

Mobile and fixed offshore units — Electrical installations —

Part 3: Equipment

ICS 29.260.99; 47.020.60; 75.180.10

National foreword

This British Standard is the UK implementation of IEC 61892-3:2007. It supersedes BS IEC 61892-3:1999 which is withdrawn.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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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 February 2008

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ISBN 978 0 580 58162 5

Amendments/corrigenda issued since publication

Date	Comments



BS IEC 61892-3:2007

IEC 61892-3

Edition 2.0 2007-11

INTERNATIONAL STANDARD

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

CONTENTS

INTRODUCTION.....	5
1 Scope.....	6
2 Normative references	6
3 Terms and definitions	8
4 General requirements	11
4.1 Degree of protection.....	11
4.2 Service conditions	11
4.3 Temperature rise	11
4.4 Nameplates and labels	11
5 Generators and motors	11
5.1 General	11
5.2 Voltage regulation of generators.....	12
5.3 Generators for special purposes.....	13
5.4 Parallel operation of general service generators – AC generators.....	13
5.5 Mechanical features (generators and motors).....	14
5.6 Lubrication (generators and motors).....	15
5.7 Prime movers	15
5.8 Cyclic irregularity	15
5.9 Lubrication (prime movers).....	16
5.10 Running speed	16
5.11 Testing	16
6 Transformers for power and lighting	16
6.1 General	16
6.2 Winding arrangement	16
6.3 Terminals	17
6.4 Cooling arrangement.....	17
6.5 Voltage regulation	17
6.6 Parallel operation	17
6.7 Tests	18
7 Switchgear and controlgear assemblies	18
7.1 Service conditions	18
7.2 Definitions	18
7.3 Low-voltage switchgear and controlgear assemblies	18
7.4 Switchgear and controlgear in the range above 1 kV up to and including 35 kV	23
7.5 Instruments for assemblies.....	24
8 Semiconductor convertors	26
8.1 General.....	26
8.2 Internal wiring	26
8.3 Cooling arrangements	26
8.4 Accessibility	26
8.5 Service conditions	27
8.6 Application	27
8.7 Diagrams.....	27

8.8	Convertor transformers.....	27
9	Secondary cells and batteries.....	28
9.1	General.....	28
9.2	Types of batteries.....	28
9.3	Charging facilities.....	28
9.4	Ventilation of secondary battery compartments	28
10	Luminaires	29
10.1	General.....	29
10.2	Construction.....	29
10.3	Temperature and temperature rise	29
10.4	Exposure to mechanical damage.....	29
10.5	Discharge lamp luminaires operating at voltages below 250 V.....	29
10.6	Discharge lamp luminaires operating at voltages above 250 V	30
10.7	Searchlights and arc lamps	30
10.8	Portable luminaires	30
11	Heating and cooking appliances	31
11.1	General.....	31
11.2	General requirements.....	31
11.3	Special requirements for galley appliances.....	33
11.4	Special requirements for space-heating appliances	33
12	Trace and surface heating	33
12.1	General.....	33
12.2	Construction.....	34
13	Communication.....	34
13.1	General.....	34
13.2	Safety requirements	34
13.3	External communication systems.....	34
13.4	Internal communication	34
13.5	Safety and maintenance	35
14	Underwater systems and appliances.....	35
14.1	General.....	35
14.2	Fixed diving systems	36
14.3	Temporary diving systems.....	36
15	Control and instrumentation.....	36
15.1	General	36
15.2	General requirements	36
15.3	Environmental and supply conditions and testing.....	36
15.4	Adjustments	44
15.5	Accessibility	44
15.6	Replacement	44
15.7	Non-interchangeability.....	44
15.8	Cooling air.....	45
15.9	Mechanical load on connectors.....	45
15.10	Mechanical features of cabinets	45
15.11	Shock and vibration absorbers	45
15.12	Internal wiring.....	45
15.13	Cable connections	45
15.14	Rodent protection	45

15.15	Sensors	45
15.16	Computer-based systems	46
16	Accessories	49
16.1	General	49
16.2	Enclosures	49
16.3	Switches	49
16.4	Socket outlets and plugs	49
Annex A (informative) Alternative method of power generation		51
Bibliography.....		57
Figure A.1 – PV Power generating system – Major functional elements, sub-systems and power flow diagram		52
Figure A.2 – Power generating system – Major functional elements		53
Figure A.3 – CCVT Operating principle block diagram.....		55
Figure A.4 – Micro turbine Typical block diagram		56
Table 1 – Limits of cyclic irregularity		16
Table 2 – Clearance and creepage distances for non type-tested assemblies		20
Table 3 – Temperature limits of exposed parts.....		32
Table 4 – Type tests, test procedures and severities.....		38

INTRODUCTION

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

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

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

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

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

Part 3: Equipment

1 Scope

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

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

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

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

2 Normative references

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

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

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

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

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

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

IEC 60068 (all parts) *Environmental testing*

IEC 60076 (all parts), *Power transformers*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test¹*

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

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

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

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields²*

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

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

IEC 61131 (all parts), *Programmable controllers*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

IMO *Code of Safety for Diving Systems*

3 Terms and definitions

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

3.1

appropriate authority

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

3.2

computer-based system

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

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

3.3

convertor

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

3.4

distribution board

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

3.5

double insulation

insulation comprising both basic insulation and supplementary insulation

3.6

electric surface heating

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

3.7

electric surface heating device

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

3.8

electric surface heating systems

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

3.9

electromagnetic compatibility EMC

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

3.10

emergency switchboard

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

3.11

expert system

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

3.12

extra-low voltage ELV

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

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

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

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

3.13

heating cable

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

3.14

inverter

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

3.15

low-voltage switchgear and controlgear assemblies

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

3.16**main switchboard**

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

3.17**non-type-tested low-voltage switchgear and controlgear assemblies NTTA**

low-voltage switchgear and controlgear assembly which does not belong to 3.18 or 3.27

3.18**partially type-tested low-voltage switchgear and controlgear assemblies PTTA**

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

3.19**rectifier**

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

3.20**reinforced insulation**

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

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

3.21**resistive device**

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

3.22**(secondary) cell** (*Syn.* (rechargeable) cell)

an assembly of electrodes and electrolyte which constitutes the basic unit of a secondary battery

3.23**section boards**

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

3.24**semiconductor device**

device whose essential characteristics are due to the flow of charge carriers within a semiconductor

3.25**skin effect device**

electric surface heating device of the skin effect heater type

3.26**software**

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

3.27**type-tested low-voltage switchgear and controlgear assembly TTA**

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

3.28

valve-regulated battery cell

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

3.29

vented (secondary) battery cell (*Syn. open (secondary) cell*)

a secondary cell having a cover provided with an opening through which gaseous products may escape

NOTE The opening may be fitted with a venting system.

3.30

gastight sealed (secondary) cell

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

4 General requirements

4.1 Degree of protection

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

4.2 Service conditions

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

4.3 Temperature rise

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

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

4.4 Nameplates and labels

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

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

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

5 Generators and motors

5.1 General

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

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

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

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

5.2 Voltage regulation of generators

5.2.1 General

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

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

5.2.2 DC generators

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

5.2.3 AC generators

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

5.2.3.1 Steady conditions: tolerance of voltage and waveform

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

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

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

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

5.2.3.2 Transient conditions

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

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

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

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

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

5.2.3.3 Steady short-circuit conditions

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

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

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

5.2.3.4 Emergency generators

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

5.3 Generators for special purposes

5.3.1 DC generators

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

5.3.2 AC generators

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

5.4 Parallel operation of general service generators – AC generators

5.4.1 Reactive load sharing

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

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

5.4.2 Load sharing

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

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

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

5.4.3 Flywheel effect for a.c. generators

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

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

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

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

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

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

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

5.4.4 Excitation of a.c. generators

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

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

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

5.5 Mechanical features (generators and motors)

5.5.1 Entry of water

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

5.5.2 Accumulation of moisture and condensation

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

5.5.3 Balance

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

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

5.5.4 Shaft currents

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

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

5.5.5 Terminals

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

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

5.6 Lubrication (generators and motors)

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

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

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

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

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

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

5.7 Prime movers

5.7.1 General

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

5.7.2 Speed governing characteristics

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

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

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

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

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

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

5.7.3 Flywheel effect

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

5.8 Cyclic irregularity

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

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

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

Table 1 – Limits of cyclic irregularity

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

5.9 Lubrication (prime movers)

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

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

5.10 Running speed

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

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

5.11 Testing

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

6 Transformers for power and lighting

6.1 General

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

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

6.2 Winding arrangement

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

NOTE For special equipment other winding arrangements may be used.

6.3 Terminals

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

6.4 Cooling arrangement

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

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

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

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

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

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

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

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

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

6.5 Voltage regulation

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

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

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

6.6 Parallel operation

For successful parallel operation, the transformers require:

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

The following shall also be considered.

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