BS IEC 61892-3:2012

BSI Standards Publication

Mobile and fixed offshore units — Electrical installations

Part 3: Equipment

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National foreword

This British Standard is the UK implementation of IEC 61892-3:2012. It supersedes BS IEC 61892-3:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee JPEL/18, Electrical installations of ships and of mobile and fixed offshore units.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 third edition cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

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

a) Table 4 in the previous edition of IEC 61892-3 regarding type testing has been deleted. Information regarding environmental conditions, including requirements to vibration, is now given in Clause 4;
b) for liquid immersed transformers requirement for overheating alarm and shut down has been added;

c) requirements for low voltage switchgear and controlgear have been rewritten, based on IEC 61439-1 and IEC 61439-2. Only additional requirements to those given in IEC 61439 are given in the standard;

d) requirements to low voltage circuit breakers, switches, contactors and fuses have been added;

e) requirement for subdivision of high voltage switchboard has been added;

f) requirements for luminaires have been deleted and replaced with reference to IEC 60598 series and IEC 60092-306;

g) requirements for heating and cooking appliances have been deleted and replaced with reference to IEC 60335 series;

h) requirement for portable equipment has been added.

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

FDIS	Report on voting
18/1241/FDIS	18/1256/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 the 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 stability 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 (IMO), 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 the 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 1 500 V (a.c. and d.c. voltages are nominal values).

This standard sets requirements for equipment, which are additional to the requirements 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1 , *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-14 *Rotating electrical machines – Part 14: Mechanical vibration of certain machines with shaft height 56 mm and higher – Measurement, evaluation and limits of vibration severity*

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

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

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

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

IEC 60076-6, *Power transformers – Part 6: Reactors*

IEC 60076-7, *Power transformers – Part 7: Loading guide for oil-immersed power transformers*

IEC 60076-8, *Power transformers – Part 8: Application guide*

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

IEC 60076-12, *Power transformers – Part 12: Loading guide for dry-type power transformers*

IEC 60092-306:2009, *Electrical installations in ships – Part 306: Equipment – Luminaires and lighting accessories*

IEC 60146-1-1:2009, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC/TR 60146-1-2:2011, *Semiconductor converters – General requirements and line commutated converters – Part 1-2: Application guide*

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

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

IEC 60269-1, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications) – Examples of standardized systems of fuses A to F*

IEC/TR 60269-5 *Low-voltage fuses – Part 5: Guidance for the application of low-voltage fuses*

IEC 60282-1, *High-voltage fuses – Part 1: Current-limiting fuses*

IEC 60282-2, *High-voltage fuses – Part 2: Expulsion fuses*

IEC 60309-4, *Plugs, socket-outlets and couplers for industrial purposes – Part 4: Switched socket-outlets and connectors with or without interlock*

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 pre-mixed flame*

IEC 60335 (relevant parts), *Household and similar electrical appliances*[1]

IEC 60519-10, *Safety in electroheat installations – Part 10: Particular requirements for electrical resistance trace heating systems for industrial and commercial applications*

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

IEC 60598-1, *Luminaires – Part 1: General requirements and tests*

IEC 60598-2-1, *Luminaires – Part 2-1: Particular requirements – Fixed general purpose luminaires*

IEC 60598-2-2, *Luminaires – Part 2-2: Particular requirements – Recessed luminaires*

IEC 60598-2-5, *Luminaires – Part 2-5: Particular requirements – Floodlights*

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1 "Relevant parts" are those parts of the standards which are relevant for use on mobile and fixed offshore units.

IEC 60598-2-6, *Luminaires – Part 2: Particular requirements – Section 6: Luminaires with built-in transformers for filament lamps*

IEC 60598-2-22, *Luminaires – Part 2-22: Particular requirements – Luminaires for emergency lighting*

IEC/TR 60616, *Terminal and tapping markings for power transformers*

IEC 60622:2002, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Sealed nickel-cadmium prismatic rechargeable single cells*

IEC 60669 (all parts), *Switches for household and similar fixed-electrical installations*

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 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3:2008, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-4-1:2009, *Low-voltage switchgear and controlgear – Part 4-1 Contactors and motor-starters – Electromechanical contactors and motor-starters*

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

IEC 61131-1, *Programmable controllers – Part 1: General information*

IEC 61131-2, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61378-1:2011, *Converter transformers – Part 1: Transformers for industrial applications*

IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61439-2:2011, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC/TR 61641:2008, *Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault*

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

IEC 61869-3, *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*

IEC 61892-1:2010, *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 61892-5, *Mobile and fixed offshore units – Electrical installations – Part 5: Mobile units*

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

IEC 62040-2, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*

IEC 62262, *Degree of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

IEC 62271-102:2001, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-106:2011, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

IEC 62271-200:2011, *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 62271-201:2006, *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*

IEC 62395-1, *Electrical resistance trace heating systems for industrial and commercial applications – Part 1: General and testing requirements*

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 and the following apply.

3.1
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 1 to entry The following types of programmable devices could form part of a computer system: mainframe, mini-computer, micro-computer, programmable logic controller.

3.2
converter
device for changing one or more characteristics associated with electric energy

Note 1 to entry Characteristics associated with energy are for example voltage, number of phases and frequency including zero frequency.

[SOURCE: IEC 60050-151:2001, 151-13-36]

3.3
trace heating
utilization of electric trace heater cables, pads, panels and support components, externally applied and used to raise or maintain the temperature of contents in piping, tanks and associated equipment

[SOURCE: IEC 60050-426:2008, 426-08-14]

3.4
electromagnetic compatibility
EMC
the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07]

3.5
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

3.6
expert system
knowledge-based system capable of solving problems in a particular domain or field of application by drawing inferences from a knowledge base developed from expert knowledge

[SOURCE: IEC 60050-351:2006, 351-21-47, modified]

3.7
extra-low voltage
ELV
voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth.

[SOURCE: IEC 60050-826:2004, 826-12-30, modified]

Note 1 to entry 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 converter is operated at its rated supply voltage.

Note 2 to entry Information about protection by extra-low voltage is given in IEC 60364-4-41.

3.8
inverter
electric energy converter that changes direct electric current to single-phase or polyphase alternating currents

[SOURCE: IEC 60050-151:2001, 151-13-46]

3.9
low-voltage switchgear and controlgear assembly
combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, with all the internal electrical and mechanical interconnections and structural parts

[SOURCE: IEC 61439-1:2011, 3.1.1]

3.10
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

3.11
rectifier
electric energy converter that changes single-phase or polyphase alternating electric currents to unidirectional current

[SOURCE: IEC 60050-151:2001, 151-13-45]

3.12
secondary cell
cell which is designed to be electrically recharged

[SOURCE: IEC 60050-482:2004, 482-01-03, modified]

3.13
semiconductor device
device the essential characteristics of which are due to the flow of charge carriers within one or more semiconductor materials

[SOURCE: IEC 60050-151:2001, 151-13-63]

3.14
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

3.15
valve regulated lead acid battery
VRLA
secondary battery in which cells are closed but have a valve which allows the escape of gas if the internal pressure exceeds a predetermined value

Note 1 to entry The cell or battery cannot normally receive additions to the electrolyte.

[SOURCE: IEC 60050-482:2004, 482-05-15]

3.16
vented cell
secondary cell having a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cell to the atmosphere

[SOURCE: IEC 60050-482:2004, 482-05-14]

4 General requirements

4.1 Environmental conditions

4.1.1 General

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.

NOTE See Annex B of IEC 61892-1:2010 for units operating in arctic areas.

4.1.2 Ambient air temperature

The pertinent information is included in IEC 61892-1.

For units which are limited to certain areas of operation where temperature range requirements are less than stated, 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.

4.1.3 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.

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

4.1.4 Vibration

4.1.4.1 General

Electrical equipment and components shall be unaffected by vibration and shock likely to arise under normal service.

As the type and arrangement of fixed offshore units vary to a great extent it is not possible to give general requirements to shock and vibration values. For such units the values will normally be specified by the owner/operator for each project.

For mobile units with class notation in a classification society the rules of the classification society shall be complied with.

NOTE 1 In the absence of specific requirements from the owner/operator or the appropriate authority, the following can be used as a guideline:

- 2 (+3-0) Hz to 13,2 Hz – amplitude ± 1 mm;
- 13,2 Hz to 100 Hz – acceleration ± 0,7 g. For severe vibration conditions such as e.g. on diesel engines, air compressors, etc.;
- 2,0 Hz to 25 Hz – amplitude ± 1,6 mm;

- 25,0 Hz to 100 Hz – acceleration ± 4,0 g.

NOTE 2 A guidance for fixed installations is not possible due to the impact of the different structures and the operational area.

NOTE 3 For further information regarding vibration testing, see IEC 60068-2-6. For vibration for mobile units, the values in IEC 60721-3-6 can be taken as guidance.

4.1.4.2 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.

4.1.4.3 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, amplification in excess of a Q factor of 1,5 is to be avoided.

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.

4.1.4.4 Steady-state acceleration

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

4.2 Degree of protection

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

4.3 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.

Switchgear shall have the same cubicle marking at front and rear of the switchgear.

All nameplates and labels shall be engraved or embossed on plastic-laminated or metallic material and be permanently fixed.

If other fixing means than screws or rivets are used, they shall provide an equivalent level of reliability.

4.4 Voltage and frequency variations

Equipment shall be designed for voltage and frequency variations as given in IEC 61892-1.

4.5 Electromagnetic compatibility

For equipment in general, electromagnetic compatibility shall be achieved. Requirements are given in IEC 61892-1. For general consideration in this context, see IEC 60533 and IEC/TR 62482.

4.6 Terminations

The means of fixing current-carrying parts shall be independent of the means of making connection thereto.

Apparatus shall be provided with suitable terminals, clearly marked, placed in an accessible position convenient for external connections. The terminals shall be effectively secured and be so spaced and/or shielded as to minimise the risk of accidental earthing or short-circuiting.

Adequate clearance shall be allowed between the cable entries and terminals so that cables can be drawn in and connected without damage. The terminations shall be arranged, or provided with means, to allow easy termination of cables without the risk of any damage to the apparatus.

5 Generators and motors

5.1 General

The provisions of Clause 5 are applicable to all rotating machines rated at 750 W or more for use in offshore units. This clause 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.

Each combined prime mover, transmission system and generator shall be designed to withstand without damage the effects of the most onerous short-circuit condition at the generator terminals when running at rated voltage and speed.

The duty types shall be in accordance with IEC 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.

Where motors are operated on a non-sinusoidal and/or variable frequency supply, care shall be taken to ensure that any additional heating does not impair the service life of the motor.

Inspection covers should be installed in order to allow visual inspection of the bearings, exciter and replacement of the rotating diodes.

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 d.c. generators in mobile and fixed offshore unit is very limited, general reference shall be made to the 60092 series.

5.2.3 AC generators

5.2.3.1 General

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

5.2.3.2 Steady conditions: tolerance of voltage and waveform

Each a.c. generator for general service driven by its prime-mover, whose governor characteristics comply with 5.7.2, 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 5.2.3.5).

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 given in IEC 61892-1.

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

5.2.3.3 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 85 % nor exceed 120 % of the rated voltage, measured at the generator terminals.

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 at generator terminals. For emergency sets, these values may be increased to ± 4 % in not more than 5 s respectively (see 5.2.3.5).

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.

To achieve satisfactory performance on board a unit, the governor of the prime-mover shall restore the speed to a steady state within the limits specified in 5.7.2 in not more than 3 s.

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

5.2.3.4 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 is acceptable, unless protection selectivity conditions exist which allow a shorter duration and provided that, in any case, the safety of the installation is ensured.

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.

5.2.3.5 Emergency generators

Emergency generator sets which are required to meet the same general requirements as in 5.2.3.3 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 for the application.

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.

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 5.2.3.3).

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 5.8.

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 can require even 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, does 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 5.2.3.2, 5.2.3.3 and 5.2.3.4.

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.

Coolers should have double pipe and leakage detection.

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 7919-1 and ISO 10816-1.

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/TS 60034-17 and IEC/TS 60034-25.

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.

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

5.6 Lubrication (generators and motors)

5.6.1 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.

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

5.6.2 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.

5.6.3 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.

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

5.6.5 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 movers for 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.

Applicable de-rating factors shall be considered. For prime mover engines this can be:

- site ambient temperature, if different from ISO conditions;
- fuel composition;
- aging and derating factor, caused e.g. by time intervals between major overhaul.

NOTE There can be a design difference between mobile and fixed units due to class requirements for 10 % additional load for 1 hour every 12 hours.

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 shall 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

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

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

5.8.3 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)

5.9.1 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 within the limits specified in IEC 61892-5.

5.9.2 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.

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 in order to ensure that the machine meets these requirements.

6 Transformers for power and lighting

6.1 General

The provisions of Clause 6 are applicable to all transformers used for power, lighting and static converters 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 60076-1, IEC 60076-5, IEC 60076-6, IEC 60076-7, IEC 60076-8, IEC 60076-11, IEC 60076-12 and IEC/TR 60616 as well as with the additional requirements given in this standard.

Transformers for use with converters, 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 61378-1:2011 or IEC 60146-1-3:1991.

LV systems supplied from HV systems shall have adequate precautions taken to prevent the LV system being charged by leakage from the HV system. This can be provided by, for example, an earthed screen between the HV and LV windings or the LV system having its neutral earthed at the transformer or a surge arrestor on the LV side.

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 should also be considered:

It is not advisable to combine transformers of widely different power rating (e.g. 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 d.c. bus can have different phase angle.

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 can 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.

Terminals shall be suitable for direct connection of copper conductors.

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 (climate), 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 IP55 enclosure for the transformer will reduce the requirement for cooling air.

6.4.2 Liquid-immersed type transformers 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 within the limits as specified in IEC 61892-5.

If provision is made for breathing, a sealed diaphragm shall be provided.

6.4.3 For liquid-immersed type transformers, overheating alarm and shutdown, as well as gas-actuated shutdown shall be provided. For hermetically sealed transformers overpressure shutdown shall be provided.

6.4.4 Liquid cooled transformers shall use a non-toxic coolant.

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. Overheating alarm and shut down facilities shall be provided.

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.

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.

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

6.6 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 Clause 7 are applicable to switchgear and controlgear assemblies, with 7.4 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 7.5 are applicable for voltages in the range from 1 kV up to and including 35 kV at rated frequencies not exceeding 60 Hz. Subclause 7.6 is applicable to both high-voltage and low-voltage assemblies.

The conditions specified in IEC 61892-1 shall take precedence over values given in Clause 7 of IEC 61439-1:2011.

7.2 Definitions

For definition of general terms used in this clause, see IEC 61439-2:2011, IEC 62271-200:2011 and this standard, Clause 3.

7.3 Locking facilities

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, switches and fixed disconnectors shall be possible.

In order to protect the operator against internal faults, circuit breaker and/or drawer in low voltage switchgear and high voltage switchgear should be provided with means to engage and disengage moving power contacts with front door fully closed. This arrangement is subjected to agreement between buyer and manufacturer.

7.4 Low-voltage switchgear and controlgear assemblies

7.4.1 General

The assemblies standard IEC 61439-1:2011 and IEC 61439-2:2011 shall be used as basis reference. Additional requirements are given in this standard (7.4.2 to 7.4.8).

Consideration should be given to constructions which allow thermographic inspection.

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.

7.4.2 Temperature rise

The temperature rise shall be in accordance with the requirements of IEC 61439-1:2011, but based on an ambient temperature of 45 °C.

7.4.3 Circuits

Individual circuits and their devices shall have durable markings with a permanent means of fixing. Protective devices with adjustable settings are to have means to identify the actual setting of the protective device. 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 can be given in the documentation instead of on the switchboard.

7.4.4 Marking of parts

Withdrawable and removable parts of an assembly shall be marked to identify where the parts can be placed in the assembly. Where polarized circuit-breakers are installed in d.c. systems, and in all similar cases, warning labels shall be so arranged as to draw attention to the possibility of incorrect connections during maintenance or replacement.

7.4.5 Design and construction

7.4.5.1 Circuit breakers, switches and fuses

Circuit breakers, switches and fuses shall comply with the following:

- circuit breakers shall be in accordance with IEC 60947-2:2006;
- switches, disconnectors, switch-disconnectors and fuse-combination units shall be in accordance with IEC 60947-3:2008;
- contactors and motor-starters shall be in accordance with IEC 60947-4-1:2009;
- fuses shall be in accordance with IEC 60269-1, IEC 60269-3 and IEC/TR 60269-5.

7.4.5.2 Structural parts of aluminium alloy

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

7.4.5.3 Insulating material

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

7.4.5.4 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.

7.4.5.5 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 distribution boards, if the dimensions are similar to main or emergency switchboards.

7.4.5.6 Door locking

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

For all switchboards with rear access, rear doors should be of a hinged type and when open, it should have a barrier against accidental touching of live parts.

7.4.5.7 Clearance and creepage distances

7.4.5.7.1 General

Clearance and creepage distances shall be in accordance with 7.4.5.7.2 for assemblies verified by testing. For assemblies not verified by testing, clearance and creepage distances

shall be in accordance with 7.4.5.7.3. 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 7.4.5.7.2 or 7.4.5.7.3 due to abnormal conditions (for example short circuits).

7.4.5.7.2 Assemblies verified by testing

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;
- rated operational voltage 1 000 V a.c., 1 500 V d.c.

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 7.4.5.7.3.

7.4.5.7.3 Assemblies not verified by testing

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 assemblies not verified by testing

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

7.4.5.8 Enclosure and degree of protection

See 8.2 of IEC 61439-2:2011, and IEC 61892-2.

7.4.5.9 Protection against direct contact

For rated operational voltages above the safety extra-low voltage of 50 V a.c. r.m.s. or 120 V 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.

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

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

7.4.5.10 Short-circuit protection and short-circuit withstand strength

Reference shall be 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 according to IEC/TR 61641:2008 shall be carried out for low voltage switchboard when the prospective fault current "I_k" is larger than 50 kA.

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.

Flash hazard risk assessment should be considered for switchboards. Arc-flash calculations and tagging should be performed as described in IEEE 1584, or corresponding IEC standards.

NOTE The objective of flash hazard assessment is to increase personnel safety by determining the arc-flash incident energy exposure during work on or near electrical equipment. The results are used to implement safety by design measures such as:

– limit incident energy by system design and equipment selection (minimize fault current magnitude);
– integrate equipment safety barriers by use of fast acting protective devices adjusted to interrupt arc currents and consider arc detection system (minimize fault duration);
– consider remote operation requirements;
– provide specific input information for operational risk assessments to determine consequence upon arc-flash incidents.

7.4.5.11 Switching devices and components installed in assemblies

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.

7.4.6 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.

Generator cubicle should be provided with warning labels regarding live terminals due to residual magnetizing even with exciter turned-off.

7.4.7 Internal electrical circuits and connections

7.4.7.1 General

See 8 of IEC 61439-2:2011. In addition, the requirements listed below shall apply.

7.4.7.2 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2:2004.

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

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

b) a maximum halogen gas emission of 0,5 %, according to IEC 60754-1:2011 and IEC 60754-2:2011.

7.4.7.3 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.

7.4.7.4 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 a bus-breaker, 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.

7.4.7.5 Cross sections and current-carrying capacity of main circuits

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 61439-2:2011 shall apply;
- termination of components: according to the rated current of the circuits and the permissible temperature limits at the terminals.

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

When allowed by ambient conditions, 40° C may be accepted for the design.

7.4.8 Design verification

7.4.8.1 General

Design verification shall be performed as required by IEC 61439-2:2011, Clause 10.

7.4.8.2 Additional requirements

In addition to the requirements of IEC 61439-2:2011, 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.

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.

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

7.5.1 General

High-voltage switchgear shall be of the metal-enclosed type in accordance with IEC 62271-200:2011, or of the insulation-enclosed type in accordance with IEC 62271-201:2006.

The main busbars of the assembly shall be subdivided into at least two isolated parts which shall normally be connected by a bus-breaker. As far as possible, the connection of the generators and any other duplicated equipment shall be equally divided between the parts.

7.5.2 Service conditions

The conditions specified in IEC 61892-1 shall take precedence over values given in IEC 62271-200:2011 and IEC 62271-201:2006.

7.5.3 Ratings

Ratings shall be in compliance with IEC 62271-200:2011 and IEC 62271-201:2006.

7.5.4 Design and construction

Design and construction shall be in compliance with IEC 62271-200:2011 and IEC 62271-201:2006.

The switchgear and controlgear shall be tested, verified and IAC classified as per IEC 62271-200:2011, Annex AA. Accessibility shall be type A (authorised personnel).

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

The service condition of the switchgear shall be LSC 2B as per IEC 62271-200:2011 and IEC 62271-201:2006.

7.5.5 Degree of protection provided by enclosures

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

7.5.6 Circuit breakers, switches and fuses

7.5.6.1 General

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

- Circuit-breakers shall be in accordance with IEC 62271-100:2008;
- switches shall be in accordance with IEC 62271-102:2001;
- contactors and motor starters shall be in accordance with IEC 62271-106:2011;
- fuses shall be in accordance with IEC 60282-1 and IEC 60282-2.

If vacuum circuit breakers are used, considerations should be given to the possibility of switching overvoltages.

If star/delta starters are used, consideration should be given to the risk of short-circuit occurring during transition to delta connection, if the line breaker is closed against out-of-phase motor electromotive force.

7.5.6.2 Additional requirements for compressed air circuit breakers

Pipes and valves of compressed-air operating mechanisms shall be of non-corrosive material.

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.

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

7.5.7 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.

Interlocked earthing switches should be preferred.

7.5.8 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.

7.5.9 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2:2004.

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

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

b) a maximum halogen gas emission of 0,5 %, according to IEC 60754-1:2011 and IEC 60754-2:2011.

7.5.10 Auxiliary systems

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

7.6 Instruments for assemblies

7.6.1 General

The requirements of 7.6 apply to both high-voltage and low-voltage assemblies.

7.6.2 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 watt-meter 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).

7.6.3 Instrument for d.c. power sources

For each d.c. power source (e.g. converters, 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).

7.6.4 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.

For critical systems consideration should be given to installation of rapid detection of the faulty circuit. This could be by means of a ring core transformer on each circuit, or by use of a portable clamp-on current transformer.

7.6.5 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.

Watt-meters 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 watt-meter shall include at least 15 % reverse power.

For watt-meters 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 $\pm$ 5 Hz around the rated frequency.

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

7.6.6 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 IEC 61869-3.

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.

NOTE IEC 61869-3 has replaced the former IEC 60044-2. General requirements to instrument transformers are given in IEC 61869-1.

7.6.7 Selection of protective devices

The requirements according to IEC 61892-2 are applicable.

7.6.8 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.

At least one synchroscope 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.

When auto-synchronization is provided, consideration should be given to separate synchro-check relay for manual operation.

7.6.9 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 converters

8.1 General

8.1.1 The provisions of Clause 8 are applicable to static converters 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 converters shall comply with the relevant requirements of IEC 60146-1-1:2009, IEC/TR 60146-1-2:2011, IEC 60146-1-3:1991, IEC 60146-2:1999, IEC 61800 series, 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 60332-1-2:2004.

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

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

b) a maximum halogen gas emission of 0,5 %, according to IEC 60754-1:2011 and IEC 60754-2:2011.

8.3 Cooling arrangements

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

8.3.2 Semiconductor converters 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 overheating alarm and gas-actuated protection devices.

8.3.4 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.

NOTE Regarding installation precautions, see IEC 61892-6.

8.4 Accessibility

The converters shall be housed in floor-mounting, metal enclosures. The converter shall be located such that necessary access for maintenance is granted.

Semiconductor converter 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 as stated in IEC 61892-1 are applicable.

8.5.2 If the converter 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 converter 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 converter equipment shall be immune to voltage transients, voltage dips, and distortion on power supply, according to IEC 62040-2.

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 converter 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 disconnection of the converter.

NOTE Reduced power output in natural air cooling mode can 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 converter 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 converter itself.

8.6.2.3 Semiconductor converters 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 converters 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.

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 converter 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.

NOTE 1 General guidance is given in IEC 60533.

NOTE 2 For requirements concerning EMC, see IEC 61892-1 and IEC/TR 62482.

8.7 Diagrams

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

8.8 Converter transformers

If transformers are used in combination with semiconductor converters on the supply side or the load side of the converter, 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, except those of the portable type, shall comply with the requirements of IEC 60622:2002, IEC 60896-11:2002, IEC 60896-21:2004 and IEC 60896-22:2004 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.

Battery casings should be made of flame retardant material.

9.2 Types of batteries

9.2.1 General

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 are 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.

9.2.2 Valve-regulated acid batteries (VRLA)

Valve regulated lead-acid batteries shall comply with the requirements of IEC 60896-22:2004.

9.2.3 Nickel-cadmium batteries

Nickel-cadmium batteries shall comply with the requirements of IEC 60622:2002.

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(s), semiconductor converter(s), 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.

Rectifier for a VRLA battery should be specified with temperature compensation floating charging, and with no provisions to boost-charging mode and low ripple content.

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 on the ventilation and the electrical installation of battery compartments.

10 Luminaires

10.1 General

Luminaires shall be in accordance with the requirements of IEC 60598-1, IEC 60598-2-1, IEC 60598-2-2, IEC 60598-2-5, IEC 60598-2-6 and IEC 60598-2-22. For luminaires for use on board ships, reference shall be made to IEC 60092-306:2009.

10.2 Luminaires for hazardous areas

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

11 Heating and cooking appliances

11.1 Construction

Heating and cooking appliances shall be in accordance with the relevant standard in the IEC 60335 series. The environmental conditions specified in IEC 61892-1 shall be taken into account when selecting equipment.

11.2 Isolation of supply to galley

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.

12 Resistance trace heating

Resistance trace heating systems shall be constructed in accordance with IEC 60519-10 and IEC 62395-1.

NOTE For general requirement to design, installation and maintenance aspects see IEC/TS 62395-2. For trace heating equipment in hazardous areas see IEC 60079-30-1 and IEC 60079-30-2.

13 Communication

13.1 General

The provisions of Clause 13 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 appropriate 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.

National as well as SOLAS requirement for operation areas should be observed. Worldwide operation shall, as a minimum, be designed as sea area A3.

Special attention should 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

13.4.1 General

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.

13.4.2 Public address and general alarm systems

Public address systems shall cover all potential work areas and have a minimum sound level of 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 announcement. 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 of 10 dB above the background noise. Areas with a noise level above 85 dB(A) shall also be covered with visual indication of the announcement.

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 loudspeakers in all areas. The duplicated loudspeakers 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.

13.4.3 Other internal communication requirements

Communication systems for work places such as crane cabins requiring two hand operations 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 13.4.2.

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 Clause 14 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 IMO. Any national requirements shall also 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 can 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 Clause 15 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.

Consideration should be given to synchronization of the Central Control System with all clocks of the electrical systems PLCs, PMS, microprocessor relays etc.

Consideration should be given to segregation of control systems for consumers that are considered important for the process. As an example, separation of process control and process shutdown systems should be considered.

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, see 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.

In control panels for mechanical equipment (package units) the power terminals and the circuit breaker should be segregated from the remainder de-energized parts after disconnection of the circuit breaker. The separation should at least be equivalent to form 2a in accordance with IEC 61439-2.

15.3 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.

15.4 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.

15.5 Replacement

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

15.6 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.

15.7 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.

15.8 Mechanical load on connecting devices

If plug and socket-outlet 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.

15.9 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.

15.10 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.

15.11 Internal wiring

Internal wiring shall be insulated and shall have either stranded or flexible conductors. The wiring shall be flame retardant as per IEC 60332-1-2:2004.

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

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

b) a maximum halogen gas emission of 0,5 %, according to IEC 60754-1:2011 and IEC 60754-2:2011.

15.12 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.

15.13 Sensors

15.13.1 Performance

Sensors shall give a stable, accurate and repeatable performance.

15.13.2 Response time

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

15.13.3 Reliability

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

15.14 Computer-based systems

Generally, programmable logic controllers shall meet the requirements of IEC 61131-1 and IEC 61131-2.

Documentation for computer-based systems used for essential functions should be provided in accordance with ISO/IEC 6592.

NOTE The environmental conditions in IEC/TR 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 IEC/TR 61131-4 are not exceeded and to consult with the manufacturer regarding special service conditions (see IEC/TR 61131-4).

15.14.1 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.

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

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

15.14.2 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 offshore.

15.14.3 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.

15.14.4 Ancillary devices

Devices such as floppy discs, hard-drives, CD-ROM drives, 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.

15.14.5 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.

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.

15.14.6 Computer communications

15.14.6.1 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.

15.14.6.2 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.

15.14.6.3 Communication protocols

The communication protocol shall be suitable for the intended application with respect to traffic rate and priority (see also 15.14.8.3 and 15.14.8.4).

15.14.7 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.

15.14.8 Man-machine interface

15.14.8.1 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.

15.14.8.2 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.

15.14.8.3 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.

15.14.8.4 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.

15.14.9 Software

15.14.9.1 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.

15.14.9.2 Expert systems

When intelligent knowledge-based systems are provided, it is recommended that they are not directly used for closed-loop real time control because of the inherent slowness of present systems.

15.14.9.3 Security

Access for alteration to programs or data shall have effective security arrangements.

Change of parameters which alter system performance (for example alarm setpoints, time delays) shall only be possible by personnel authorized for this type of operation for the system in question, by means such as key arrangements, or the use of dedicated codes, etc. Consideration should be given to the automatic print-out of the changes on the data logger or alarm printer.

Access to computer applications software shall be highly restricted and any alteration of programs after validation shall be notified to the appropriate authority.

15.14.10 Precautions against design failures

Electronic modules, assemblies and PC cards, including spares and repaired units, that serve essential functions, shall have sufficient "burn-in" time to prevent failures occurring at an early stage.

Generally, the equipment shall be subject to an equivalent of 72 h at 70 °C with power connected to the device. Alternatively, consideration shall be given to the manufacturer's quality assurance system.

15.14.11 Testing

Factory tests shall include functional and electrical tests on modules, subassemblies and spares. Factory and/or commissioning validation tests on complete systems (that is integrated hardware and software) shall be carried out according to a programme agreed between supplier and purchaser including, where applicable:

- transfer of monitoring or control responsibility between workstations;
- alarm inhibiting functions;
- alarm acknowledgement procedures;
- activation of relevant data communication links;
- functional testing of workstations;
- simulation of internal and external faults, including power supply variations, failure and restoration;
- reaction to wrong manual data input.

15.14.12 Manuals

Manuals shall include instructions for operator-initiated test routines and the use of any special purpose test equipment necessary to enable a defective module to be located and

identified, the procedures for replacement of faulty modules, and the setting-to-work of replacements.

Special attention shall be drawn to the procedures necessary to avoid program corruption:

- test probes causing short circuits;
- temporary removal of electromagnetic screening;
- inadequate protection against electrostatic discharges.

15.14.13 Spares

An appropriate policy regarding the quantity and future availability (including software support) shall be agreed between supplier and purchaser. At least one printed circuit board of each type included in the computer system(s) for essential functions shall be provided on the unit.

16 Accessories

16.1 General

16.1.1 The provisions of Clause 16 are applicable to accessories for use in offshore units.

16.1.2 Accessories shall be so designed and constructed that the passages for 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.

16.1.3 Accessories shall be designed and the insulated conductors installed in such a way that the latter cannot apply stress to any terminal to which the conductors may be connected.

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

16.1.5 Cable entries shall conform to the class of enclosure of the accessory.

16.2 Enclosures

Enclosures shall be of metal which is, or has been rendered, corrosion-resistant, or of flame-retardant insulating material. Where electrolytic corrosion may occur between a metal enclosure and the surface upon which it is mounted, suitable insulating material shall be inserted and separate means shall be provided to bond the case to earth.

16.3 Switches

16.3.1 Switches shall comply with the relevant requirements of IEC 60669 series.

16.3.2 In galleys, laundries, bathrooms, machinery and other spaces where moisture may be present, switches shall be in accordance with the relevant degree of protection given in the IEC 61892-2 or be of an all-insulated construction.

16.3.3 On weather decks, switches and their cable entries shall be in accordance with the relevant degree of protection given in IEC 61892-2. The entries shall be done in the lower part of the enclosures.

16.3.4 Every switch not specially designed to break an inductive load of its full rated capacity shall, if used to control a discharge lighting circuit, have a current rating of not less than twice the total steady current which it shall carry or, if used to control filament lighting and

discharge lighting, shall have a current rating of not less than the sum of the current flowing in the filament lamps and twice the total steady current flowing in the electric discharge lamps.

16.4 Socket-outlets and plugs

16.4.1 Socket-outlets and plugs shall comply with the relevant requirements of IEC 60309-1, IEC 60309-4, IEC 60884 series or IEC 60906 series according to their application.

DC socket-outlets shall be controlled by a switch immediately adjacent, or be interlocked with a switch, or have integral switching.

AC socket-outlets with a rated current above 16 A shall be interlocked with a switch or have integral switching.

NOTE 1 AC socket-outlets up to 16 A are not required to be switched.

NOTE 2 In the United Kingdom the IEC 60884 and IEC 60906 series of standards are not applicable. In the United Kingdom, socket-outlets and plugs shall comply with IEC 60309-1 or IEC 60309-2.

16.4.2 Socket-outlets shall be so constructed that they cannot be readily short-circuited. It shall not be possible for any contact of the plug to be engaged with any live contact of its associated socket-outlet while any other contact of the plug is completely exposed.

16.4.3 Where differing distribution systems supplying socket-outlets are in use, the socket-outlets and plugs shall be designed so that an incorrect connection cannot be made.

16.4.4 All three-phase socket-outlets shall be of the same phase rotation.

16.4.5 Plug and socket-outlet combinations with a declared degree of protection against moisture ingress shall have a degree of protection against mechanical impacts of IK08 according to IEC 62262, and be in accordance with the relevant degree of protection given in IEC 61892-2, and shall retain the degree of protection when the plug is removed.

Where a loose cover is used for this purpose, it shall be anchored to its socket-outlet, for example by means of a chain. When the plug is inserted into its socket-outlet, the combined fitting and the interlocking switch, if any, shall retain the same degree of protection.

16.4.6 Plugs shall be such that connections are made so that no strain is transmitted to the terminals and contacts. The plugs or socket-outlets shall be so designed that when in place they will be held in positive contact.

16.4.7 In washplaces and in spaces containing a fixed bath or shower there shall, with the exception of a connection reserved solely for the use of electric shaver, be no socket-outlets and there shall be no provision for connecting other portable appliances.

16.4.8 Each socket-outlet or receptacles shall have a plate indicating the service voltage and rated current.

16.4.9 Socket-outlet to be installed on external areas shall be of metal which is, or has been rendered, corrosion-resistant, or of flame-retardant insulating material. Where electrolytic corrosion may occur between a metal enclosure and the surface upon which it is mounted, suitable insulating material shall be inserted and separate means shall be provided to bond the case to earth.

17 Portable equipment

When hand-held equipment is used it shall be of a type suitable for use in marine environment.

Class I appliances should be used in preference to class II appliances.

Annex A
(informative)

Alternative method of power generation

A.1 General

Annex A is a non-mandatory guide giving details of alternative method of power generation for electrical installations in small fixed offshore units.

In small installations with low electrical power consumption, new types of d.c. generators like photovoltaic cells, wind generators or closed cycle vapour small turbines have become widely used.

Some of these systems, for instance photovoltaic cells and wind generators, should be utilized in a hybrid system with a back-up diesel generator.

A.2 Photovoltaic generation system

Photovoltaic (PV) power generating systems consist of components and sub-systems that are used to convert incident solar radiation directly into electrical energy.

The PV systems carry out the full charge and trickle charge the storage batteries, simultaneously with the power supply to the users' loads.

The PV power generating systems may operate in parallel with some other auxiliary power source(s) that are connected to appropriate interface(s). The system may comprise but is not limited to:

- photovoltaic array field;
- d.c. conditioner;
- charge regulators;
- d.c./d.c. load interface;
- storage batteries;
- inverter (only in case of a.c. loads);
- a.c./a.c. interface (only in case of a.c. loads).

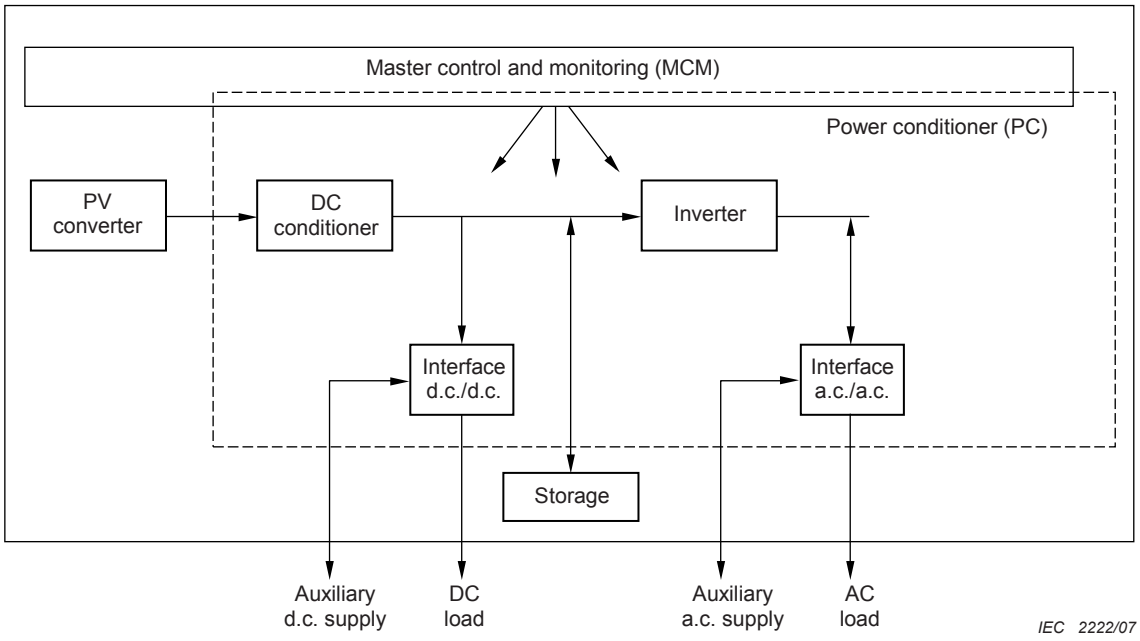

Figure A.1 – PV Power generating system – Major functional elements, sub-systems and power flow diagram

The photovoltaic cells are manufactured in single crystal or multiple crystal silicon in circular or square shape; the cells are assembled in module and installed on a self-sustaining frame. The photovoltaic field includes a group of modules assembled in arrays, connected in series or parallel and fixed to the main structure. The structure inclination shall be defined together with the sizing calculation of the system.

The modules making up the arrays shall be connected in series, in order to achieve the rated voltage and in parallel to obtain the maximum value of allowed current from the circuit-breaking equipment.

The PV control system will include a number of non-dissipation units with adjustable intervention threshold, equal to the number of arrays on which the photovoltaic field will be divided.

Each unit shall provide the control of the Pb or Ni-Cd accumulator batteries voltage. The electric charge regulator shall charge the batteries with a constant voltage system or a step-by-step system.

NOTE During the constant voltage charge, the regulator will continue charging the battery until it reaches the maximum charge capacity. When it reaches the maximum charge, the charge can be stopped and it will be restarted after a pre-set period of time.

In the event that the photovoltaic generation system is not able to supply enough power to obtain the maximum charge voltage, the shutdown device will be activated, and the regulator will restart the charging operations after a pre-set period of time.

During the step-by-step charging, the shutdown device will remain closed until the system has reached its maximum charge level. The system will successively and constantly control the batteries voltage, and when it goes below 1,4 V (Ni-Cd) or 2,4 (Pb-Ca) with respect to the maximum limit of the charge end voltage, the shutdown device will be shut again, and the regulator restarts the electric charge phase.

In both types of charge, prior to activating the shutdown device, the system can carry out all the necessary tests to verify the relevant conditions, in particular, the regulator will activate the charge phase when the following conditions are met:

VP > VB,

where VP = Panel voltage,

VB = Battery voltage;

the regulator will stop the charge phase when the following conditions are met:

VB ≥ V max.,

*I*c = 0,

where *V* max = Battery maximum charge voltage (given by the thermowell, or by the pre-set maximum value),

*I*c = Current between the panel and the battery.

For more information regarding system characteristics and sizing, see IEC 61892-2.

A.3 Wind energy generation system

Wind energy generating systems consist of components and sub-systems that are used to convert wind energy directly into electrical energy. The wind generators carry out the full charge and trickle charge of the storage batteries, simultaneously with the power supply to the users' loads. The wind energy generating systems may operate in parallel with some other auxiliary power source(s) that are connected to appropriate interface(s). The system may comprise but is not limited to:

- windmill with electric wind generator;
- d.c. conditioner;
- charge regulators;
- d.c./d.c. load interface;
- storage batteries;
- inverter (only in case of a.c. loads);
- a.c./a.c. interface (only in case of a.c. loads).

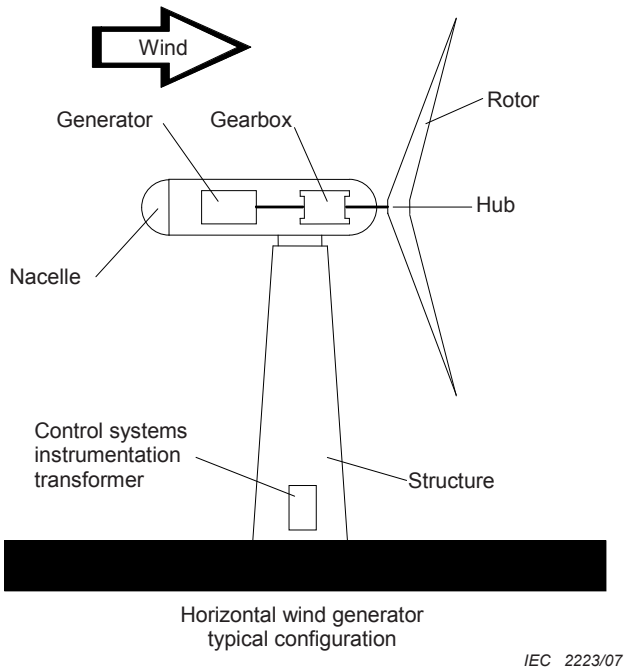

Figure A.2 – Power generating system – Major functional elements

The electric generators can be of two types:

- constant speed and constant frequency (VCFC);
- variable speed and constant frequency (VVFC).

The VCFC type will be obtained with the following items:

- synchronised generators coupled with constant speed windmill. Two or more generators may operate in parallel with the network and shall maintain a constant rotation speed, not affected by the wind velocity. They shall be complete with devices for the control of the speed;
- asynchronous generators (or induction generators with a creeping between 1 % and 5 %) coupled to windmills with almost constant speed. They shall be started as motors. The installation of devices for improving the power factor shall be provided.

The VVFC system shall be obtained with:

- variable speed and constant frequency generators, coupled with variable speed windmills;
- permanent magnets generators.

The control system may govern functions or parameters such as:

- power limitation;
- rotor speed;
- connection to the electrical load;
- start up and shut-down procedures;
- shut-down at loss of electrical network or electrical load;
- cable twist limits;
- alignment to the wind.

The electric charge regulator shall charge the batteries with a constant voltage system or a step-by-step system. For more information regarding system characteristics and sizing, see IEC 61892-2 and IEC 61400 series.

A.4 Close cycle vapour turbo-generators (CCVT)

The CCVT system provides the transformation of thermal energy, generated by a vapour turbine, to electrical energy delivered from a turbine driven generator group.

The operating principle of the Generation Units is a Rankine close cycle with organic fluid, as shown in the block diagram (see Figure A.3).

The organic fluid contained in the vapour generator, vaporised by the heat from a natural gas burner, flows into the turbine and causes it to rotate. The outlet vapour (from the turbine) twins into an equal state through the condenser and goes back to the vapour generator in the form of a liquid.

The alternator coupled with the turbine supplies an output voltage in function of the speed of the turbine rotation; whereas the generated power is proportional to the heat released by the burner.

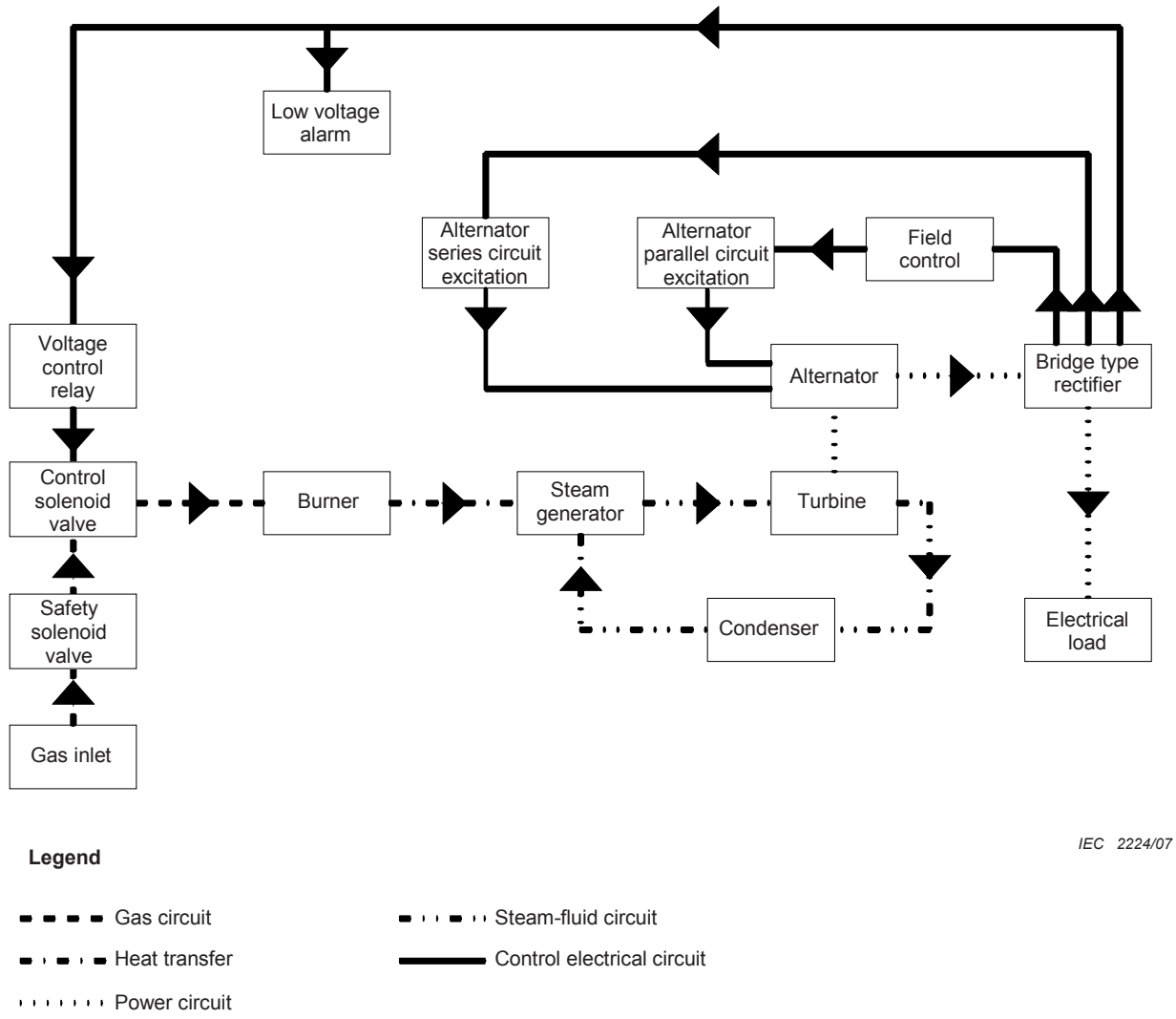

Figure A.3 – CCVT operating principle block diagram

Standard size of CCVT is from 0,5 kW to 6 kW for each unit. The CCVT systems normally expect 2+1 units at least running in parallel.

A.5 Multi-fuel micro-turbine generators

A micro turbine generating system provides electrical power for primary or stand-by application both in parallel with an electrical utility (grid connected) mode or isolated.

This kind of generators derived from aeronautical models can be utilized with different gas or liquid fuel: natural gas, diesel oil, propane, LNG, kerosene, low-grade landfill/digester gases.

The micro turbine system includes compressor, recuperator (exhaust gas heat exchanger), combustor, turbine and permanent magnet alternator. The micro turbine engine is air-cooled and supported on air-lubricated compliant foil bearings.

Power electronics are solid state, double conversion type, producing three-phase alternating current from high frequency alternate current engine output.

The main characteristics are: the ability to feed a variable load from 0 % to 100 % of power rating value without loss of efficiency or any damage, the absence of lubrication system (air-bearing is provided) and cooling systems, the low vibration and emissions.

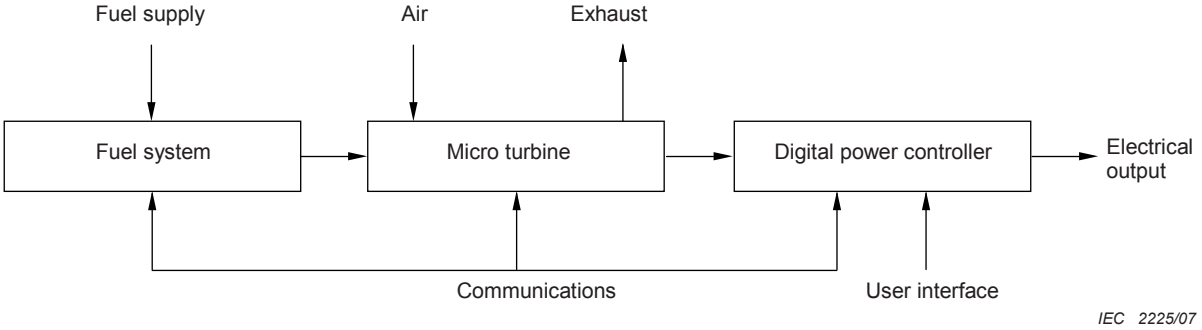

Figure A.4 – Micro turbine typical block diagram

Standard size of micro-turbines is included from 25 kW to 100 kW for each unit. The micro-turbines systems normally expect 1+1 units at least running in parallel.

The micro-turbines allow a co-generation application, with combined thermal and electrical power generated on site. This solution includes chiller applications and boiler re-powering.

A.6 Secondary cells and batteries for solar photovoltaic energy system

Secondary cells and batteries used in a photovoltaic system are of the following types:

- vented (flooded);
- valve-regulated;
- gastight sealed (nickel-cadmium only).

The battery is designed to supply energy under specified conditions for a period of time from 3 days to 15 days without or with minimum solar irradiation. Some systems can have significantly more or less than this time.

Typical charge currents generated by the PV generator:

- maximum charge current: $I_{20} = C_{20}/20$ h;
- average charge current: $I_{50} = C_{50}/50$ h.

Discharge current determined by load:

- average discharge current $I_{120} = C_{120}/120$ h.

Depending on the system design the charge and the discharge current may vary in a wider range.

The batteries are normally exposed to a daily cycle, with typical discharge in the range of 2 % to 20 % of the battery capacity, and to a seasonal cycle. In period of low solar irradiation the battery can go down to 20 % of the battery capacity.

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