation of general service generators – AC generators

5.4.1 Reactive load sharing

When a.c. generators are operated in parallel, the reactive load of the individual generating sets shall not differ from their proportionate share of the total reactive load by more than 10 % of the rated output of the largest machine, or more than 25 % of the smallest machine where this value is lower than the former.

NOTE The alternator design should incorporate sufficient damping in the rotor circuits to avoid power oscillations and instability when running in parallel.

5.4.2 Load sharing

For a.c. generating sets operating in parallel, the governing characteristics of the prime-movers shall be such that, within the limits of 20 % and 100 % total load, the load on any generating set does not normally differ from its proportionate share of the total load by more than 15 % of the rated output of the largest machine, or more than 25 % of the rating of the individual machine concerned.

The facilities for adjusting the governor at normal frequency shall be sufficiently accurate to permit a minimum adjustment of the load on the engine not exceeding 5 % of the rated load (see also note 2 of 5.2.3.2).

NOTE It is assumed that the speed of the prime-mover decreases with the application of the load and increases with its removal, permanent variation being such that the speed does not at any load vary from the straight line joining rated load and no load by more than one-fifth of the maximum permanent speed variation involved.

5.4.3 Flywheel effect for a.c. generators

For a.c. generators operating in parallel, the combined flywheel effect of the flywheel and alternator shall be such that the angular deviation in either direction, from the position of uniform rotation, does not at any time exceed 3,5 electrical degrees, in addition to complying with the limit of cyclic irregularity given in 5.9.

The engine manufacturer shall inform the supplier of the alternator as to the total flywheel effect which he considers should be provided to ensure that the maximum calculated angular deviation of 3,5 electrical degrees is not exceeded. The engine manufacturer shall be responsible for achieving the necessary flywheel effect.

The engine manufacturer shall also state the frequencies of such engine-disturbing forces as are of significant magnitude and the supplier of the alternator shall then specify to the engine manufacturer what additional flywheel effect, if any, is necessary in order to avoid the effects of electromechanical resonance (due to the vibration of the generator).

The generator manufacturer shall provide all necessary information to the engine manufacturer who will be responsible for checking the whole system for critical speeds and for calculating the torsional rigidity and torsional strength of the complete shaft system. The engine manufacturer shall state what reasonable changes, if any, in generator shafting are necessary to avoid excessive stresses from occurring, and such changes shall be undertaken by the generator manufacturer.

NOTE 1 The angular deviation specified is that calculated on the assumption that the torque of the alternator, i.e. the torque opposing the motion of the engine, is uniform throughout the engine cycle.

NOTE 2 The angular deviation specified apply to alternators for ordinary regulation. Alternators designed for special regulation may require still closer uniformity of rotation.

NOTE 3 Avoidance of effects of resonance means that the natural frequency of oscillation of the alternator with its flywheel, when connected to the electrical system with which it is to work in parallel, should not approach a frequency of any engine impulses of significant magnitude.

5.4.4 Excitation of a.c. generators

The components of the excitation system, including the automatic voltage regulator if used, shall be of a type suitable for offshore conditions and shall be capable of operating under all specified conditions of steady and transient load, including short circuit, as stated in 5.2.3.1, 5.2.3.2 and 5.2.3.3.

When it is intended to operate two or more generators in parallel, means shall be provided to divide the reactive power properly between the generators (see 5.4.1).

NOTE It is desirable to ensure that failure of the excitation system (including the automatic voltage regulator if used) does not cause damage to the installation.

5.5 Mechanical features (generators and motors)

5.5.1 Entry of water

Where water cooling is used, the cooler shall be so designed as to avoid entry of water into the machine, whether by leakage or condensation in the heat-exchanger.

5.5.2 Accumulation of moisture and condensation

Consideration shall be given to providing effective means to prevent accumulation of moisture and condensation within the machines, especially when these are idle for appreciable periods, for example by means of space heaters.

5.5.3 Balance

Vibration level for machines shall comply with the requirement of IEC 60034-14.

NOTE For vibration level during operation, see ISO 7919 and ISO 10816.

5.5.4 Shaft currents

Measures shall be taken, if necessary, to prevent the circulation of current between the shaft and the bearings.

NOTE For motors fed from VSD, guidance with regard to insulated bearings can be found in IEC 60034-17.

5.5.5 Terminals

The main terminals, and star point terminals, if any, shall be brought out to terminal box(es) on the outside of the generator/motor hood. The terminals shall be clearly marked. The terminals shall be effectively secured and shall be so spaced and/or shielded that they cannot accidentally be earthed, short-circuited or touched.

NOTE Protecting earthing bars and instrument bars should have direct connection with sufficient cross sectional area to the main enclosure to avoid circulating HF currents.

5.6 Lubrication (generators and motors)

5.7.1 Generators and motors shall have efficient and continuous lubrication at all running speeds and all normal working bearing temperatures, with any variation of the inclination of the unit from normal as specified in IEC 61892-5.

NOTE Motors driving gas compressors should not share a common lubrication system with the compressor.

5.7.2 Means shall be provided to prevent the lubricant from creeping along the shaft or otherwise gaining access to the insulation of the machine or to any live part thereof.

5.7.3 Each oil-lubricated bearing shall be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, prevents the bearing from containing an excess of oil.

5.7.4 Where ring lubrication is employed, the rings shall be so constrained that they cannot leave the shaft.

5.7.5 Each self-lubricated sleeve bearing shall be fitted with an inspection lid and means for the visual indication of oil level or the use of an oil-gauge. This requirement does not apply to machines under 100 kW (d.c.) or 100 kVA (a.c.).

5.7 Prime movers

5.7.1 General

Prime-mover-driven generators intended to supply power to services specified in IEC 61892-2 shall have a rating and overload capacity compatible with the rating and the specified overload capability of the driven generators.

5.7.2 Speed governing characteristics

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

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

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

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

Where the driven generators are required to operate in parallel, the governor of the prime mover must restore the speed to a steady state within the limits specified in not more than 5 s.

NOTE See also IEC 60092-101 and ISO 8528-5.

5.7.3 Flywheel effect

The flywheel effect provided shall comply with the requirements of 5.4.3.

5.8 Cyclic irregularity

5.9.1 The maximum permissible cyclic irregularity in a reciprocating engine throughout one engine cycle shall conform to the requirements given hereafter.

5.9.2 For an engine with one or two cylinders, the cyclic irregularity shall not be worse than 1/75 unless a closer limit is specified.

5.9.3 For an engine with more than two cylinders, the cyclic irregularity shall not be worse than the values given in Table 1.

Table 1 – Limits of cyclic irregularity

Number of engine impulses per second *f*	Cyclic irregularity to be not worse than
Up to 4	1/150
6	1/220
8 to 20	1/(200/f – f)
Above 20	1/75
NOTE Cyclic irregularity is defined as the ratio of the maximum variation in angular velocity at the flywheel during one engine cycle to the mean angular velocity when the engine is running at any load up to and including rated load and at rated speed. This is conveniently expressed as follows: $\frac{\text{Max. speed} - \text{Min. speed}}{\text{Mean speed}}$	

5.9 Lubrication (prime movers)

5.10.1 Prime movers shall be efficiently and continuously lubricated at all running speeds and at all working oil temperatures without risk of spilling oil, at any inclination of the installation with the limits specified in IEC 61892-5.

5.10.2 Generating sets dependent on forced lubrication shall be arranged to shut down automatically in case of failure of lubrication, and effective lubrication shall be provided to prevent damage to the bearings during running down.

5.10 Running speed

The normal speed on a combined generating set shall not approach critical speed.

NOTE The relation between critical speed n_{cr} and nominal speed n_N should be ($n_N < 0.9\ n_{cr}$).

5.11 Testing

Sufficient tests shall be made in accordance with IEC 60034-1 and other relevant parts of the IEC 60034 series, unless otherwise specified, in order to ensure that the machine meets these requirements.

6 Transformers for power and lighting

6.1 General

The provisions of this clause are applicable to all transformers used for power, lighting and static convertors and, where appropriate, to starting transformers, static balancers, saturable reactors and transductors for use in offshore units, including single-phase transformers rated at less than 1 kVA, and three-phase transformers rated at less than 5 kVA, unless special requirements are specified. All equipment referred to shall comply with the relevant requirements of IEC 60076 series as well as with the additional requirements given in this standard.

Transformers for use with convertors, invertors, variable speed drives, etc., shall be so designed as to be suitable for use on non-sinusoidal supplies and/or variable frequency supplies, and shall comply with IEC 60146-1-3.

6.2 Winding arrangement

Transformers shall be double-wound (two separate windings) or triple-wound (three separate windings). Starting transformers may be of the auto-transformer type.

NOTE For special equipment other winding arrangements may be used.

6.3 Terminals

Suitable terminals, clearly marked, shall be provided in an accessible position, convenient for external connections. The terminals shall be effectively secured and shall be so spaced and/or shielded that they cannot be accidentally earthed, short-circuited or touched.

6.4 Cooling arrangement

6.4.1 When installed indoors, transformers shall preferably be of the dry, air-cooled type. The classes of dry type transformers shall be C1 (environmental), E2 (Environmental), F0 (fire behaviour) as minimum according to the requirements of IEC 60076-11.

NOTE 1 In some countries oil-filled equipment is not permitted on offshore units.

NOTE 2 An air to water cooler integrated in an IP 55 enclosure for the transformer will reduce the requirement for cooling air.

6.4.2 Transformers of the liquid-immersed type shall preferably be hermetically sealed. If of the conservator type, they shall be so designed that they operate without risk of spilling liquid under all conditions, with the offshore units inclined from the normal as specified in IEC 61892-5

If provision is made for breathing, a suitable dehydrator shall be provided.

A spill catchment surrounding the base of liquid filled transformers shall be provided.

6.4.3 For liquid-immersed type transformers, consideration shall be given to the possibility of providing over-temperature alarm and gas-actuated protection devices.

6.4.4 Liquid cooled transformers shall use a non-toxic coolant which does not readily support combustion.

6.4.5 Where forced cooling is used, it shall be possible to operate at reduced power on failure of a pump or a fan. Consideration shall be given to the provision of suitable indicating and alarm facilities.

6.5 Voltage regulation

The voltage drop in the secondary voltage between no load and rated load shall be agreed between the purchaser and the manufacturer.

NOTE For more information and relative formulae, see IEC 60076-8.

When determining the transformer ratio and the short-circuit impedance, consideration should be given to total voltage drop to be expected in the supply and distribution system. In this respect, see also IEC 61892-2.

6.6 Parallel operation

For successful parallel operation, the transformers require:

- the same phase- angle relation – clock hour number;
- the same ratio with some tolerance and similar tapping range;
- the same relative short circuit impedance - percentage impedance – with some tolerance. This also means that the variation of relative impedance across the tapping range should be similar for the two or more transformers.

The following shall also be considered.

- It is not advisable to combine transformers of widely different power rating (say, more than 1:2). The natural relative impedance for optimal designs varies with the size of the transformer.
- Transformers built according to different design concepts are likely to present different impedance levels and different variation trends across the tapping range.
- The consequences of a small mismatch of data should not be overestimated. It is not necessary, for example, to provide precisely the same tapping voltages on two parallel transformers.

- In practice, a mismatch of relative loading of no more than about 10 % between two transformers of non-identical designs should be regarded as reasonable.

NOTE Transformers with rectifiers for parallel supply to one DC bus do not require the same phase angle.

6.7 Tests

The routine test, type test and special test (when required) shall comply with IEC 60076-1.

If a short-circuit test is required to prove the short-circuit ability of a transformer, it will be a type test and shall comply with IEC 60076-5.

7 Switchgear and controlgear assemblies

7.1 Service conditions

The provisions of this clause are applicable to switchgear and controlgear assemblies, with 6.3 containing provisions for rated voltages not exceeding 1 000 V a.c. at rated frequencies not exceeding 60 Hz or 1 500 V d.c., while the provisions of 6.4 are applicable for voltages in the range from 1 kV up to and including 35 kV at rated frequencies not exceeding 60 Hz. Clause 6.5 is applicable both to high-voltage and low-voltage assemblies.

The conditions specified in IEC 61892-1 shall take precedence over values given in clause 6 of IEC 60439-1.

7.2 Definitions

For definition of general terms used in this clause, see IEC 60439-1, IEC 62271-200 and this standard, clause 3.

7.3 Low-voltage switchgear and controlgear assemblies

7.3.1 General

The product standard IEC 60439 is used as basis reference. Additional requirements are given in this standard, clauses 7.3.2 to 7.3.13.

7.3.2 Classification of assemblies

See clause 3 of IEC 60439-1.

7.3.3 Electrical characteristics of assemblies

See clause 4 of IEC 60439-1.

7.3.4 Information to be given regarding the assemblies

See clause 5 of IEC 60439-1.

7.3.5 Temperature rise

See clause 7.3 of IEC 60439-1.

NOTE It is recommended that facilities for thermographic inspection or the use of thermostrips are provided to support inspections/surveys during operation of a unit.

7.3.6 Circuits

Individual circuits and their devices shall have durable markings with a permanent means of fixing. The setting of protective devices shall be indicated. When, for fuses above 500 V, the fuse holders permit the insertion of fuses of a lower nominal voltage, special warning labels or symbols shall be provided that read, for example: "Caution 690 V fuses only".

NOTE The rating of fuses and the setting of protective devices may be given in the documentation instead of on the switchboard.

7.3.7 Marking of parts

Withdrawable and removable parts of an assembly shall be marked to identify where the parts can be placed in the assembly.

7.3.8 Instruction for installation, operation and maintenance

7.3.8.1 See clause 5.3 of IEC 60439-1.

7.3.8.2 Where polarized circuit-breakers are installed in d.c. systems, and in all similar cases, warning labels shall be so arranged as to guard against the possibility of incorrect connections during maintenance or replacement.

7.3.9 Design and construction

7.3.9.1 Mechanical design

See IEC 60439-1.

7.3.9.2 Structural parts of aluminium alloy

If structural parts and/or busbars are of aluminium alloy, the material shall be suitable for use in the marine environment and precautions shall be taken to avoid galvanic corrosion.

7.3.9.3 Insulating material

The insulating material shall be in accordance with the general requirements as stated in IEC 61892-1.

7.3.9.4 Section and distribution boards

Enclosures shall be made of flame-retardant material and so constructed or located that they can be opened only by authorized personnel.

7.3.9.5 Handrails or handles on mobile units

Every main or emergency switchboard shall be provided with an insulated handrail, located on a fixed part, or insulated handles suitably fitted on the front of the switchboard. Where access to the rear of above mentioned switchboards is necessary for operational or maintenance purposes, an insulated handrail, located on a fixed part, or insulated handles shall be fitted. It may be necessary to provide handrails or handles for section boards, if the dimensions are similar to main or emergency switchboards.

7.3.9.6 Door locking

Doors on which electrical equipment is fitted, which is live when the doors are open, shall be provided with locking facilities for the open position.

7.3.9.7 Clearance, creepage distances and isolating distances

7.3.9.7.1 General

See clause 7.1.2 of IEC 60439-1. In addition, 7.3.9.7.2 to 7.3.9.7.4 shall be applied.

7.3.9.7.2 Clearance and creepage distances

Clearance and creepage distances shall be in accordance with 7.3.9.7.3 for type-tested and partially type-tested assemblies. For non-type-tested assemblies, clearance and creepage distances shall be in accordance with 7.3.9.7.4. The clearance and creepage distances between busbars and/or connectors other than cables in assemblies shall not be permanently reduced below the values specified in 7.3.9.7.3 or 7.3.9.7.4 due to abnormal conditions (for example short circuits).

7.3.9.7.3 Type tested and partially type-tested assemblies

For these assemblies the following requirements for the clearance and creepage distances of busbars shall apply:

- pollution degree 3: (conductive pollution occurs, or dry, non-conductive pollution occurs, which becomes conductive due to expected condensation);
- overvoltage category III: (distribution circuit level);
- inhomogeneous field conditions (case A);
- rated operational voltage 1 000 V a.c., 1 500 V d.c.;

- group of insulation material III a.

As a result of these requirements the values are as follows:

- minimum clearance: 8 mm
- minimum creepage distance: 16 mm

If a pollution degree higher than 3 is applicable because of the location of the assembly, e.g. in diesel-engine rooms, the requirements shall be as stated in 7.3.9.7.4.

NOTE The above mentioned clearances and creepage distance are the minimum values.

7.3.9.7.4 Non type-tested assemblies

For these assemblies the requirements for the clearance and creepage distances shall be as stated in Table 2.

The values in Table 2 apply to clearance and creepage distances between live parts and between live and exposed conductive parts.

Table 2 – Clearance and creepage distances for non type-tested assemblies

Rated insulation voltage a.c. r.m.s. or d.c. V	Minimum clearance mm	Minimum creepage distances mm
≤250	15	20
>250 and ≤690	20	25
>690	25	35

7.3.9.8 Enclosure and degree of protection

See clause 7.2 of IEC 60439-1 and IEC 61892-2.

7.3.9.9 Protection against direct contact

For rated operational voltages above the safety extra-low voltage of 50 V a.c. r.m.s. or d.c. as specified in IEC 61892-1, assemblies shall have a degree of protection against direct contact of at least IPXXB according to IEC 60529 and IEC 61892-2.

Means for isolation of generator circuit breakers shall be provided to permit safe maintenance while the main busbars are alive.

NOTE 1 Safety interlock between different boards in order to avoid the possibility to open a panel in one switchboard without opening the above connected circuit breakers placed in another switchboard (in the same or in different electrical room) should be provided.

NOTE 2 The provision of means for isolation for other important parts of assemblies is recommended.

7.3.9.10 Short-circuit protection and short-circuit withstand strength

Reference is made to IEC 61892-2.

Precautions shall be taken to prevent the escape of gases from internal short-circuits through the front or into adjacent cubicles of the assemblies.

A short-circuit withstand test shall be carried out for low voltage switchboard when the prospective fault current “Ik” is larger than 50 kA.

NOTE It is recommended to install an arc detection system for limitation of the damages in case of a short circuit. Fault finding guide for guidance to the place of the fault should be included.

7.3.9.11 Switching devices and components installed in assemblies

7.3.9.11.1 General

See clause 7.6 of IEC 60439-1.

7.3.9.11.2 Design of switching devices/installation of components

Each switching device shall be designed and arranged in such a way that, in the off position, it cannot accidentally move sufficiently to close the circuit.

Wherever possible, components of main circuits with different nominal voltages shall be installed separately from each other.

7.3.10 Barriers between generator sections

Where the aggregate capacity of generators connected to the main busbar of an assembly exceeds 100 kVA a.c., barriers between the generator sections and adjacent sections shall be installed to limit gas propagation through the assembly.

7.3.11 Electrical connections inside an assembly: bars and insulated conductors

7.3.11.1 General

See clause 7.8 of IEC 60439-1. In addition, the requirements listed below apply.

7.3.11.2 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2.

NOTE Wiring should have low emission of smoke and halogen gases in the case of fire. The following minimum requirements should be met:

i) a minimum light transmission value of 60 % according to IEC 61034-2;

ii) a maximum halogen gas emission of 0,5 % according to IEC 60745-1.

7.3.12 Busbars

7.3.12.1 Busbar phase or polarity arrangements

Where practicable, consideration shall be given to providing a standard pattern of busbar phase and polarity arrangements, as viewed from the front of the assemblies.

NOTE Examples for such patterns are for a.c. switchgear and controlgear assemblies busbar 1, 2, 3 counting from front to rear, top to bottom or left to right.

7.3.13 Main busbar subdivisions

Where the aggregate capacity of generators connected to a main busbar of an assembly exceeds 100 kVA a.c. the main busbars of the assembly shall be subdivided into at least two isolated parts which shall normally be connected by removable links or other approved means. As far as possible, the connection of the generators and any other duplicated equipment shall be equally divided between the parts.

7.3.13.1 Cross sections and current-carrying capacity of main circuits

7.3.13.1.1 General

Busbars shall consist of electrolytic copper for conductive use or of copper-surrounded aluminium alloy. The rating of current-carrying conductors in a main circuit shall be as outlined below.

- Main busbar: 100 % of the current load on the main busbars at the maximum load condition of the busbar concerned.
- Distribution busbars in sections: unless otherwise specified the diversity factors given in IEC 60439-1 shall apply.
- Termination of components: according to the rated current of the circuits and the permissible temperature limits at the terminals.

NOTE The main busbar design should be prepared for extension in both end of the switchboard.

7.3.13.1.2 Cross-sections and current-carrying capacity of main busbars and distribution busbars in sections

The basis for rating busbars shall be according to IEC 60439-1.

Temperature rise limits, with the following changes:

- 45 °C ambient air temperature;
- 45 °C temperature rise under rated current conditions of busbars for NTTA. For TTA and PTTA, clause 7.3 of IEC 60439-1 shall apply.

NOTE To limit the air temperature inside assemblies to the design value, in certain cases special provisions may be necessary, for example natural or forced ventilation.

7.3.14 Test specifications

7.3.14.1 General

Testing shall be performed as required by IEC 60439-1, clause 8.

7.3.14.2 Additional requirements

7.3.14.2.1 Except for type-tested assemblies, the short-circuit withstand strength of busbars may be verified by calculation on the basis of IEC 60865-1.

7.3.14.2.2 In addition to the requirements of IEC 60439-1, the following apply:

For every assembly for which a function test is required (main switchboards, emergency switchboards, switchboards for propulsion plants), the functions of all mechanical components and the function of the electrical control shall be verified to be in accordance with the functional diagrams.

The following shall be verified in detail:

- function of the switching devices (switching, interlocking) after installation;
- function of indicating, monitoring and protecting devices;
- assessment of protective measures.

For non type-tested assemblies (NTTA) the test voltage shall be applied for 1 min.

7.3.14.3 Verification of insulation resistance

For PTTA which have not been subject to a dielectric test according to the requirements of IEC 60439-1, an insulation measurement using a measuring device at a voltage of at least 500 V shall be carried out.

In this case, the test is deemed satisfactory if the insulation resistance between circuits and exposed conductive parts is at least 1 000 Ω/V per circuit referred to the nominal voltage to earth of these circuits.

Exceptionally, items which according to their specific requirements are current-consuming components (e.g. windings, measuring instruments) at the application of the test voltage or are not designed for the full test voltage shall be disconnected as appropriate.

7.3.14.4 Measurement of insulation resistance

During the routine test an insulation resistance measurement of the main and auxiliary circuits shall be carried out prior to and following the verification of dielectric properties.

The insulation measurement shall be carried out with at least 500 V d.c. It is allowed to subdivide large assemblies into several sections.

The insulation resistance shall be at least 1 MΩ per section.

7.3.14.5 Verification of temperature-rise limits

The temperature-rise limits shall be verified, by comparison with measurements obtained during tests on similar assemblies and calculations, or, if necessary, by suitable tests under operating conditions.

7.3.14.6 Use of test data of individual equipment

Unless otherwise agreed, it is not required that routine tests be carried out on individual equipment of an assembly when it can be verified that the manufacturer of this equipment has already carried out a routine test.

7.4 Switchgear and controlgear in the range above 1 kV up to and including 35 kV

7.4.1 General

High-voltage switchgear shall be constructed in accordance with the following subclauses.

High-voltage switchgear shall be of the metal-enclosed type in accordance with IEC 62271-200, or of the insulation-enclosed type in accordance with IEC 62271-201.

NOTE In addition, national standards may apply.

7.4.2 Service conditions

The conditions specified in IEC 61892-1 shall take precedence over values given in IEC 62271-200.

7.4.3 Ratings

Ratings shall be in compliance with IEC 62271-200.

7.4.4 Design and construction

Design and construction shall be in compliance with IEC 62271-200.

The switchgear and controlgear shall be tested and verified IAC classified as per IEC 62271-200, Annex A. Accessibility shall be type A (authorised personnel).

NOTE It is recommended to install an internal arc detection devise sensitive to light, heat, pressure or mean for rapid fault clearance.

A short-circuit withstand test shall be carried out for the high-voltage switchboard when the prospective fault current "Ik" is larger than 31,5 kA.

The service condition of the switchgear shall be LSC 2B as per IEC 62271-200, 8.2.3.

7.4.5 Degree of protection provided by enclosures

Depending on its location, electrical equipment shall as a minimum have the degree of protection as given in IEC 61892-2.

7.4.6 Circuit breakers, switches and fuses – General

7.4.6.1 Circuit-breakers and switches shall be of the type that minimizes fire hazard**.**

7.4.6.2 Circuit-breakers shall be in accordance with IEC 62271-100.

7.4.6.3 Switches shall be in accordance with IEC 62271-102.

7.4.6.4 Fuses shall be in accordance with IEC 60282.

7.4.6.5 Conduit pipes and valves of compressed-air operating mechanisms shall be of non-corrosive material.

7.4.6.6 If compressed air-operated circuit-breakers are used, the compressed-air system shall be so designed that switching on is possible only if sufficient switch-off pressure is available for every circuit-breaker on the compressed-air system. Any loss of air pressure shall be indicated.

7.4.6.7 In a compressed-air system, means shall be present to provide clean and dry air. These means shall be duplicated to allow maintenance.

7.4.6.8 Circuit-breakers shall be of the withdrawable type, or with equivalent means or arrangements permitting safe maintenance whilst the busbars are live.

7.4.6.9 Withdrawable circuit-breakers and switches shall be provided with mechanical locking facilities in both service and disconnected positions.

For maintenance purposes, key-locking of withdrawable circuit-breakers and switches and fixed disconnectors shall be possible.

7.4.7 Earthing and short-circuiting

For maintenance purposes, an adequate number of earthing and short-circuiting devices shall be available to enable a sufficient number of circuits to be worked upon with safety. Alternatively, integral means of earthing and short-circuiting may be fitted.

The earthing terminal shall be located outside the enclosure.

7.4.8 Protection against live parts

The fixed contacts of withdrawable circuit-breakers and switches shall be so arranged that, in the withdrawn position, the live contacts are automatically covered, or full withdrawal is possible only after manual insertion of covers.

7.4.9 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2 and have low halogen properties and low smoke and toxic gas emission.

NOTE Wiring should have low emission of smoke and halogen gases in the case of fire. The following minimum requirements should be met:

i) a minimum light transmission value of 60 % according to IEC 61034-2.

ii) a maximum halogen gas emission of 0,5 % according to IEC 60745-1.

7.4.10 Auxiliary systems

If electrical energy and/or physical energy is required for the operation of circuit-breakers and switches, a stored supply of such energy shall be provided for an adequate number of operations.

7.5 Instruments for assemblies

7.5.1 General

The requirements of this clause is applicable both to high-voltage and low-voltage assemblies.

7.5.2 Instrument for a.c. generators

Each a.c. generator shall be at least provided with the following instruments:

- a voltmeter for measuring each phase and between each phase and neutral (when applicable);
- an ammeter for measuring each phase;
- a three-phase wattmeter for generators rated more than 50 kVA, if parallel operation is possible;
- a frequency meter.

NOTE For voltmeters and ammeters, change-over switches can be used to connect an instrument to the different phases (or to neutral).

7.5.3 Instrument for d.c power sources

For each d.c. power source (e.g. convertors, rectifiers and batteries) a voltmeter and an ammeter shall be provided, except for d.c. power sources for starting devices (e.g. starting motor for emergency generators).

7.5.4 Instruments measuring the insulation level to earth

When a distribution system, whether primary or secondary, for power, heating or lighting, with no connection to earth is used (IT-system), a device capable of continuously monitoring the insulation level to earth and giving an audible and visual indication of an abnormally low insulation level shall be provided. A means shall be provided to silence the audible alarm.

7.5.5 Design of instruments

For each assembly, the measuring error of instruments for single consumers shall not exceed 3 % of the full scale value.

The measuring error of instruments for other purposes shall not exceed 1,5 % of the full scale value.

A d.c. power source instrument for both polarities shall be provided.

Voltmeters shall have a measuring range of at least 120 % of rated voltage.

Ammeters shall have a measuring range of at least 130 % of the highest current expected in continuous operation. Ammeters shall be able to withstand the starting current of motors.

Wattmeters shall have a measuring range of at least 120 % of the rated power.

For generators arranged for parallel operation, the measuring range of a three-phase wattmeter shall include at least 15 % reverse power.

For wattmeters using one current circuit only, the measurement of the current of all generators shall be made in the same phase.

Frequency meters shall have a measuring range of at least ±5 Hz around the rated frequency.

When electronic multifunction devices are used, at least three separate ammeters for each main feeder and one separate voltmeters for each busbars shall be provided.

7.5.6 Transformers provided for instrumentation, protection and control circuits

Current and voltage transformers used for measuring purposes shall have at least accuracy class 1 as stated in IEC 60044-1, respectively 60044-2.

Current transformers used for protective devices shall be suitable for the overcurrent range that is expected may occur.

Current transformers provided for instrumentation, protection and control shall have their secondary windings connected to earth.

7.5.7 Selection of protective devices

The requirements according to IEC 61892-2 are applicable.

7.5.8 Synchronizing devices

For protection against the effects of incorrect synchronization while paralleling generators, at least one blocking device (e.g. a check synchronizer) shall be provided to avoid synchronizing failures, or a current limiting reactance.

At least one synchroscope or three synchronizing lamps or equivalent means for manual synchronization shall be provided as well as dual frequency and dual voltage meter.

Provision shall be made for manual speed control of the prime mover at the switchboard for manual synchronization.

7.5.9 Speed governor

For a.c. generators arranged to operate in parallel, a device for the remote speed control of each set shall be provided. The device shall allow at least manual control of the frequency from at least 20 % below to at least 10 % above the system rated frequency. The time taken to cover this range shall be sufficient to enable a satisfactory sharing of load.

8 Semiconductor convertors

8.1 General

8.1.1 The provisions of this clause are applicable to static convertors using semiconductor rectifying elements such as diodes, reverse blocking triode thyristors, transistors, etc., for use in offshore units. The conversion may be from a.c. to d.c., from d.c. to a.c., from d.c. to d.c. and from a.c. to a.c.

8.1.2 Semiconductor convertors shall comply with the relevant requirements of IEC 60146-1-1, IEC 60146-1-2, IEC 60146-1-3, IEC 60146-2, IEC 61800, as well as with the additional requirements given in this standard.

8.2 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2 and have low halogen properties and low smoke and toxic gas emission.

NOTE Wiring should have low emission of smoke and halogen gases in the case of fire. The following minimum requirements should be met:

i) a minimum light transmission value of 60 % according to IEC 61034-2;

ii) a maximum halogen gas emission of 0,5 % according to IEC 60745-1.

8.3 Cooling arrangements

8.3.1 Semiconductor convertors shall preferably be of the dry, air-cooled type.

8.3.2 Semiconductor convertors of the liquid cooled type shall preferably be hermetically sealed. If provision is made for breathing, a suitable dehydrator shall be provided.

8.3.3 Liquid cooled semiconductor devices shall use a non-toxic coolant, which does not combust easily. Consideration shall be given to the provision of a liquid over-temperature alarm and gas actuated protection devices.

NOTE 1 Regarding installation precautions, see IEC 61892-6.

NOTE 2 Where a cooling medium for electrical equipment is used, consideration should be given to the detection of leakage in an equipment enclosure and provision of an alarm indication. In addition, the flow of coolant should be monitored to operate an alarm in the event of loss of flow.

8.4 Accessibility

The convertor shall be housed in free-standing, floor-mounting, metal-enclosed enclosures permitting front and rear access.

Semiconductor convertor stacks or semiconductor components shall be mounted in such a manner that they may be removed from the equipment without dismantling the complete unit.

The equipment shall be designed to minimize risk of an internal short circuit. It shall also provide safety to personnel and safe operation during inspection and maintenance. Under extreme conditions of major short circuits or badly operation, there shall be no danger to persons in the vicinity of the equipment.

8.5 Service conditions

8.5.1 The service conditions, for example ambient temperature, stated in IEC 61892-1, are applicable.

8.5.2 If the convertor equipment requires drying for maintenance and inspection purposes, special care shall be taken that the maximum permissible temperature limits are not exceeded when applying heat to the equipment.

8.5.3 The convertor equipment shall be suitable for operation, with nominal power output, under steady state variations of input voltage and frequency, according to IEC 61892-1.

8.5.4 The convertor equipment shall be immune to voltage transients, voltage dips, and distortion on power supply, according to IEC 62040.

8.6 Application

8.6.1 Forced cooling

Where forced cooling is utilized, the circuit shall be so designed that power cannot be applied to, or retained, on convertor stacks or semiconductor components, unless effective cooling is maintained.

When forced cooling is unavoidable, the failure of any one cooling fan on any thyristor stack shall not impair the unit performance. The changeover standby fans shall be automatic.

Particular attention shall be paid to the location of ventilation louvers and their arrangement. Dust filters shall be provided on all louvers and shall be easily replaceable during operation without no disconnection of the convertor.

NOTE Reduced power output in natural air cooling mode may be considered.

8.6.2 Effects from and on the supply or load system

8.6.2.1 Precautions shall be taken to guard the convertor equipment against the harmful effects of overcurrent or overvoltage due to disturbance on the supply or load system, including the effects of regenerated power if the load can operate in such a way.

8.6.2.2 Precautions shall also be taken to guard the supply and the load system against the harmful effects of any disturbance in the convertor itself.

8.6.2.3 Semiconductor convertors shall not cause distortion in the voltage waveform of the power supply to levels exceeding the voltage waveform tolerances at the other user input terminals. This is, in particular, applicable to convertors that employ electronic switches operating once or more than once per cycle of the power supply voltage.

If fitted, filters shall not decrease the insulation resistance between the supply phases and earth to unacceptable levels. In cases where the earth current exceeds 30 mA, isolating transformers shall be fitted.

NOTE 1 Current harmonics, interacting with the impedance of the supply will generate voltage harmonics. Both the current and voltage harmonics can cause malfunction and overheating in other items of equipment in the unit, if their possible presence has not been taken into account in the equipment design. For systems where a convertor rating is large and a significant proportion of the system rating, it may not be feasible to suppress such harmonics at the source. Consequently, appropriate measures may have to be taken to attenuate these effects on critical equipment. Such measures may include electrical isolation, e.g. MG sets, filters in the supply to critical equipment; correct screening of cables and construction of enclosures, etc.

General guidance is given in IEC 60533.

NOTE 2 For requirements concerning EMC, see IEC 61892-2.

8.7 Diagrams

All applications shall contain schematic and wiring diagrams, or else instruction books shall be provided.

8.8 Convertor transformers

If transformers are used in combination with semiconductor convertors on the supply side or the load side of the convertor, these transformers shall comply with the requirements of clause 6.

In case of systems were harmonic contents are expected, transformers shall be sized with consideration to the recommended derating according to IEC Standards.

9 Secondary cells and batteries

9.1 General

Secondary cells and batteries shall comply with the requirements of IEC 60896-11, IEC 60896-21 and IEC 60896-22 and the requirements of this clause. The requirements are applicable to secondary cells and batteries of the vented type, valve regulated and sealed types, which are installed permanently for use in mobile and fixed offshore units.

It is not applicable to batteries of the portable type.

9.2 Types of batteries

In general, secondary cells and batteries may be of the lead-acid or nickel-alkaline type, or any other proved type, due consideration having been given to suitability for any specific application.

NOTE The secondary cells and batteries are then divided in

- vented type,
- valve regulated type,
- sealed type.

According to the different characteristics, the above mentioned kind of cells should be suitable to feed UPS, utility, emergency loads, telecommunication and for motive power.

The majority of the secondary cells and batteries are utilized in floating operation

A battery in floating operation has a constant voltage permanently applied to its terminal which is sufficient to maintain it in a state close to full charge and is intended to supply a circuit whose normal power supply fails.

9.3 Charging facilities

9.3.1 For floating service or for any other conditions where the load is connected to the secondary battery while it is on charge (being charged), the maximum battery voltage under any conditions of charge shall not exceed the safe value of any connected apparatus. The voltage characteristics of the generator or generators, semiconductor convertor or semiconductor convertors, which will operate in parallel with the battery, shall be suitable for each individual application. Where apparatus capable of operation at the maximum charging potential is not available, a voltage regulator or other means of voltage control shall be provided.

9.3.2 Where the voltage of an emergency-lighting secondary battery is the same as that of the unit d.c. supply, the battery may be arranged for charging in two equal sections, a charging resistor being provided for each section.

Alternatively, a booster generator may provide charging voltage. With either method, the arrangement of automatic transfer switching shall be such that emergency supply is available whether the battery is on charge (charged) or not.

9.3.3 Except when a different charging rate is necessary and is specified for a particular application, the charging facilities shall be such that the completely discharged battery can be recharged to 80 % capacity within a period of 10 h.

9.3.4 For secondary batteries which normally stand idle for long periods, trickle charging to neutralize internal losses shall be provided where practicable.

An indication shall be provided to indicate a charging voltage present at the charging unit.

9.3.5 Protection against reversal of the charging current shall be provided.

9.4 Ventilation of secondary battery compartments

For ventilation of battery compartments, see IEC 61892-7.

NOTE The choice of type of battery (vented, valve regulated or sealed) will have an important impact with the ventilation and the electrical installation of battery compartments.

10 Luminaires

10.1 General

10.1.1 The provisions of this clause are applicable to fixed or portable luminaires for use in offshore units. It does not apply to battery-operated torches.

10.1.2 Luminaries to be installed in hazardous areas shall comply with IEC 61892-7.

10.2 Construction

10.2.1 Luminaires shall be so designed and constructed that the passages for the insulated conductors are of ample size and are free from rough projections, sharp angles and abrupt bends. All outlets for cables shall have well-rounded edges or be suitably bushed.

10.2.2 Luminaires shall be so designed and the insulated conductors installed in such a way that they cannot apply stress to any terminal to which they may be connected.

10.2.3 Luminaires shall be so designed and fixed that dust and moisture cannot readily accumulate on live parts and on their insulation.

10.2.4 Current-carrying parts of luminaires shall be insulated from the frame or enclosure.

10.2.5 All metal parts of luminaires shall be electrically connected together and shall be provided with a suitable terminal for earthing. For exceptions, see IEC 61892-6, and clause 10.8 of this part.

10.2.6 Supports of live parts in lampholders shall be at least of flame-retardant material for fluorescent lamps and of incombustible material for incandescent lamps.

10.2.7 In bathrooms, washplaces, laundries, galleys and other similar places, those parts of a lampholder likely to be touched by a person replacing a lamp shall be constructed of or shrouded in insulating material, and fitted with a protective shield.

NOTE The use of totally enclosed luminaires is desirable.

10.2.8 Where centre-contact bayonet or Edison screw lampholders are used on single-pole and earthed neutral systems, the outer or screwed contact shall be connected to the neutral conductor.

10.2.9 Floodlights shall be provided with an extra safeguarding against falling down if the screwed connections loosen.

10.2.10 Lampholders of type E40 shall be provided with effective means for locking the lamp in the holder.

10.3 Temperature and temperature rise

10.3.1 Luminaires shall be so constructed as to provide adequate dissipation of heat from lamps, ballasts, capacitors, etc.

10.3.2 The temperature of surface parts which can be touched in service shall normally not exceed 60 °C.

10.3.3 The temperature rise of terminals for connection of supply cables shall not exceed 40 °C.

10.3.4 Wires used for internal connections shall be of a temperature class which corresponds to the maximum temperature within the luminaire and shall be of flexible type.

NOTE Temperature rise tests should be performed at rated voltage and frequency and maximum lamp rating should not result in temperatures in excess of 5 °C above the limits specified.

10.4 Exposure to mechanical damage

Luminaires likely to be exposed to more than the ordinary risk of mechanical damage shall be protected against such damage or be of specially robust construction.

10.5 Discharge lamp luminaires operating at voltages below 250 V

In discharge lamp installations operating at voltages below 250 V, all independent ballasts, capacitors and other auxiliaries mounted separately from the luminaire shall be enclosed in an earthed metal casing.

Every capacitor of 0,5 mF or more shall be provided with means for reducing the voltage of the capacitor to less than 55 V within 1 min after disconnection from the supply source.

10.6 Discharge lamp luminaires operating at voltages above 250 V

10.6.1 General

Discharge lamps operating at voltages above 250 V shall be used only in fixed luminaires. Discharge lamp installations shall, where practicable, be provided with durable and suitable notices bearing the following inscription:

10.6.2 Construction of lamps and lampholders

Caps and lampholders for discharge lamps shall be of robust construction in function of the voltage employed.

10.6.3 Protection of live parts

All live parts of discharge lamp luminaires shall be so designed, placed and installed that they cannot be touched accidentally or inadvertently.

The creepage distance along the surface of the glass tube shall be taken into consideration.

10.6.4 Transformers

Transformers for discharge lamps shall have their primary and secondary windings electrically separated and shall not contain flammable liquid.

Transformers shall be placed within the discharge lamp luminaire or located as closely as possible to the luminaire installation.

10.7 Searchlights and arc lamps

All parts of searchlights or arc lamps to be handled for their operation or adjustment while in use shall be so arranged that there is no risk of shock to the operator.

Disconnection of every searchlight or arc lamp shall be by a multipole (all poles) disconnecting switch.

If a series resistor is used with an arc lamp, the disconnecting switch shall be so placed in the supply circuit that both the series resistor and the arc lamp are disconnected when the switch is in the off position.

For both FPSO (Floating Production and Storage Offshore Units) and FSO (Floating Storage Units) units, searchlights shall be installed, in a way to assist the whole perimeter of the embarkation, with maximum distance of 100 m among adjacent spotlights; the search spotlights for aid of the offloading operations can be integrated into the system of man's searchlights to the sea.

Searchlights shall be armoured, strong construction, protection degree IPW 55, sealed completely provided with heat radiators and suitable to operate on structures subject to vibration and winds of up to 50 m/s.

10.8 Portable luminaires

Portable luminaires shall be so constructed and arranged that there is no risk of shock to the operator, in accordance with one of the methods given below.

- Supply from an isolating transformer supplying one luminaire only.

- Supply at extra low voltage.
- Double or reinforced insulation.
- Earthing by means of an earth continuity conductor.
- Suspension.

Portable luminaires intended to be used on decks, in holds, engine rooms and other similar spaces shall be provided with a hook or ring by which the luminaire can be suspended to avoid stress on the supply cable.

11 Heating and cooking appliances

11.1 General

The provisions of this clause are applicable to heating and cooking appliances for use in offshore units.

Equipment shall be designed and constructed as per applicable IEC standards.

NOTE Requirement to heating and cooking appliances is found in IEC 60335 series.

11.2 General requirements

11.2.1 Heating elements

The heating elements shall be of materials which are resistant to the highest temperature which they attain in normal service and shall be so arranged that they can be readily replaced.

11.2.2 Internal connections

11.2.2.1 Electrical connections between heating elements shall be effected either by joining parts of the elements themselves, or by a construction such that the terminals and the connecting conductor will not deteriorate at the maximum temperature to which they may be subjected.

11.2.2.2 The connections between heating elements and the switches and to the supply cables shall be carried out with the aid of suitable terminals. The connections shall be such that the terminals and switches are not increased in temperature above that for which they are designed. At ambient temperatures that are in accordance with IEC 61892-1 the temperature of the terminals for the supply cables (including the internal earthing) may exceed 75 °C. These terminals shall be clearly labelled.

11.2.2.3 Connections between heating elements and between heating elements and terminals to which insulated cables may be connected, unless they are self-supporting or rigidly fixed in position, shall be continuously insulated with suitable incombustible material.

11.2.2.4 Bare connections shall be made of corrosion-resistant material, shall be suitable for the temperature involved and be self-supporting. Supports of bare connections shall comply with 11.2.3.

11.2.2.5 Ceramic beads shall be used only when the connections are so fixed or supported that they cannot change their position and the beads cannot be damaged in normal use.

11.2.3 Supports of live parts

All live parts subjected to heat, be they heating elements, bare connections or terminals, shall be carried on incombustible material, which is moisture resistant or effectively protected against the penetration of moisture.

11.2.4 Guarding of live parts

Heating elements shall be suitably guarded. The guards shall be of robust construction and so fitted that they cannot be brought into contact with any current-carrying part when in service. The openings of the protecting guard shall be sufficiently narrow to prevent the heating elements from being touched or short-circuited when the standard test finger is applied. Live parts of cooking appliances shall be so protected that the cooking utensils cannot be brought

into contact with them. Spilling or overflowing of liquid or food shall not cause short circuits or insulation failures.

11.2.5 Temperature limits of exposed parts

Electric heating and cooking appliances shall be so constructed that parts which are necessarily handled in use cannot become heated to a temperature exceeding the values given in Table 3.

Table 3 – Temperature limits of exposed parts

Handles, grips and the like made of	Maximum temperature during normal use held in the hand °C	
	For long periods	For short periods
Metal	55	60
Porcelain and vitreous material, moulded material, rubber or wood	65	70

For ambient temperature, see IEC 61892-1.

Higher temperatures may be acceptable for parts which normally will not be handled with unprotected hands, such as handles of drawers for spilled liquid in cooking ranges.

11.2.6 Control of heating and cooking appliances

Control switches, when in the off position, shall isolate the heating elements in all non-earthed poles.

Control switches shall be installed in such way that the highest temperature does not damage them.

11.2.7 Position of controller

11.2.7.1 The position of overcurrent protection devices, switches and other control elements fitted in or near the appliances shall be such that they will not be subject to temperatures above those for which they are designed and will be accessible for inspection, for example through separate covers.

11.2.7.2 A means by which power to the galley can be cut off in the event of a fire shall be fitted outside the galley exits in positions not likely to be made inaccessible by such a fire.

11.2.8 Earthing

Appliances, whether portable or fixed, shall be provided with suitable terminals for earthing the metallic framework; such terminals shall be effectively connected to earth.

11.2.9 Rating plates

Appliances shall be clearly and indelibly marked at least with the manufacturer's name and address and type designation, rated voltage(s), rated input, relevant IEC product standard and where necessary, with the nature of supply and frequency.

11.2.10 Insulation tests

11.2.10.1 Appliances, including their control equipment, shall be tested when cold by the manufacturers, and shall be able to withstand the application of an a.c. voltage of 1 000 V plus twice the rated voltage, with a minimum of 1 500 V at a frequency of 25 Hz to 100 Hz, for 1 min, between all current-carrying parts and the metallic frame.

11.2.10.2 For portable appliances, the leakage current shall not exceed 1 mA, and for stationary appliances 1 mA or 1 mA per kW rated input, whichever is the larger, for each heating element which can be switched off separately.

11.2.11 Excess temperature protection – Thermal cut-outs

11.2.11.1 Heating apparatus is to be provided with a device which will switch off the apparatus before dangerous temperatures occur, unless the apparatus is specially approved without such a device. The cut-out device is to be free-tripping and manual-resetting. When thermostats are provided in addition to the excess temperature protection, these shall operate independently. A fault in one of them or in its supply connection shall not put the other out of operation.

11.2.11.2 Galley equipment, which may give rise to overheating and fire, shall be fitted with thermal protection devices to interrupt the supply in the event of overheating.

11.3 Special requirements for galley appliances

11.3.1 Enclosures of heating and cooking galley appliances

Cooking and heating appliances and their control equipment fitted in galley spaces shall have a degree of protection of at least IP44 according to IEC 60529. Enclosures shall be corrosion-resistant and provided with one or more drainholes.

11.3.2 Electric separation of combined heating and cooking appliances

Combined heating and cooking appliances shall be of such construction that the live parts of the different sections are mechanically separated and that, when replacing components on one section, no live parts of the other section can be touched.

11.3.3 Stability

Portable cooking appliances shall be shape and weight preventing them from being easily overturned.

11.4 Special requirements for space-heating appliances

11.4.1 Types of space-heating appliances

Space heaters shall be of the convector type and of the permanently fixed type; however, heaters with a visible element may be used, provided they are designed and installed in such a manner as to eliminate the risk of fire.

11.4.2 Construction of space-heating appliances

Space heaters shall be durable and all parts shall be of strong construction. All screws and nuts shall be effectively locked.

11.4.3 Shielding

Space heaters shall have an inclined top-plate which fits closely against a bulkhead, or a corresponding shield, and shall be so designed and protected that combustible articles, clothes and similar are prevented from coming into contact. Shields and other protection shall be designed and located so that adjacent bulkheads, etc. are not heated excessively.

12 Trace and surface heating

12.1 General

The provisions of this clause are applicable to electrical trace and surface heating equipment on offshore units.

NOTE For general requirement see IEC 60079-30-1 and for design, installation and maintenance aspect see IEC 60079-30-2.

12.2 Construction

Trace or surface heating systems shall be constructed in accordance with a standard acceptable to the appropriate authority.

13 Communication

13.1 General

The provisions of this clause are related to

- equipment for radio communication either by atmospheric path or via satellite,
- manual and automatic alarms for personnel and public address and/or call systems,
- internal communication,
- telephone, telex, telefax and closed-circuit television systems.

13.2 Safety requirements

Electronic equipment shall comply with the safety requirements of IEC 60065 where applicable.

13.3 External communication systems

Equipment shall comply with the performance standards required by the International Convention for the Safety of life at Sea (SOLAS) and the National Authority, when applicable, and shall comply with the requirements of the appropriate standards in the IEC 61097 series giving performance requirements, methods of testing and required test results.

Mobile units shall comply with the SOLAS requirements for GMDSS installation relevant to the area of operation.

Special attention shall be made regarding the requirement for a back up radio station as per the MODU Code for mobile offshore drilling units.

NOTE 1 National as well as SOLAS requirement for operation areas must be observed. World wide operation must, as a minimum, be designed as sea area A3.

NOTE 2 Special attention must be made for mobile offshore units to the SOLAS requirement to use two out of the following three solutions for GMDSS installations:

-duplication of equipment;

-on-board maintenance;

-on-shore maintenance.

13.4 Internal communication

Internal communication requirements cover both fixed and portable communication systems.

Fixed communication systems include public address systems, general alarm systems and other communication systems such as crane communication systems.

13.4.1 Public address and general alarm systems

Public address systems shall cover all potential work areas and have a sound level minimum 6 dB above the background noise level. Areas with a noise level above 85 dB A shall also be covered with visual indication of the annunciation. The visual indication shall be different from the colour of the general alarm colour.

General alarm systems shall cover all potential work areas and have a sound pressure level 10 dB above the background noise. Areas with a noise level above 85 dB A shall also be covered with visual indication of the annunciation.

The general alarm system can be used for both general alarms such as fire or hydrocarbon gas detected as well as abandon unit. A unit where there is a risk for H_2S gas shall be covered with a dedicated audible signal and visual signal in a specific colour.

The public address and the general alarm system can be combined as a duplicated system with duplication of both control panels and loud speakers in all areas. The duplicated loud speakers shall be connected to two different cable systems following different cable routing.

The alarm system shall be in accordance with the requirements of the appropriate authority.

13.4.2 Other internal communication requirements

Communication systems for work places such as crane cabins requiring two hand operation shall be equipped with hand free operation such as automatic lift off, knee or foot contact.

All work areas shall be covered with a telephone system connected to a PABX. Work areas with a noise level above 85 dB A shall have a visual indication for an incoming call. The colour of the visual indication shall differ from the colour of public address and general alarm visual indications.

Telephones in noisy areas shall be installed in acoustic hoods.

13.5 Safety and maintenance

13.5.1 All items of equipment, accessories and cables shall be of robust design and so installed as to insure an ample margin of safety and reliability in operation under both normal and fault conditions. Fire resistant cables complying with the relevant part of the IEC 60331 series shall be used for the part of internal communication system described in 13.4.1.

NOTE Requirements for required cable diameter, temperature and mechanical impact must be considered for selection of standard reference.

13.5.2 Special attention shall be made regarding the need for trip of some equipment in relation to the requirement to trip of ignition sources during gas detection alarm.

13.5.3 Portable communication equipment shall be certified for hazardous area zone 1.

13.5.4 Equipment which operates under automatic or remote control shall do so without danger to personnel who may be in close proximity**.**

13.5.5 As a minimum, warning notices shall be provided in equipment areas where there is a danger from shock, radio-frequency burns and other injuries from radiation, including X-rays.

Adequate means of isolation shall be provided, preferably interlocked, to prevent accidental shock or exposure to radiation during maintenance.

13.5.6 Communal antennas for broadcast reception shall have facilities for isolation, muting and/or protection.

13.5.7 Means shall be provided for the discharging to earth of any lightning energy that may be induced in radio and navigational equipment antennas. Consideration shall be given to the installation of transient protective devices such as spark gaps or surge diverters**.**

13.5.8 Communications equipment required to operate in the event of power failure shall be provided with an alternative power supply independent of the primary supply. Units where the compliance with the SOLAS requirements is relevant shall follow the requirement for power supply to GMDSS installations.

14 Underwater systems and appliances

14.1 General

The provisions of this clause are applicable to electrical installations for use under water, which are connected to or operated from an offshore surface unit.

14.2 Fixed diving systems

Electrical installations for fixed diving systems shall be in accordance with the "Code of safety for diving systems", published by the International Maritime Organization (IMO), any national requirements shall apply.

14.3 Temporary diving systems

Electrical installations for temporary systems for use during diving operations, not belonging to the permanent installation as a part of the vessel/offshore unit, shall comply with requirements as stipulated for the permanent installation.

NOTE 1 Such temporary equipment could be a surface diving station, a Remote Operated Vehicle (ROV), etc.

NOTE 2 For definitions of the terms "fixed diving systems" and "temporary diving systems", see the Code of Safety for Diving Systems, published by the IMO.

15 Control and instrumentation

15.1 General

The provisions of this clause are applicable to electrical, electronic and programmable equipment intended for control, monitoring, alarm and protection systems for use of electrical equipment for the generation, storage, distribution and utilization of electrical energy for all purposes in offshore units.

NOTE 1 If control and instrumentation aspects of closures in watertight bulkheads or shell plating, bilge pumping, fire protection, fire extinction, are carried out by electrical methods, attention is drawn to additional requirements in SOLAS, Chapter II-1, Regulations 15, 16, 17, 21 and Chapter II-2.

NOTE 2 For specific installations, guidance may be found in IEC 60092-504 where applicable.

15.2 General requirements

15.2.1 Operation

Operation of the control equipment shall be simple to perform.

15.2.2 Reliability

Each component or system shall possess a degree of reliability in accordance with the importance of the control system of which it forms part.

15.2.3 Stability

Each automatic control system, together with its controlled process, shall be stable throughout its range of operation.

15.2.4 Repeatability and accuracy

The repeatability and accuracy of instruments and control equipment shall be adequate for their proposed use and shall be maintained at their specified value during their expected lifetime and normal use.

15.2.5 Segregation

Protection (safety) systems shall be, as far as possible, continuously available and fully independent from other control and alarm systems.

15.3 Environmental and supply conditions and testing

15.3.1 General conditions

For general environmental conditions see IEC 61892-1.

For electric and electromagnetic compatibility, see 15.3.5 and 15.3.6.

In view of the special type of components, etc., used in control equipment, some design parameters severities have been established for certain environmental factors and are stated in 15.3.2 to 15.3.5. All control equipment shall operate satisfactorily within the described limits under those environmental conditions.

15.3.2 Ambient air temperatures

The pertinent information is included in IEC 61892-1.

NOTE For units which are limited to certain areas of operation where temperature range requirements are less than stated, the above alternative values may be agreed with the appropriate authority.

This range of temperatures may be reduced where equipment is located in a controlled environment provided with an alarm for abnormal conditions and when alternative means are provided to maintain the required environment in the event of a failure of the normal air conditioning.

Where extreme ambient temperatures are expected to exist, for example in positions directly adjacent to engines, boilers, etc., or exposed to radiation from the sun, special consideration shall be given. When equipment is located in panels or cubicles, consideration shall be given to the temperature rise inside those panels due to the dissipation of heat from its own components.

15.3.3 Humidity

See IEC 61892-1 for the pertinent information.

15.3.4 Mechanical conditions

15.3.4.1 Vibration

15.3.4.1.1 General

The stationary sinusoidal vibration shall be taken as having the following parameters and severities:

- displacement amplitude of 1,5 mm in the frequency range 2 Hz to 13 Hz;
- acceleration amplitude of 10 m/s² in the frequency range 13 Hz to 100 Hz.

If the natural frequencies of equipment, suspension and supports, including individual parts, cannot be kept outside the specified range by constructional design methods, vibration shall be damped to a suitable value if malfunction is to be expected.

15.3.4.1.2 Vibration at special locations

At special locations, for example directly on all engines, diesel engine exhaust systems, diesel generator sets, compressors, and in steering-gear rooms, the stationary sinusoidal vibration shall be taken as having the following parameters and severities:

- displacement amplitude of 1,5 mm in the frequency range 2 Hz to 28 Hz;
- acceleration amplitude of 50 m/s² in the frequency range 2 Hz to 200 Hz.

15.3.4.2 Appliances with mass in excess of 10 kg

Appliances with a mass M in excess of 10 kg shall be designed for acceleration amplitude of $500/M$ m/s² with a minimum value of 10 m/s².

With respect to natural frequencies (see 15.3.4.1.1), amplification in excess of a Q factor of 1,5 is to be avoided.

NOTE Very special conditions may exist on exhaust manifolds of diesel engines and on diesel generator sets mounted on vibration and shock isolators. Values may be obtained from the manufacturer of the diesel concerned.

15.3.4.3 Steady-state acceleration

The steady-state acceleration in the vertical direction is to be taken as 10 m/s².

15.3.5 Voltage and frequency variations

15.3.5.1 AC power

See IEC 61892-1 for the pertinent information.

NOTE 1 In units where large consumers are supplied via power electronics, special consideration is required to ensure compatibility of the total system.

NOTE 2 See also 15.16.5.

15.3.5.2 DC power

DC power supply (battery maintained supply) to equipment shall be taken as having voltage variations from the nominal value in the range +15 % to –10 %, or as determined by the charging/discharging characteristics, including ripple voltage, from the charging device.

When equipment is not connected to the battery during charging, the highest value may be reduced to +20 %.

15.3.6 Electromagnetic compatibility

For equipment in general, electromagnetic compatibility shall be achieved. For general consideration in this context, see IEC 60533.

15.3.7 Testing

If type tests are required in order to verify the ability of equipment to withstand the environmental conditions specified in the preceding clauses, it is recommended that they be carried out according to the test procedures and severities specified in Table 4.

Table 4 – Type tests, test procedures and severities

	Test [a]	Procedure according to	Severity		Other information
1	Visual inspection				Examination of the equipment for: – conformity to drawings and design data; – compliance with applicable IEC standards; – quality of workmanship and construction.
2	Functional test to equipment specification				Standard atmospheric conditions: – temperature: 25 °C ± 10 °C – relative humidity: 60 % ± 30 % – air pressure: 90 kPa ± 10 kPa
3	High-voltage test		Rated insulation voltage U_n V	Test voltage AC V	Frequency of test voltage: 50 Hz or 60 Hz. Separate circuits to be tested against each other. All circuits connected with each other are to be tested against earth. Contact pieces are to be tested across their open points of contact. Printed circuits with electronic components which could be subject to damage may be removed during the test.
			$U_n \leq 65$	$2 \times U_n + 500$	
			$66 < U_n \leq 250$	1 500	
			$251 < U_n \leq 500$	2 000	
			$501 < U_n \leq 690$	2 500	
			Period of application of test voltage: 1 min		

Table 4 *(continued)*

<table>
<tr><th></th><th>Test [a]</th><th>Procedure according to</th><th>Severity</th><th>Other information</th></tr>
<tr><td>4a</td><td>Power supply variations</td><td>IEC 61000-4-11</td><td>AC supply
<table>
<tr><td>Combination No.</td><td>Voltage variation (permanent) %</td><td>Frequency variation (permanent) %</td></tr>
<tr><td>1</td><td>+6</td><td>+5</td></tr>
<tr><td>2</td><td>+6</td><td>–5</td></tr>
<tr><td>3</td><td>–10</td><td>–5</td></tr>
<tr><td>4</td><td>–10</td><td>+5</td></tr>
<tr><td></td><td>Voltage transient (duration 1,5 s)</td><td>Frequency transient (duration 5 s)</td></tr>
<tr><td>5</td><td>+20</td><td>+10</td></tr>
<tr><td>6</td><td>–20</td><td>–10</td></tr>
</table>
DC supply
<table>
<tr><td>Voltage tolerance continuous</td><td>±10 %</td></tr>
<tr><td>Voltage cyclic variation</td><td>5 %</td></tr>
<tr><td>Voltage ripple</td><td>10 %</td></tr>
</table>
Electrical battery supply:
+30 % to –25 % for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device;
+20 % to –25 % for equipment not connected to the battery during charging.</td><td>Each combination shall be tested.</td></tr>
<tr><td>4b</td><td>Power supply failure</td><td>IEC 61000-4-11</td><td>Three interruptions during 5 min
30 s break time</td><td>Verification of the following:
– specified action of the equipment on loss and restoration of supply;
– there is no corruption of program or data held in programmable electronic systems, where applicable.</td></tr>
</table>

Table 4 *(continued)*

	Test [a]	Procedure according to	Severity				Other information
5	Insulation resistance [b]		Rated supply voltage V	Test voltage V	Minimum insulation resistance		Between all circuits and earth; on the supply terminals where appropriate. Resistance shall be measured before and after high-voltage test, damp heat test, cold test and salt mist test.
					Before test MΩ	After test MΩ	
			$U_n \leq 65$	$2 \times U_n$ min. 24	10	1	
			$U_n > 65$	500	100	10	
6	Cold with gradual change of temperature [c]	IEC 60068-2-1 Test Ab for non-heat dissipating equipment IEC 60068-2-1 Test Ad for heat dissipating equipment	+5 °C ± 3 °C 2 h		–25 °C ± 3 °C 2 h		Initial measurement of insulation resistance (see test 6) Equipment not operating during conditioning except for operational tests Operational test during last hour at test temperature Insulation resistance measurement and operational test after recovery
7	Dry heat with gradual change of temperature [d]	IEC 60068-2-2 Test Bb for non-heat dissipating equipment	55 °C ± 2 °C 16 h		70 °C ± 2 °C 2 h		Equipment operating during conditioning Operational test during last hour at test temperature Operational test after recovery
		IEC 60068-2-2 Test Bd for heat dissipating equipment	55 °C ± 2 °C 16 h		70 °C ± 2 °C 2 h		Equipment operating during conditioning with cooling system on if provided Operational test during last hour at test temperature Operational test after recovery

Table 4 *(continued)*

	Test [a]	Procedure according to	Severity	Other information	
8	Damp heat, cyclic (12 h+12 h cycle) [i]	IEC 60068-2-30 Test Db	Temperature: 55 °C Humidity: 95 % Duration: two cycles (12 h + 12 h)	Measurement of insulation resistance before test Equipment operating during the complete first cycle and switched off during second cycle except for functional test Functional test during the first 2 h of the first cycle at the test temperature and during the last 2 h of the second cycle at the test temperature Recovery at standard atmosphere conditions Insulation resistance measurements and performance test	
9	Salt mist [e]	IEC 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each		Initial measurement of insulation resistance and initial functional test Equipment in its normal position during test Equipment not operating during conditioning Operational test on day 7 of each spraying period Insulation resistance measurement and performance test 4 h to 6 h after the recovery period
10	Vibration (sinu-soidal)	IEC 60068-2-6 Test Fc	For general applications 2^{+3}_{-0} Hz to 13,2 Hz amplitude ±1 mm 13,2 Hz to 100 Hz acceleration ±0,7 *g* Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; – 30 Hz if no resonance frequency is recorded.	For equipment mounted on reciprocating machines, installed in steering gear compartment or similar locations 2^{+3}_{-0} Hz to 25 Hz Amplitude ±1,6 mm 25 Hz to 100 Hz Acceleration ±4 *g* Endurance at: – each resonance frequency at which an amplification factor $Q \geq 2$ is recorded; –30 Hz if no resonance frequency is recorded.	During the vibration test, operational conditions are to be demonstrated. Tests to be carried out in three mutually perpendicular planes. It is recommended as guidance that *Q* does not exceed 5. If sweep test is chosen, where several resonance frequencies are detected close to each other, duration of test shall be 120 min.
			90 min		
			40 Hz to 2 000 Hz acceleration ±10 *g* 90 min		Only for extreme conditions e.g. on exhaust manifolds of diesel engines

Table 4 *(continued)*

	Test [a]	Procedure according to	Severity	Other information	
11a	Inclination steady [a,]		22,5°		Each direction Equipment operating
11b	Inclination dynamic		22,5° 0,1 Hz		Each direction Equipment operating Duration of test not less than 15 min
12	Enclosure protection	IEC 60529	Dependent on location		See Table 7 of IEC 61892-2 for minimum requirements.
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 8 kV Interval between single discharges: 1 s No. of pulses: 10 per polarity According to level 3 severity standard		Electrostatic discharge as may occur when persons touch the appliance The test is to be confined to the points and surfaces that can normally be reached by the operator. Performance criterion B: see note [f].
14	Electro-magnetic field	IEC 61000-4-3	Frequency range: 80 MHz – 2 GHz Modulation: 80 % AM at 1 000 Hz Field strength: 10 V/m Frequency sweep rate: $\leq 1{,}5 \times 10^{-3}$ decades/s (or 1 %/3 sec) According to level 3 severity standard.		Electromagnetic fields radiated by different transmitters If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A: see note [g].
15	Conducted low frequency	IEC 60533	AC: Frequency range: rated frequency to 200th harmonic; Test voltage (r.m.s.): 10 % of supply to 15th harmonic reducing to 1 % at 100th harmonic and maintain this level to the 200th harmonic, max 2 W DC: Frequency range: 50 Hz – 10 kHz; Test voltage (r.m.s.): 10 % of supply, max. 2 W		Distortions in the power supply system generated for instance by electronic consumers and coupled in as harmonics Method of the test in accordance with IEC 60945 Performance criterion A: see note [g].
16	Conducted radio frequency	IEC 61000-4-6	Frequency range: 150 kHz – 80 MHz Amplitude: 3 V r.m.s. [h] Modulation: 80 % AM at 1 000 Hz Frequency sweep range $\leq 1{,}5 \times 10^{-3}$decades/s (or 1 %/3 s) According to level 2 severity standard		Electromagnetic fields coupled as high frequency into the test specimen via the connecting lines If for tests of equipment an input signal with a modulation frequency of 1 000 Hz is necessary, a modulation frequency of 400 Hz may be chosen. Performance criterion A: see note [g].

Table 4 *(continued)*

	Test	Procedure according to	Severity	Other information
17	Burst/fast transients	IEC 61000-4-4	Single pulse time: 5 ns (between 10 % and 90 % value) Pulse width: 50 ns (50 % value) Amplitude (peak): 2 kV line/line on power supply port; 1 kV lines/earth on I/O data control and signal lines; Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to level 3 severity standard	Arcs generated when actuating electrical contacts Interference effect occurring on the power supply, as well as the external wiring of the test specimen Performance criterion B: see note [f].
18	Surge/show transient	IEC 61000-4-5	Pulse rise time: 1,2 µs, (between 10 % and 90 % value) Pulse width: 50 µs (50 % value) Amplitude (peak): 1 kV line/earth; 0,5 kV line/line Repetition rate ≥1 pulse/min No. of pulses: five per polarity Application: continuous According to level 2 severity standard	Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers Test procedure in accordance with Figure 10 of the standard for equipment where power and signal lines are identical Performance criterion B: see note [f].
19	Radiated emission	CISPR 16-1 CISPR 16-2	For equipment installed in the bridge and deck zone Frequency range: Limits: 0,15 MHz– 0,3 MHz 80 – 52 dBµV/m 0,3 MHz– 30 MHz 52 – 34 dBµV/m 30 MHz– 2 000 MHz 54 dBµV/m except for: 156 MHz – 165 MHz 24 dBµV/m For equipment installed in the general power distribution zone Frequency range: Limits: 0,15 MHz – 30 MHz 80 – 50 dBµV/m 30 MHz– 100 MHz 60 – 54 dBµV/m 100 MHz – 2 000 MHz 54 dBµV/m except for: 156 MHz – 165 MHz 24 dBµV/m	Procedure in accordance with the standard but distance 3 m between equipment and antenna

Table 4 *(continued)*

	Test [a]	Procedure according to	Severity	Other information
20	Conducted emission	CISPR 16-1 CISPR 16-2	For equipment installed in the bridge and deck zone Frequency range: Limits: 10 kHz – 150 kHz 96 – 50 dBµV 150 kHz – 350 kHz 60 – 50 dBµV 350 kHz – 30 MHz 50 dBµV For equipment installed in the general power distribution zone Frequency range: Limits: 10 kHz – 150 kHz 120 – 69 dBµV 0,15 MHz – 0.5 MHz 79 dBµV 0,5 MHz – 30 MHz 73 dBµV	

[a] The static inclination test is not required on equipment with no moving parts.

[b] Insulation resistance test to be carried out before and after damp heat test, cold test and salt mist test.

[c] For equipment installed in non-weather-protected locations or cold locations, test is to be carried out at –25 °C.

[d] Dry heat at 70 °C is to be carried out to withstand a high degree of heat, e.g. for equipment to be mounted in consoles, housings.

[e] Salt mist test to be carried out for equipment to be installed in non-weatherprotected areas, for example on open deck.

[f] Performance criterion B: the equipment under test (EUT) shall continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is, however, allowed but no change of actual operating state or stored data is allowed.

Recovery times shall be consistent with continued safe operation, taking due account of the need to preserve essential services.

[g] Performance criterion A: the equipment under test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed, as defined in the technical specification published by the manufacturer.

[h] For equipment installed on the bridge and deck zone the test levels shall be increased to 10 V r.m.s. for spot frequencies in accordance with IEC 60945 at 2; 3; 4; 6,2; 8,2; 12,6; 16,5; 18,8; 22; 25 MHz.

[i] This test shall be carried out for equipment located in non-air-conditioned spaces.

15.4 Adjustments

The control equipment shall be constructed for simple adjustment.

The set points shall be readily identifiable and suitable means shall be provided to protect against changes due to vibration and against accidental causes.

15.5 Accessibility

Control equipment shall be constructed to permit easy access to the interior parts, and those requiring maintenance shall, as far as practicable, be clear of high voltage, high temperature, or other unsafe working conditions.

15.6 Replacement

Each replaceable assembly shall be simple to replace and shall be constructed for easy and safe handling.

15.7 Non-interchangeability

Preferably, all replaceable parts shall be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts, as well as the appertaining plug or similar device, shall be clearly identified.

15.8 Cooling air

Preferably, apparatus shall not depend on forced air cooling and measures shall be taken, when necessary, to prevent the build-up of dust on cooling surfaces.

If forced air cooling is required, the apparatus shall be protected against failure of the cooling air supply causing dangerous temperature rise in the apparatus.

NOTE Special precautions are required for forced ventilated cabinets in machinery spaces to prevent insulation breakdown due to pollution deposits.

15.9 Mechanical load on connectors

If plug and socket connections are used, the contacts shall not carry any mechanical load other than that which is necessary to ensure satisfactory contact pressure, even when withdrawing or replacing a unit.

Plug-in trays or printed circuit boards shall incorporate a retainer to prevent ejection due to shock or vibration.

15.10 Mechanical features of cabinets

Cabinets shall be of simple mechanical construction and the need for special tools avoided. All nut and bolt connections shall be locked.

15.11 Shock and vibration absorbers

If anti-shock or anti-vibration mounts are used, adequate clearance shall be provided between cabinet and rack to allow full freedom of travel. Systems with shock or vibration mounts in series shall be avoided. Connecting leads shall be arranged so that they do not interfere with the shock and vibration isolation.

15.12 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2 and have low halogen properties and low smoke and toxic gas emission.

NOTE Wiring should have low emission of smoke and halogen gases in the case of fire. The following minimum requirements should be met:

i) a minimum light transmission value of 60 % according to IEC 61034-2

ii) a maximum halogen gas emission of 0,5 % according to IEC 60745-1.

15.13 Cable connections

Terminal boards on control equipment, including transducers, shall be constructed so that sufficient space is available to enable cables to be satisfactorily connected, preferably each conductor on its own terminal. All terminals shall be clearly identified and suitable arrangements provided to connect cable screens.

15.14 Rodent protection

All cabinets shall provide protection against the penetration of rodents to the degree of protection IP3X of IEC 60529. Besides this protection, it shall be specified the minimum protection required against dust/salt and water.

15.15 Sensors

15.15.1 Performance

Sensors shall give a stable, accurate and repeatable performance.

15.15.2 Response time

Sensors shall have a response time compatible with changes in the measured variable.

15.15.3 Reliability

Sensors shall be mechanically robust and have good mechanical protection and reliable electrical connections.

15.16 Computer-based systems

Documentation for computer-based systems used for essential functions shall be provided in accordance with ISO 6592:2000.

Generally, programmable logic controllers shall meet the requirements of IEC 61131-1 and IEC 61131-2, together with the environmental conditions of 15.3.

NOTE The environmental conditions in IEC 61131-4 are, in general, less onerous than those in this standard. It is the user's responsibility to ensure that the normal service conditions given in 2.1 of IEC 61131-4 are not exceeded and to consult with the manufacturer regarding special service conditions (see 2.2 of IEC 61131-4).

15.16.1 Safety applications

For computer-based systems, which are not backed-up by non-computer-based devices and which have safety functions (or which would, in the event of failure, have safety implications affecting the unit, its personnel or the environment), a consequence analysis shall be carried out. The results of this analysis shall satisfy the appropriate authority.

NOTE 1 To meet the desired availability, the design configuration may require features such as redundancy and separation or diversity.

NOTE 2 Guidance for highly reliable hardware and software can be found in IEC 61508 and IEC 61511.

15.16.2 Hardware modularity

The equipment shall be designed so that the modules can be replaced readily. Calibration and adjustment carried out using the instrumentation and documentation on the unit are considered acceptable.

NOTE Bench repairs down to component level, which require specialist skills and test equipment, are not normally presumed possible on board.

15.16.3 Memory

Application programs and data held in the system(s) that is stored in non-volatile memory (ROM) or a volatile memory with a secure no-break supply shall be protected from corruption due to loss of power. Where any part of the program is stored in volatile memory, a permanent copy, and the means to re-enter the program, shall be provided on the unit.

15.16.4 Ancillary devices

Devices such as floppy discs, hard-drivers, CD-ROM drivers, magnetic tape and cartridge discs shall be protected for use in the marine environment.

NOTE These devices are particularly vulnerable to dirt, dust, heat, vibrations, magnetic fields, mechanical impact, etc.

15.16.5 Power supplies

Means shall be incorporated, as far as practicable, to protect the system against

- accidental reversal of power supply polarity,
- voltage spikes,
- harmonic interference.

NOTE The total harmonic distortion of power supply should be no more than 5 %. Where the generated power source exceeds this value, the necessary filtering should be provided for the utilization equipment.

15.16.6 Computer communications

15.16.6.1 Network topology

System architecture shall be arranged so that essential functions will continue to operate satisfactorily in the event of a communication failure between any work station or computer and other parts of the system. If data links are redundant, they shall be as far apart as geographically practicable. Computers situated in other geographical locations may act as back-up for a failed computer, provided the main data link is not overloaded.

15.16.6.2 Function priorities

When computer-based systems are interconnected in data networks and include functions such as condition monitoring, stock inventory, planned maintenance and administrative routines, special precautions shall be taken to provide normal operation (that is without undue time delays) of essential functions.

15.16.6.3 Communication protocols

The communication protocol shall be suitable for the intended application with respect to traffic rate and priority (see also 15.16.8.3 and 15.16.8.4).

NOTE Further guidance can be found in IEC 60955.

15.16.7 Monitoring and fault diagnosis

Computer-based systems shall be self-monitoring as far as is practicable. Faults causing loss of an essential function shall be detected, as far as practicable, and an alarm given. The location of a fault shall be indicated to a level compatible with the system designed replacement/repair policy.

NOTE The optimum level of modular design, spares holding and fault diagnosis facilities will depend on the particular application and is to be agreed upon between supplier and purchaser.

Interconnected systems shall be capable of testing the communication links and the data exchange management.

15.16.8 Man-machine interface

15.16.8.1 General

At least two means of information presentation and command shall be provided for all essential functions. One of these may be a portable, easily replaceable type, or may be non-computer-based.

15.16.8.2 Command devices

Error in the normal operation of input devices, for example keyboards, shall not cause computer failure, loss of stored data, or alteration of programs. The switch-over function to a standby system, if provided, shall be simple to execute.

15.16.8.3 Visual display units

The presentation of information, for example mimic diagrams, shall be in accordance with ergonomic principles. The maximum time delay for the creation of new display pages shall be agreed between supplier and purchaser, taking into account the importance of the function described thereon. The maximum time delays shall preferably not exceed 2 s for a safety shutdown indication.

NOTE Guidance can be found in IEC 60073 and IEC 60447.

15.16.8.4 Alarms

When an alarm essential for the safety and propulsion of the unit is activated, the alarm channel shall be displayed within 2 s and clearly described. Where the indication of alarm monitoring is via video displays, a separate indication on the screen(s) shall be provided to show that there are current alarm conditions to be viewed at all times by the operator.

In colour graphic systems, the means of distinguishing between unacknowledged and acknowledged alarms shall not be by colour only.

15.16.9 Software

15.16.9.1 Development and verification

The user (specification) requirements, design, implementation, test and maintenance phases of applications software shall be developed in a documented methodical fashion, permitting an independent audit (that is quality assurance) for verification purposes.