



BSI Standards Publication

Mobile and fixed offshore units — Electrical installations

Part 2: System design

National foreword

This British Standard is the UK implementation of IEC 61892-2:2019. It supersedes BS IEC 61892-2:2012, which is withdrawn.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.

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Mobile and fixed offshore units – Electrical installations –
Part 2: System design**

**Unités mobiles et fixes en mer – Installations électriques –
Partie 2: Conception du système**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
2 Normative references	12
3 Terms, definitions and abbreviated terms	13
3.1 Terms and definitions.....	13
3.2 Abbreviated terms.....	20
4 Sources of electrical power for manned units.....	20
4.1 General.....	20
4.2 Main sources of electrical power	21
4.2.1 Common requirements.....	21
4.2.2 Capacity of main and essential power source	22
4.2.3 Load shedding arrangement	22
4.3 Essential source of electrical power	23
4.4 Emergency source of electrical power	23
4.5 Starting arrangements for emergency generators.....	26
4.6 Additional requirements for periodically unattended machinery spaces	27
4.7 Uninterruptible power system (UPS) source of power.....	27
4.7.1 General	27
4.7.2 UPS functionality – Uninterruptible source of power for critical/sensitive loads	28
4.7.3 UPS – Design planning issues.....	28
4.8 Transmission systems including main power from shore	30
4.9 Alternative sources of power.....	31
5 Sources of electrical power for unmanned units.....	32
5.1 General.....	32
5.2 Power sources	32
5.2.1 Sources to be evaluated	32
5.2.2 Cable from other unit or from shore	32
5.2.3 Local generator (gas or diesel)	32
5.2.4 Alternative sources of power.....	32
5.2.5 UPS.....	33
5.3 Factors affecting power supply requirements	33
6 System earthing	33
6.1 General requirements	33
6.2 Neutral earthing for systems up to and including 1 000 V AC	34
6.3 Neutral earthing for systems above 1 000 V AC	34
6.4 Parallel operated power sources	35
6.5 Earthing resistors, connection to hull/structure.....	35
7 Distribution systems	36
7.1 DC distribution systems	36
7.1.1 Types of distribution systems.....	36
7.1.2 TN DC systems.....	37
7.1.3 IT DC systems	40
7.1.4 DC voltages.....	41
7.2 AC distribution systems	42

7.2.1	Primary AC distribution systems	42
7.2.2	Secondary AC distribution systems	42
7.2.3	TN AC systems	42
7.2.4	IT AC systems	44
7.2.5	AC voltages and frequencies	44
7.2.6	Earthing systems	46
8	Distribution system requirements	46
8.1	Methods of distribution	46
8.2	Balance of loads	47
8.2.1	Balance of load on three-wire DC systems	47
8.2.2	Balance of loads in three- or four-wire AC systems	47
8.3	Final circuits	47
8.3.1	General	47
8.3.2	Final circuits for lighting	47
8.3.3	Final circuits for heating	47
8.3.4	Final circuits for sockets	47
8.4	Control circuits	48
8.4.1	Supply systems and nominal voltages	48
8.4.2	Circuit design	48
8.4.3	Protection	48
8.4.4	Arrangement of circuits	49
8.5	Motor circuits	49
8.5.1	Starting of motors	49
8.5.2	Means of disconnection	50
8.5.3	Starters remote from motors	50
8.6	Isolation of supply to galley	50
9	Cables and wiring systems	50
9.1	Cables	50
9.2	Voltage drop	51
9.3	Demand factors	51
9.3.1	Final circuits	51
9.3.2	Circuits other than final circuits	51
9.3.3	Application of diversity and demand factors	51
9.4	Motor circuits	51
9.5	Cross-sectional areas of conductors	52
9.6	Correction factors for cable grouping	52
9.7	Separation of circuits	52
10	System study and calculations	53
10.1	Electrical studies – General	53
10.2	Electrical load study	54
10.3	Load flow calculations	55
10.4	Short-circuit calculations	56
10.5	Protection and discrimination study	58
10.6	Power system dynamic calculations	59
10.7	Calculation of harmonic currents and voltages	61
11	Protection	61
11.1	General	61
11.2	Characteristics and choice of protective devices with reference to short-circuit rating	62

11.2.1	General	62
11.2.2	Protective devices	62
11.2.3	Backup protection	63
11.2.4	Rated short-circuit breaking capacity	63
11.2.5	Rated short-circuit making capacity	64
11.2.6	Co-ordinated choice of protective devices with regard to discrimination requirements	65
11.3	Choice of protective devices with reference to overload	65
11.3.1	Protective devices	65
11.3.2	Fuses for overload protection	65
11.4	Choice of protective devices with regard to their application	65
11.4.1	General	65
11.4.2	Generator protection	65
11.4.3	Protection of UPS	66
11.4.4	Protection of transformers	67
11.4.5	Transformers – Isolation of windings	67
11.4.6	Circuit protection	67
11.4.7	Motor protection	67
11.4.8	Protection of lighting circuits	68
11.4.9	Protection of power from external sources	68
11.4.10	Secondary cells and battery protection	68
11.4.11	Protection of static or solid-state devices	68
11.4.12	Protection for heat tracing systems	69
11.5	Undervoltage protection	69
11.5.1	Generators	69
11.5.2	AC and DC motors	69
11.6	Overvoltage protection	69
11.6.1	General	69
11.6.2	AC machines	69
11.6.3	DC networks	69
12	Lighting	70
12.1	General	70
12.2	General lighting system	70
12.3	Emergency lighting system	70
12.4	Escape lighting system	71
12.5	Lighting circuits in machinery spaces, accommodation spaces, open deck spaces, etc.	71
12.6	Navigation and obstruction signals and lights	71
13	Energy control, monitoring and alarm system	72
13.1	General	72
13.2	Alarm system	72
13.3	Network topology	72
13.4	Router communication	72
13.5	Communication protocols	72
13.6	Monitoring and fault diagnosis	73
13.7	Cybersecurity	73
13.8	Energy management and control systems (EMCS)	73
13.8.1	General	73
13.8.2	EMCS architecture	73

13.8.3	Interaction with protection system	74
13.8.4	Performance	74
13.9	Electromagnetic compatibility	74
13.10	Time identification and event logs	75
13.11	Remote controls	75
13.11.1	Continuous status information	75
13.11.2	Independent control	75
13.11.3	Exclusive control	75
13.11.4	Interlocks in operative command	75
13.12	Human-machine interface	75
13.13	Emergency stop	75
13.14	Automatic control of electrical power sources	75
13.14.1	Initiation of starting commands	75
13.14.2	Pre-starting conditions	76
13.14.3	Standby indication	76
13.15	Automatic connecting onto a dead busbar	76
13.15.1	Connection at blackout	76
13.15.2	Short-circuit	76
13.16	Delayed disconnection	76
13.17	Automatic starting arrangements for electrical motor-driven auxiliaries	76
13.17.1	Prevention of overload via sequential restart	76
13.17.2	Start inhibit	76
13.18	General alarm systems	76
13.18.1	Audibility	76
13.18.2	Minimum sound level	77
13.18.3	Fault tolerance	77
13.18.4	Power supplies	77
13.19	System integration	77
13.19.1	Alarm functions	77
13.19.2	Essential and emergency control functions	77
13.20	Software	78
13.20.1	Version control of software	78
13.20.2	Configuration – Support functions	78
13.20.3	Documentation	78
13.21	Tests	79
13.21.1	General	79
13.21.2	Hardware	79
13.21.3	Software	79
13.21.4	System testing	79
14	Special facilities – Swivel/turret	80
14.1	Standards, codes and regulations	80
14.2	Bonding and protective earthing of power swivel	80
Annex A (informative)	Essential source of electrical power	81
Annex B (informative)	Emergency source of electrical power	82
Annex C (informative)	Applicable examples of HVDC VSC technologies	83
Annex D (informative)	Swivel/turret	87
D.1	General	87
D.2	Swivel design and service location	87

D.3	Fault exposure of high-voltage electrical swivels	88
D.4	Enclosure and purging system	88
D.5	Ingress protection	88
D.6	Anti-condensation	89
D.7	Inspection and functional testing of swivel unit.....	89
Annex E	(informative) Guidelines for design of unmanned units	90
E.1	Factors affecting power supply requirements	90
E.2	Guideline for defining power sources requirement.....	90
E.2.1	One main power supply and UPS.....	90
E.2.2	One emergency power supply and UPS	91
E.2.3	One main power supply, one emergency power supply and UPS	91
E.2.4	Renewable sources of energy.....	91
E.3	Layout.....	92
E.4	Switchboard arrangements.....	92
E.5	High-voltage equipment	94
E.6	Lighting system.....	95
Annex F	(informative) Alternative sources of electrical power	96
F.1	General.....	96
F.2	Photovoltaic system	96
F.3	Wind turbine system	97
F.4	Microturbines	100
F.5	Closed cycle vapour turbines (CCVT).....	101
F.6	Thermoelectric generators (TEG).....	102
Annex G	(informative) Illumination level.....	104
G.1	General illumination level.....	104
G.2	Emergency lighting	104
G.3	Escape lighting	104
G.4	Verification of lighting level	105
Annex H	(informative) Enhanced software simulation.....	106
H.1	General.....	106
H.2	Scope of HiL testing.....	106
H.3	Schedule and work process	106
H.4	Requirements relating to the control system vendor or system integrator	106
H.5	Documentation and approval.....	107
Annex I	(informative) Architecture for energy control, monitoring and alarm system – Level reference and segmentation architecture	108
Bibliography		109
Figure 1	– Continuity of supply/continuity of service.....	15
Figure 2	– Power system hierarchy in an offshore unit	21
Figure 3	– TN-S DC system	38
Figure 4	– TN-C DC system	39
Figure 5	– TN-C-S DC system.....	40
Figure 6	– IT DC system	41
Figure 7	– TN-S AC system	43
Figure 8	– TN-C-S AC system.....	43
Figure 9	– TN-C AC system	44

Figure 10 – IT AC system	44
Figure 11 – Use of FCL in emergency switchboard	64
Figure C.1 – Typical HVDC VSC transmission between onshore grid and offshore petroleum unit; symmetric monopole	84
Figure C.2 – Typical symmetric and asymmetric monopole and bipole HVDC VSC arrangement	84
Figure C.3 – Principle drawings of possible topology arrangements for two-level (left) and multi-level (right) types with indication of corresponding filtered (blue) and non-filtered (green) output voltage wave forms	86
Figure E.1 – Example of electrical arrangement for an unmanned unit	93
Figure E.2 – Example of electrical arrangement for an unmanned unit	94
Figure E.3 – Example of electrical arrangement for an unmanned unit	94
Figure F.1 – PV Power generating system – Major functional elements, subsystems and power flow diagram	97
Figure F.2 – Typical diagram for the island function of a wind generation system – Unmanned unit	98
Figure F.3 – Typical diagram for the island function of a wind generation system – Manned unit	99
Figure F.4 – Microturbine typical block diagram	100
Figure F.5 – CCVT operating principle block diagram	101
Figure F.6 – Typical diagram for the thermoelectric generation system (TEG)	102
Figure I.1 – IEC 62443 reference architecture	108
Table 1 – Summary of principal features of the neutral earthing methods	36
Table 2 – Voltages for DC systems	41
Table 3 – AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment	45
Table 4 – AC three-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment	46
Table G.1 – General lighting illumination levels	104
Table G.2 – Recommended measuring points for measuring illumination in an area	105

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MOBILE AND FIXED OFFSHORE UNITS –
ELECTRICAL INSTALLATIONS –****Part 2: System design****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61892-2 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 2012. This edition constitutes a technical revision.

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

- a) the requirement for sources of electrical power has been rewritten. Requirements both for manned and unmanned units are given. Requirements for essential services of electrical power have been added;
- b) the requirement in relation to dead start has been added;
- c) the requirement for emergency stop for motor-driven fuel-oil transfer and fuel-oil pressure pumps has been added;

- d) general requirements regarding cables and wiring systems have been added;
- e) the description of unit interfaces to electrical transmission systems has been included;
- f) requirements in relation to energy control, monitoring and alarm system have been rewritten;
- g) new clauses regarding swivel/turret and unmanned facilities have been added;
- h) informative annexes regarding the following have been added:
 - essential source of electrical power;
 - emergency source of electrical power;
 - applicable examples of HVDC VSC technologies;
 - swivel/turret;
 - power sources for unmanned units, with separate or combined main and emergency switchboard;
 - alternative power sources of electrical power – general requirements;
 - illumination level;
 - enhanced software simulation;
 - architecture for energy control, monitoring and alarm system.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
18/1650/FDIS	18/1661/RVD

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

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

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INTRODUCTION

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

This part of IEC 61892 incorporates and coordinates, as far as possible, existing rules and forms a code of interpretation, where applicable, of the requirements of the International Maritime Organization (IMO), and constitutes a guide for future regulations which may be prepared and a statement of practice for offshore unit owners, designers, installers and appropriate organizations.

This document is based on solutions and methods which are in current use, but it is not intended to impede the development of new or improved techniques.

In this revision, voltage limitations have been removed. However, voltage limitations may be given in the referenced equipment standards. The removal of voltage limitations is considered necessary due to the interconnection of, and supply from shore to offshore units. In such cases, transmission voltages up to 132 kV AC and 150 kV DC are used and higher voltages are being planned.

The IEC 61892 series aims to constitute a set of International Standards for the offshore petroleum industry, but it is not intended to prevent their use beyond petroleum installations.

MOBILE AND FIXED OFFSHORE UNITS – ELECTRICAL INSTALLATIONS –

Part 2: System design

1 Scope

This part of IEC 61892 is applicable to system design of electrical installations and equipment in mobile and fixed offshore units including pipeline, pumping or "pigging" stations, compressor stations and single buoy moorings, used in the offshore petroleum industry for drilling, production, accommodation, processing, storage and offloading purposes.

It applies to all installations, whether permanent, temporary, transportable or hand-held, to AC installations and DC installations, without any voltage level limitation. Referenced equipment standards may give voltage level limitations.

This document specifies requirements such as those concerning

- sources of electrical power for manned and unmanned units,
- system earthing, both for low-voltage and high-voltage installations,
- interface for electric transmission systems with power supplied from shore, between interconnected offshore units, and with power supplied by offshore units to subsea installations,
- distribution systems,
- cables and wiring systems,
- system studies and calculations,
- protection against electrical faults,
- lighting,
- energy control, monitoring and alarm systems, and
- turret/swivel.

This document gives information and guidance on topics such as

- applicable examples of HVDC VSC technology, and
- guidelines for illumination level.

This document does not apply to

- fixed equipment for medical purposes,
- electrical installations of tankers, and
- control of ignition sources other than those created by electrical equipment.

NOTE 1 For medical rooms, IEC 60364-7-710 provides specific requirements. Requirements for tankers are given in IEC 60092-502.

NOTE 2 Guidance on protection of non-electrical equipment can be found in ISO 80079-36, ISO 80079-37 and IMO 2009 MODU Code, 6.7.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60038:2009, *IEC standard voltages*

IEC 60092-504:2016, *Electrical installations in ships – Part 504: Automation, control and instrumentation*

IEC 60331-1, *Tests for electric cables under fire conditions – Circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

IEC 60331-2, *Tests for electric cables under fire conditions – Circuit integrity – Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

IEC 60331-21, *Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*

IEC 60447, *Basic and safety principles for man-machine interface, marking and identification – Actuating principles*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull*

IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC TR 60909-1, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculation of short-circuit currents according to IEC 60909-0*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters*

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

IEC 61131-2, *Industrial-progress measurement control – Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61363-1, *Electrical installations of ships and mobile and fixed offshore units – Part 1: Procedures for calculating short-circuit currents in three-phase a.c.*

IEC 61892-1:2019, *Mobile and fixed offshore units – Electrical installations – Part 1: General requirements and conditions*

IEC 61892-3:2019, *Mobile and fixed offshore units – Electrical installations – Part 3: Equipment*

IEC 61892-4:2019, *Mobile and fixed offshore units – Electrical installations – Part 4: Cables*

IEC 61892-6:2019, *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 62040-1, *Uninterruptible power systems (UPS) – Part 1: Safety requirements*

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

IEC 62040-3:2011, *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements*

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

IALA, *Recommendation O-139 on The Marking of Man-Made Offshore Structures*

ICAO, *Convention on International Civil Aviation, Annex 14, Aerodromes*

IMO, *Code on Alerts and Indicators*

IMO, *Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972*

IMO, *International Convention for the Safety of Life at Sea (SOLAS), consolidated edition 2014*

IMO, 2009 MODU Code, *Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009, 2010 edition*

IMO, MSC/Circ. 645, *Guidelines for vessels with dynamic positioning systems, Annex*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 61892-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

AC systems of distribution

3.1.1.1

single-phase two-wire AC system

AC system comprising two conductors only, between which the load is connected

Note 1 to entry: This system can be used for phase-to-phase connection of the load and phase-to-neutral connection of the load.

Note 2 to entry: In some countries, this system with phase-to-phase connection of the load is designated as a two-phase system.

3.1.1.2

three-phase three-wire AC system

AC system comprising three conductors connected to a three-phase supply

3.1.1.3

three-phase four-wire AC system

AC system comprising four conductors of which three are connected to a three-phase supply and the fourth to a neutral point in the source of supply

3.1.2

arc-flash hazard

dangerous condition associated with the release of energy caused by an electric arc

[SOURCE: IEEE 1584:2002, 3.1]

3.1.3

availability

state of an item of being able to perform its required function

[SOURCE: IEC 60050-603:1986, 603-05-04]

3.1.4

backup protection

protection which is intended to operate when a system fault is not cleared in due time because of:

- failure or inability of a protective device closest to the fault to operate, or
- failure of a protective device, other than the protective device closest to the fault, to operate

[SOURCE: IEC 60050-448:1995, 448-11-14, modified – The definition has been rewritten.]

3.1.5

blackout

<offshore unit> state characterised by the fact that

- normal operations have ceased due to the unplanned loss of the main source of electrical power and if installed,
- the essential source of power has not been established in a timely manner,
- the emergency generator(s) has not started,

but the transitional power system is still operational, for example by means of the UPS accumulator batteries

3.1.6

dead start

<offshore unit> restoration of power and services after a major event in which the following has occurred:

- i) all sources of electrical power have been shut down, and
- ii) stored energy systems have been completely exhausted

3.1.7

centralized control

control of all operations of a controlled system from one central control position

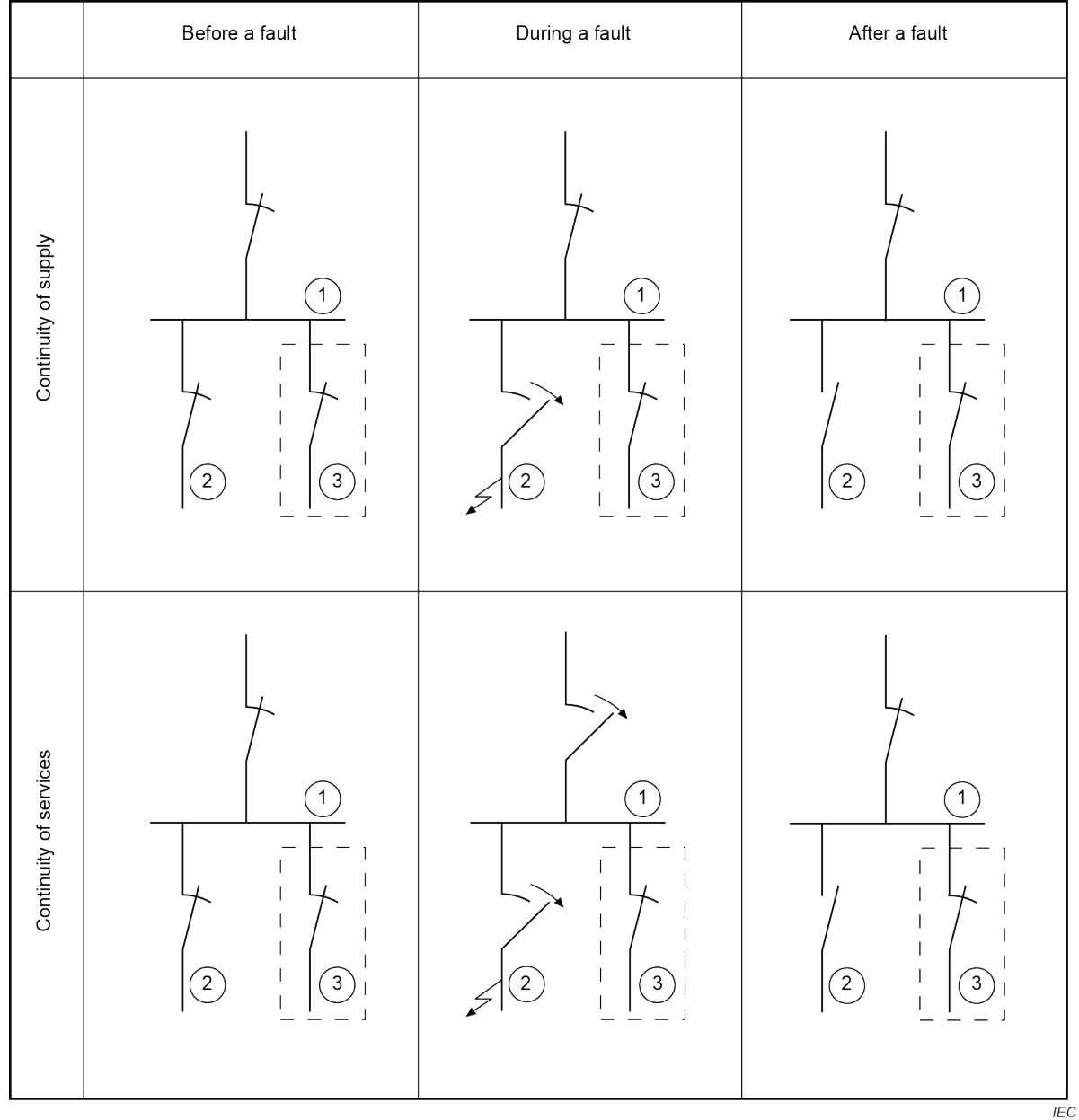
3.1.8
computer-based system

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

3.1.9
continuity of service

condition where, after a fault in a circuit has been cleared, the supply to healthy circuits is re-established

Note 1 to entry: See circuit 3 in Figure 1.



IEC

Figure 1 – Continuity of supply/continuity of service

3.1.10
continuity of supply

condition where, during and after a fault in a circuit, the supply to healthy circuits is permanently ensured

Note 1 to entry: See circuit 3 in Figure 1.

3.1.11

control function

functions intended to regulate the behaviour of equipment or systems

3.1.12

control position

control station

group of control devices by which an operator can control the performance of a machine, apparatus, process or assembly of machines and apparatuses

3.1.13

DC systems of distribution

3.1.13.1

two-wire DC system

DC system comprising two conductors only, between which the load is connected

3.1.13.2

three-wire DC system

DC system comprising two conductors and a middle wire, the supply being taken from the two outer conductors or from the middle wire and either outer conductor, the middle wire carrying the difference-current only

3.1.14

demand factor

ratio, expressed as a numerical value or as a percentage, of the maximum demand of an installation or a group of installations, to the corresponding total installed load of the installation(s)

[SOURCE IEC 60050-691:1973, 691-10-05, modified – The words "within a specified period" have been deleted from the definition and the note to entry has been deleted.]

3.1.15

coincidence factor

ratio, expressed as a numerical value or as a percentage, of the simultaneous maximum demand of a group of electrical appliances or consumers within a specified period, to the sum of their individual maximum demands within the same period

[SOURCE: IEC 60050-691:1973, 691-10-03, modified – The note to entry has been deleted.]

3.1.16

diversity factor

ratio, expressed as a numerical value or as a percentage, of the sum of the individual maximum demands of a group of electrical appliances or consumers within a specified period, to their simultaneous maximum demand within the same period

Note 1 to entry: The diversity factor is the reciprocal of the coincidence factor.

3.1.17

fiscal metering

metering at a point of logged transaction that takes place any time measurable quantities of electric energy are passed from the possession of one party to another

3.1.18

function

elementary operation performed by the system which, in conjunction with other elementary operations (system functions), enables the system to perform a task

3.1.19**high voltage**

set of voltage levels in excess of low voltage

[SOURCE: IEC 60050-601:1985, 601-01-27, modified – The restrictive sense of the term and the abbreviated term have been omitted.]

3.1.20**low voltage**

set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V AC or 1 500 V DC

[SOURCE: IEC 60050-601:1985, 601-01-26, modified – The DC voltage has been added.]

3.1.21**hull return system**

system in which insulated conductors are provided for connection to one pole or phase of the supply, the structure of the unit or other permanently earthed structure being used for effecting connections to the other pole or phase

3.1.22**integrity**

capability of a system to satisfactorily perform the required functions under all the stated conditions within a stated period of time

3.1.23**control room**

room or spaces where centralized controls and measuring and monitoring equipment for main equipment and essential auxiliary machinery are located together with the appropriate means of communication

3.1.24**overcurrent**

current exceeding the rated current

[SOURCE: IEC 60050-441:2000, 441-11-06]

3.1.25**overcurrent discrimination**

co-ordination of the operating characteristics of two or more overcurrent protective devices such that, on the incidence of overcurrents within stated limits, the device intended to operate within these limits does so, while the other(s) does (do) not

[SOURCE: IEC 60050-441:2000, 441-17-15, modified – The note to entry has been deleted.]

3.1.26**overload**

operating conditions in an electrically undamaged circuit, which cause an overcurrent

[SOURCE: IEC 60050-441:2000, 441-11-08]

3.1.27**partial discrimination****partial selectivity**

overcurrent discrimination where, in the presence of two or more overcurrent protective devices in series, the protective device closest to the fault effects the protection up to a given level of short-circuit current without causing the other protective devices to operate

3.1.28

total discrimination

overcurrent discrimination where, in the presence of two or more overcurrent protective devices in series, the protective device on the load side effects the protection without causing the other protective devices to operate

3.1.29

reliability

probability that an item can perform a required function under given conditions for a given time interval

3.1.30

safety function

functions intended to prevent harm or danger to personnel, equipment and unit

3.1.31

short-circuit

accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal to or close to zero

[SOURCE: IEC 60050-195:1998, 195-04-11]

3.1.32

software

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

3.1.33

sources of electrical power

3.1.33.1

emergency source of electrical power

source of electrical power intended to supply the emergency system in the event of failure of the supply from the main source of electrical power

3.1.33.2

essential source of electrical power

source of electrical power intended to supply the services necessary to maintain the unit in habitable condition and the equipment necessary for asset preservation, standby and re-starting

Note 1 to entry: A fuel or energy source independent of the production status shall be available.

3.1.33.3

main source of electrical power

source of electrical power intended to supply all services necessary for maintaining the unit in normal operational and habitable condition

3.1.34

system

collection of components organised to accomplish a specific function or set of functions

3.1.35

energy management and control system

EMCS

comprehensive monitoring and control system covering entire energy systems with a typical focus on operational status, operational forecasts, transfer between operational modes, periodic testing of equipment, and identification of operational fall-backs during a fault

Note 1 to entry: This note applies to the French language only.

3.1.36**voltage dip**

sudden reduction of the voltage at a point in the system, followed by voltage recovery after a short period of time, from a few cycles to a few seconds

[SOURCE: IEC 60050-161:1990, 161-08-10, modified – The wording "an electrical system" has been replaced by "the system".]

3.1.37**voltage drop**

change of the voltage between two given terminals of an electric circuit due to the change of the operating conditions

[SOURCE: IEC 60050-151:2001, 151-15-09, modified – The second preferred term "tension drop" has been omitted.]

3.1.38**single point mooring**

mooring to the seabed arranged from a single location on a floating unit with multiple mooring lines

3.1.39**spread mooring system**

multi-point mooring system that moor a floating unit to the seabed using multiple mooring lines and where the mooring lines can be directly attached to strong structural points in the hull of the vessel as well as indirectly using conventional buoy mooring systems on the sea surface

3.1.40**turret**

cylindrical single point mooring system geostationary with the seabed allowing rotation of the FPSO or FSO vessel in response to wave and wind conditions (weathervaning)

3.1.41**fluid transfer system****FTS**

method of transfer of fluids via a geostationary turret to the floating unit's process plant, its storage systems and subsea transport systems, including exchange of electric power and information

Note 1 to entry: This note applies to the French language only.

3.1.42**weathervaning**

rotation of the floating unit about a geostationary turret in response to wind, wave and sea current conditions

3.1.43**free weathervaning**

free-wheeling turret systems which allow rotation through 360° and are equipped with swivels in the fluid transfer system

3.1.44**partial weathervaning**

restricted rotation of the floating unit about the turret

EXAMPLE For turrets with drag chain fluid transfer systems, the unit's sector orientation is limited up to maximum of $\pm 270^\circ$ in either direction.

3.2 Abbreviated terms

CCVT	closed cycle vapour turbine
TEG	thermoelectric generator
PE	protective earth
IE	instrument earth
AVR	automatic voltage regulator
FCL	fault current limiter
IED	intelligent electronic device
CCR	central control room
HVDC VSC	high-voltage direct current voltage source converter
DOL	direct on line
FPSO	floating production storage and offloading unit
FSO	floating storage and offloading unit
HiL	hardware-in-the-loop test

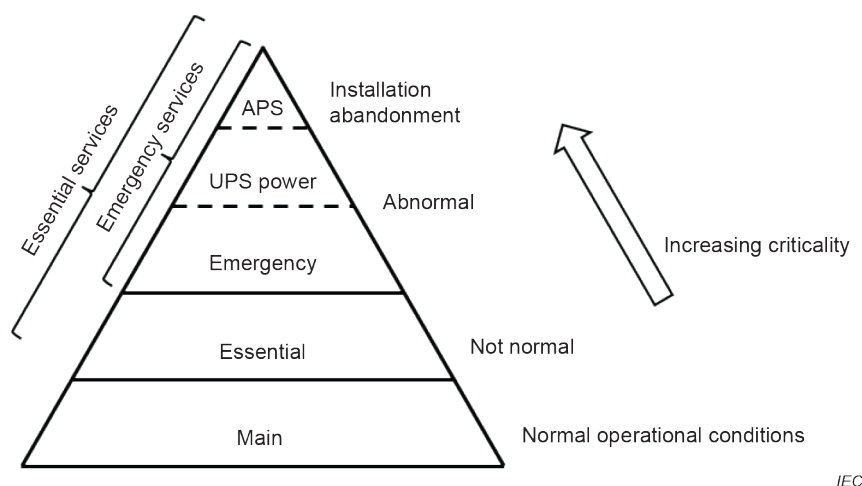
4 Sources of electrical power for manned units

4.1 General

The requirements of Clause 4 apply to manned units. For unmanned units, the requirements of Clause 5 apply.

Electrical installations shall be such that

- a) all electrical services necessary for maintaining the unit in normal operational and habitable condition shall be assured without recourse to the emergency source of electrical power,
- b) the electrical system for offshore units shall have a layered structure to provide increasingly resilient sources of electrical power for increasingly important services under progressively onerous conditions of operation, and
- c) as a minimum, all units shall have a main source of power and an emergency source of electrical power, unless the main source of electrical power is designed to also serve as the emergency source of power.



APS (abandon platform shutdown), or AVS (abandon vessel shutdown).

NOTE 1 APS is not an APS power source feeding consumers, but is mentioned to illustrate that some safety critical equipment can be kept live after initiating APS and isolating of the UPS battery systems by use of own battery. This includes for example maritime navigational aid systems and escape route light fixtures with internal batteries.

NOTE 2 The term "unit" is used instead of "platform" in this document; however the term "APS" is commonly used in the industry to designate the last level of shutdown of a unit.

Figure 2 – Power system hierarchy in an offshore unit

A typical example of a power system hierarchy in an offshore unit is given in Figure 2.

The failure of a lower priority source of electrical power shall not prevent higher priority sources of electrical power from performing their required function. UPS units shall be able to complete their duty for the full length of their design autonomy period without overheating due to loss of ventilation normally fed by lower criticality sources of electrical power.

Not all units will require all categories of sources of electrical power. The provision of essential power is more typical for large manned units.

Where specific loads require other tolerances for voltages in order to maintain functionality or performance, then specific calculations should be made to confirm values of voltage drop, particularly in cables.

For mobile units, reference shall be made to the IMO MODU Code.

4.2 Main sources of electrical power

4.2.1 Common requirements

Electrical main power shall be available by at least two independent power sources. An assignment of N+1 main power source arrangements shall be considered.

The minimum requirement related to redundant main power sources may be fulfilled for example by

- a) two main generators,
- b) one main generator and one essential generator,
- c) two independent external cable supplies from shore or other offshore units, and
- d) one external cable supply (normally main power supply) and one local generator (main or essential).

Where transformers, converters or similar appliances constitute a part of the main power system, the system shall be so arranged as to ensure the same continuity of supply as stated in 4.2.

The subdivision of the requested power generation capacity in more than two power sources can improve efficiency for power generation systems operating at part load and with variable loads, and guarantee high system flexibility during plant life. Such design arrangements, for example $3 \times 50\%$ or $4 \times 33\%$, may otherwise relieve developers of unwanted high concentrations of fault currents.

Decisions taken at an early stage, due to the long delivery time for equipment such as main gas turbine generator sets, will have a subsequent influence on the fault level for example. So as not to put electrical system design limits at risk with later implications of major nature, the electrical system requirements shall be analysed and specified at the time of selection of such equipment.

4.2.2 Capacity of main and essential power source

The capacity of the main and essential power sources should be such that, in the event of any one power source being unavailable, it shall still be possible, without recourse to the emergency source of electrical power, to supply those services necessary to provide

- a) normal operational conditions (however, it may not be required that full production shall be maintained with one power source being unavailable),
- b) comfortable conditions of habitability, and
- c) asset preservation for a defined standby period of time.

Auxiliary systems supporting main and essential power sources, such as air intakes, fuel system, cooling system, lubrication system, and control system for the generator sets, should be segregated as far as possible to reduce common mode failures.

The functioning of the emergency source of power shall be ensured in the event of a fire or other casualty in the space(s) containing the main and/or essential power system.

4.2.3 Load shedding arrangement

If the electrical power is normally supplied by more than one generator operating in parallel, provisions shall be made by means such as load shedding or by appropriate separation of the switchboard busbar to ensure that, in the event of loss of one of these generating sets, the remaining set(s) are kept in operation without overload to permit station-keeping, propulsion and steering, and to ensure the safety of the unit.

Where the load consists of essential services and non-essential services, consideration shall be given to a load shedding arrangement which will automatically exclude non-essential services when any one generator becomes overloaded and which will function to prevent the overload ability of the generating sets being exceeded.

For fixed units, load shedding priority levels shall be affected to loads in order to minimize the impact of load shedding on operation and production.

When a dynamic positioning system (DPS) is used for station-keeping of the unit, the line-up of the unit's electrical power generation system shall be in accordance with IMO MSC/Circ. 645 and the DP equipment class specified by the appropriate authority.

4.3 Essential source of electrical power

4.3.1 An essential source of power is an optional non-emergency power source. Safety does not depend on the performance of the essential power system as this function is provided by the emergency source(s) of power, should the essential source of power fail.

The provision of essential power is more likely on

- a) large manned units,
- b) on manned units on which the main source of power is a single imported power cable connection,
- c) on units where the main generating sets are unsuited to operation outside normal production conditions, and
- d) where the restart power requirements are too large to be supported by the emergency source of power.

4.3.2 4.3.2 describes requirements in relation to essential power, for example:

- a) the capacity of the essential generator shall as a minimum meet the requirements of 4.2.2 (see also Annex A);
- b) requirements regarding the location of essential power sources shall be identified;
- c) the essential source of electrical power shall not be the same as the emergency source of electrical power;
- d) when the main power supply system consists of several main power sources, a main source of electrical power may be used as an essential source of power if all the functional requirements in relation to an essential source of power are met.

The essential generator should start automatically upon failure of the supply from the main source of electrical power to the switchboard, to which the essential generator is connected.

4.4 Emergency source of electrical power

4.4.1 A self-contained emergency source of electrical power shall be provided as required by the appropriate authority. Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency source of electrical power may, in exceptional cases and for periods of short duration, be used to supply non-emergency circuits subject to the agreement of the appropriate authority.

The emergency source of electrical power shall be sufficient to supply all those services that are considered mandatory and safety oriented in a case of emergency for at least 18 h or for the time defined by the appropriate authority. Due regard shall be paid to such services as may have to be operated simultaneously.

4.4.2 The emergency power supply system shall comprise a combination of a transitional power source (e.g. UPS with energy storage elements), and a diesel engine driven generator. For fixed offshore units, a power cable from another independent unit may be considered as an alternative to a diesel driven engine, depending on the approval of the appropriate authority. For units where emergency consumption is limited, UPS with energy storage elements can be used as source for the entire emergency power requirement.

NOTE A diesel engine can have several ratings, for example standby (time at full load not to exceed 5 % of the duty cycle), intermittent (time at full load not to exceed 50 %) and continuous. Further information can be found in ISO 3046-1.

For examples of emergency power load, see Annex B.

In systems where a separate emergency generator is used, the emergency switchboard and the emergency generator should be located in separate rooms close to each other within the same fire zone. Emergency main distribution board for lighting and small power should be

located in the emergency switchboard room. There is no such restriction concerning emergency sub-distribution panels.

For units where the main source of electrical power is located in more than one space, the requirements of 4.4.1 may be considered satisfied without an additional emergency source of electrical power, subject to approval of the appropriate authority, provided the conditions in 4.4.2 a) through f) are fulfilled:

- a) there are at least two generator spaces; and
- b) for each generator space there is a wide separation of prime-mover air intakes, prime-mover auxiliaries, and of switchboard interconnection (bus-tie) cables; and
- c) a fire or other casualty in any one of the spaces will not affect the power distribution from the others, or to the services required by the appropriate authority; and
- d) if two generator spaces, there are at least two generators in each of the two spaces; or if three or more generator spaces, at least one generator in each space; and
- e) at least two of the generators in two different spaces comply with the requirement as to emergency generators given in 4.4.4 and 4.4.5 and these two generator spaces have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces; and
- f) the emergency switchboard shall be located in a room separate from the fire zone where the generators are located, with independent supplies from the two (or more) generators described in 4.4.2 e). The cable routing of the supplies shall be separated.

As an alternative to an emergency switchboard, the emergency consumers are to be redundant, each consumer with separate supplies from main switchboards in separate fire zones.

In case of using a dedicated emergency switchboard to feed emergency consumers to be used in an emergency, this emergency switchboard is to be fed by both main switchboards.

If consumers to be used in an emergency are redundant, each redundant system shall be fed by different main switchboards.

In both cases, the redundant systems including associated switchboards are to be located in different fire zones.

The requirement in e) will normally require a separate control system for these generators, and with only the minimum protection as allowed for in 4.4.5, when operated as an emergency generator.

The power available, duration of supply and services provided for safety in an emergency shall be as required by the appropriate authority.

4.4.3 The emergency source of electrical power, any associated fuel storage and transforming equipment, the emergency switchboard and related cables shall be separated from any machinery space containing the main source of electrical power, by classified partitions as defined in the IMO MODU Code.

The emergency generator, its ventilation and combustion air intakes, emergency switchgear, transformers and further peripherals shall be located above the worst damage waterline, in a place not susceptible to collision by another vessel, with easy access. The location of the openings shall not be susceptible to incoming water (sea water, spill water, etc.).

For diesel-generator assemblies with radiator fan driven by engine, special precautions shall be taken in the emergency generator room ventilation air intake arrangement, to avoid ingress of rain water in the room through intake louvers due to the suction promoted by radiator fan.

The intake air louvers shall be adequately sheltered and protected against water.

The emergency power system shall be arranged so as to permit total electrical separation from the main power system. During normal service, interconnection from the main switchboard shall supply power to the emergency switchboard provided that automatic interruption of the interconnection at the emergency switchboard is ensured in the event of failure of the main source of electrical power.

The electrical, process and utility systems should remain operative with a disconnection of power supply to emergency switchboard for a short period. This design measure will enable a test of the automatic starting arrangement for the emergency generator without affecting the unit's production process or its utility functions. An alternative method to obtain the same result as provision for temporary parallel operation between the main and the emergency source of power or dedicated load banks should be considered.

For floating fixed units, the emergency power shall be able to function at damaged conditions as given in the stability study for the unit. If no such information is available, the values given in IEC 61892-5 may be used as guidance.

Requirements concerning the functioning of the emergency generator on mobile units are given in IEC 61892-5.

4.4.4 Where the emergency source of electrical power is a generator, it shall be

- a) driven by a suitable prime mover with an independent supply of fuel and cooling medium,
- b) started automatically upon failure of the supply from the main source of electrical power to the emergency system, and it shall be automatically connected to the emergency system, and
- c) provided with a transitional source of emergency electrical power according to 4.7.

NOTE For the starting arrangements of emergency generators, see 4.5.

4.4.5 Prime movers for emergency generators shall have as few automatic safety functions as possible in order to ensure continuous operation. Normal prime mover and generator protection shall be provided if running unattended for test of the emergency generator or if it is used as a harbour generator.

4.4.6 Where the emergency source of electrical power is an accumulator battery, the following applies:

- a) the emergency source of electrical power shall carry the emergency electrical load without recharging whilst maintaining the voltage of the battery throughout the discharge period within $\pm 15\%$ of its nominal voltage; where the emergency and/or transitional emergency loads are supplied from a battery via an electronic converter or inverter, the maximum permitted DC voltage variations are to be taken as those not exceeding acceptable variations on the load side of the converter or inverter;
- b) DC distribution system voltage tolerances below -15% may be considered for deep discharge tolerant batteries provided that the connected DC loads are rated to perform their intended function without impairment at these stated wider voltage tolerances;
- c) the requirements of IEC 61892-1:2019, Table 3, do not apply to equipment items with integral battery; wider DC voltage tolerances are permissible if the equipment is rated to fulfil their intended function without impairment during the required autonomy period;
- d) the emergency source of electrical power shall connect automatically to the emergency switchboard in the event of failure of the main source of electrical power supply; and
- e) the emergency source of electrical power shall immediately supply at least those services required for the transitional source of electrical power.

4.4.7 The transitional source of emergency electrical power shall consist of an accumulator battery suitably located for use in an emergency. It shall operate without recharging whilst maintaining the voltage of the battery throughout the discharge period within $\pm 15\%$ of its

nominal voltage and be arranged so as to automatically supply the services required by the appropriate authority in the event of failure of any of the main, essential or emergency source of electrical power. The battery discharging capacity shall be sufficient for a period of at least 30 min or for the period defined by the appropriate authority.

4.4.8 Discharging of an emergency battery shall give indication/alarm at a manned station.

4.4.9 Trip of supply to emergency lighting shall give an alarm at a manned station.

4.4.10 Provisions shall be made for the testing at regular intervals of the complete emergency power system and shall include the testing of the automatic starting arrangements and any transitional systems. Testing at regular intervals shall also cover load operations and battery discharge operations.

Fast transfer of load from emergency power to main power or the opposite with a transfer time of less than three seconds does not require design for short-circuit of the combined system. However, this is not applicable if testing of the emergency generator is done by parallel operation of the emergency generator and main power system.

4.4.11 All testing, manual operation, starting, transfers of power and stopping of the emergency generator shall be possible to be performed by one operator at one location (emergency generator control panel).

4.5 Starting arrangements for emergency generators

4.5.1 Each emergency generator shall be automatically started and be capable of supplying the required services within 45 s. The starting arrangements shall be acceptable to the appropriate authority and with a storage energy capability of at least three consecutive starts. A second source of energy shall be provided for an additional three starts within 30 min.

4.5.2 Where both the main and secondary source of energy arrangements is electrical, the systems shall be independent and include two chargers, and two batteries. When the source of energy is pneumatic, the systems shall include two air receivers.

Consideration should be given to the provision of two starter motors.

NOTE If the emergency generator supplies fire water pumps, the requirements of NFPA 20 apply.

4.5.3 All starting, charging and energy-storing devices shall be located in the emergency generator room. These devices shall not be used for any purpose other than the operation of the emergency generator set. This does not preclude the supply to the air receivers of the emergency generator set from the main or auxiliary compressed air system through non-return valves fitted in the emergency generator room.

4.5.4 For a unit which is normally manned, the readiness of the emergency generator to start shall be indicated in a manned location, for example, the control room.

The integrity of the automatic starting and control systems of the emergency generator shall be ensured in the event of fire in the manned control location or control room. An emergency stop for the emergency generator shall be located inside the emergency generator room. In addition, it shall be possible to manually close the fuel oil shut-off valve from outside the room.

4.6 Additional requirements for periodically unattended machinery spaces

4.6.1 Units intended for operation with periodically unattended machinery spaces shall comply with 4.6.2 to 4.6.5 inclusive.

NOTE The term "unattended" is used both in the IMO SOLAS Convention, Consolidated Edition 2014, and in the IMO 2009 MODU Code, 2010 edition. However, neither of those publications contains any definition of the term.

4.6.2 In the event of failure of the generating set(s) in service, provision shall be made for the automatic starting and connection to the main switchboard of a standby generating set of sufficient capacity to supply those services necessary to ensure that the safety of the unit with regard to station-keeping, propulsion and steering, is at least equivalent to that of a unit having the machinery space manned.

4.6.3 The arrangement shall permit automatic re-starting of all essential services, which may be sequentially started if necessary.

4.6.4 The automatic starting system and characteristics of the standby generating set shall be such as to permit the standby generator to carry its full load as quickly as is safe and practicable.

4.6.5 Arrangements shall be provided to prevent more than one (1) automatic closing of a given generator circuit-breaker under short-circuit conditions at the generator switchgear.

4.7 Uninterruptible power system (UPS) source of power

4.7.1 General

Several UPS technologies have been developed to meet the requirements for continuity and quality of power in relation to different types of loads ranging from a few watts to several megawatts.

The requirements of 4.7 are for UPS, which is part of the emergency source of electrical power (see 4.4.2 and 4.4.4). The requirement of UPS, being part of an emergency system, fulfils the requirements for the transitional source of power described in 4.4.2 and 4.4.4. The detailed requirements for UPS for other purposes have to be set by the project. An example is a UPS for consumers which can malfunction upon voltage transients, including temporary situations with reduced supply voltage quality.

UPS for other purposes shall have the same requirements in terms of ventilation, battery installation, and distribution.

There can be other requirements for backup time, location, shutdown, type of consumers, supply to charger unit, for example, from main or essential power.

This document refers to IEC 62040-1, IEC 62040-2 and IEC 62040-3 as the UPS equipment standard.

UPS battery normative guidelines and equipment standards are referred to in IEC 61892-3.

NOTE New battery technologies developed for automotive and shipping industries can be referred to as being fit for service in UPS applications on offshore units. The high energy density and fast charge-discharge cycles in new battery technologies can add flexibility in the design planning of emergency, main and essential sources of power, with energy storage elements distributed in various unit locations. In particular, the energy storage elements can be assigned integral to distributed load controllers, subject to approval by the applicable authority.

UPS semiconductor converters are described in IEC 62040-3, while rotary UPS equipment is only referenced.

4.7.2 UPS functionality – Uninterruptible source of power for critical/sensitive loads

The following applies to UPS for critical/sensitive loads:

- a) the UPS source of power may be provided by AC or DC UPS;
- b) the UPS shall be designed with energy storage elements;
- c) minimum autonomy time shall be 30 min unless otherwise required by the applicable authorities; the autonomy time as power source to critical/sensitive loads shall be as required in design or by the applicable authority, or if any alternative autonomy time is defined, it shall be specified and/or approved by the owner of the unit;
- d) a need for periodic maintenance, replacement and repair due to maximum design lifetime of integral UPS components shall be identified and verified by statement of the UPS manufacturer.

The UPS shall be designed so as to automatically supply sufficient power in the event of failure or shutdown of all other sources of electrical power, to operate for a period as defined by the safety assessment for the unit.

The following equipment is to be in operation after an emergency shutdown:

- 1) the emergency lighting located at the control stations, along every evacuation route, at muster stations, temporary refuge, embarkation area or means of escape to the sea;
- 2) public address systems and the abandonment alarm system;
- 3) helicopter landing areas and related approach alarm systems;
- 4) external emergency communication systems;
- 5) blow-out preventer, power unit and control systems;
- 6) general alarm systems.

These abandonment loads shall not be automatically disconnected except for end of discharge protection of batteries.

4.7.3 UPS – Design planning issues

Configuration – UPS configuration alternatives are referred to in IEC 62040-3:2011, Annex A. It is recognized that IT systems are normatively defined for UPS load service in offshore units.

In normal mode of operation, with fully charged batteries or with UPS by-pass in operation, the UPS shall maintain full selectivity and protection effectiveness within the distribution. In UPS-mode of operations, this should be the aim for as long as possible.

Supply arrangement – In emergency systems which include an emergency generator, the UPS shall be charged from this emergency switchboard. In case of dual redundant UPS, then at least one of the two shall be charged from the emergency switchboard.

For the recharge of energy storage elements, typically batteries, the power source shall have the capacity to both simultaneously recharge the batteries within a specified time and supply power to distributed UPS loads. Recharge of energy storage elements is normally carried out by the main power sources and, only in the event of unavailability of these, by emergency source. Arrangements for charging of batteries from alternative power sources, such as essential power where present, should be considered.

For UPS units providing a power supply to safety and emergency functions, an external bypass that is hardwired and manually operated is to be provided to the UPS, to allow for isolation of the UPS for safety during maintenance and to maintain continuity of load power. Such UPS are to be charged from the emergency system.

Dependability – UPS in configurations that serve to increase reliability, for example by paralleling more UPS units, or by multiple redundant integral UPS components or more paralleled UPS energy storage elements, shall have all necessary provisions to secure continued UPS load services after occurrence of a fault in one redundant item.

Location – UPS equipment shall be installed in rooms fit for emergency and critical load services, with controlled ambient temperatures and clean operating conditions.

Batteries may be installed in battery rooms or together with UPS converters and UPS main distribution boards. Battery technology that emits explosive gases shall be installed in battery rooms, according to hazardous area classification.

NOTE Requirements concerning the location of batteries are given in Clause 9 and Table 1 of IEC 61892-6:2019.

These items shall be defined in advance:

- a) battery protection and isolation devices;
- b) shutdown control of battery;
- c) recovery from blackout and dead start conditions;
- d) exposure to shock, tilting or vibrations;
- e) load fault clearing capability in UPS energy storage mode (on battery).

Load distribution – UPS installations can be arranged in a centralized or decentralized manner. UPS main distribution boards and sub-distribution boards will normally be used for centralized large rated UPS. In both events, a safe fault clearing capacity at load side shall be verified for all relevant operating modes of the UPS, including both the UPS minimum (operation in battery-inverter mode) and maximum design capacity (in bypass operation or with a maximum number of battery-inverter mode units in service) to deliver short-circuit current. The selectivity in a load distribution will be influenced by the short-circuit current provided by the UPS and the combination of trip characteristics established in the UPS main and sub-distribution boards. Special attention is required with respect to inrush current and saturation distortions in consumer elements.

Monitoring – Comprehensive UPS status monitoring is mandatory as it forms part of a number of vital and critical load services in emergency and abandonment conditions. Upon failure of the power supply to safety and emergency functions, an alarm to an operator attended location shall be initiated unless loss of function will otherwise be unambiguously alarmed. In case of duplicated or independent power supplies, both supplies shall be monitored. UPS unit abnormal/fault conditions which could lead to loss of UPS supply shall be alarmed, as a common alarm or individually, to an operator attended location.

UPS alarms should have a one-minute delay at loss of input power, in order to avoid alarm flooding before start-up of any standby or emergency generator feeding the input circuit.

The fire and/or blast survivability requirements for compartments containing UPS units supporting safety and emergency functions shall not be less than the survivability requirements for the equipment that they serve, or shall otherwise be separated from fire/blast hazard by fire/blast walls or by safe distance.

Maintenance provisions – UPS maintenance procedures shall be defined for the individual UPS unit. The procedures shall include reference to fulfilment of service requirements set by the applicable authority, and logs of any maintenance work undertaken by operators or by external servicemen representing the UPS supplier or manufacturer.

DC load side UPS equipment may form an alternative to AC load side UPS equipment. The ability to serve DC UPS voltage within acceptable design tolerances may prove favourable in terms of simplicity in design and constitute an alternative for defined load services that accept DC.

UPS availability calculations – When the reliability integrity level of the UPS is requested, it shall be guided by IEC 62040-3:2011, Annex K.

4.8 Transmission systems including main power from shore

4.8.1 Subclause 4.8 gives additional requirements regarding electrically interconnected units, including units with power from shore.

4.8.2 For offshore units which only import/receive power via electrical interconnector(s) and do not re-export such import power, simplified design and control measures in system operation will apply. Examples could be production facilities connected to a field centre or to other offshore and shore side located processing facilities, floating storage units, self-elevated drilling rigs, unmanned offshore units like remotely controlled wellhead units and satellite units.

In the event of re-export of import power to another unit, additional measures concerning design and system operation will apply. Long distances may introduce a need to add compensation equipment and control equipment for the other unit interconnector(s). The design and control measures shall also cover any sequential influences on the importing interconnector.

For large offshore units where bidirectional power exchange between generating sets on more facilities shall be possible, a comprehensive analysis of design and control measures shall take place to define the system requirements, operational limitations that may influence the design of the cable interconnector, and the primary equipment connected for all relevant modes of operation, when interconnected and when in autonomous operation, without interconnector.

Any hunting effect between governors and various source controllers in any connected primary equipment shall be avoided when designing such systems.

For electrically interconnected facilities, it shall be necessary to arrange for an overall power control central in one unit at a minimum, with a breaker manoeuvring hierarchy that clarifies operational priorities via the electric interconnector(s) to all interconnected facilities. Fiscal metering of energy transport and various operational costs running the interconnector(s) shall be monitored and logged by the various facilities when considered necessary. The interconnectors may be equipped with distance protection to identify and clear cable faults fast.

NOTE 1 For converter installations offshore where the requirements of this document may not be sufficient, guidance can be found in IEC 61936-1 and IEC TS 61936-2.

NOTE 2 For system aspects of electrical energy supply, guidance can be found in standards issued by IEC TC 8. For HV DC transmission systems, guidance can be found in standards issued by IEC TC 115.

4.8.3 It is recognized that, in power systems run by land based utilities, solid earthed neutral is regularly used in high-voltage transmission networks, where insulation costs are high. In this solution, a low-impedance path is provided for the earth-fault current to close and, as result, its magnitude is comparable with three-phase fault currents. Since the neutral remains at the potential close to the earth, voltages in unaffected phases remain at levels similar to the pre-fault ones.

For long distance sea cables, the ability to transfer active power is reduced due to the capacitive coupling to earth. Countermeasures shall have to be defined to compensate for reactive currents in the event that the total loading of the cable exceeds its limits of permissible operation. Influence of reduced cooling in shallow waters, in open air, in risers and J-tubes, and sun exposed deck areas may effectively de-rate a sea cable's calculated thermal capacity.

The selected transmission voltage will depend on project-specific conditions and may need to be simulated and verified by design calculations or by use of relevant design experience data.

Transmission interface connection points shall be defined close to the sea cable entry points on an offshore unit. Safe provisions for installation and connection to the unit's distribution system shall be identified and aligned with any applicable hazardous zone requirements on the offshore unit.

Protection schemes shall be defined for the transmission system, for autonomous operation of individual units with no electric interconnection engaged, and for autonomous units with electric interconnector engaged.

The location of any compensation equipment in a transmission system shall be optimized for relevant modes of operation. It will ordinarily be installed either at one or at both ends of a sea cable, but means that can effectively support cable compensation can also be installed in the generation or distribution systems that are interconnected.

High-voltage equipment that forms part of a sea cable transmission system shall include safe means for isolation and earthing of the sea cable and any subsequent compensation equipment, before any potentially live parts in the transmission system are accessed by operators.

For compensated transmission systems, a neutral earthing resistor (NER) on sea cable side will not normally be used. For short distance transmission systems with galvanic split and without compensation, an NER may be installed to monitor and protect against transmission system earth fault.

Low frequency AC transmission (LFAC) may be evaluated to increase the active power transfer capacity of metal conductors in sea cables, or alternatively to increase the step-out distance of such interconnectors. Choice of transmission system earthing concept will not obstruct the use of reduced frequency.

Type tested equipment established in electrical railways (16 2/3 Hz, 25 Hz) may be considered for LFAC design components.

For DC transmission systems, the earthing of cable poles and strategies for operation of semiconductor controlled converters will be subject to proposals by relevant manufacturers according to the requirements of the appropriate authorities. Examples of applicable technology are given in Annex C.

4.9 Alternative sources of power

Alternative sources of power may be used as either main or essential power source, provided the requirements of 4.2.2 are met and subject to the approval of the appropriate authority. Provided the requirements of 4.4 are met, the alternative source may also be used as an emergency power source, subject to the approval of the appropriate authority.

A renewable source of power can be an alternative source of power. A renewable source of power may not fulfil the availability requirements for main or essential source of power. Combined with energy storage of suitable design and capacity, this can be achieved.

Special attention should be given to the capacity of the energy storage facility on units where thrusters are used for position keeping.

5 Sources of electrical power for unmanned units

5.1 General

Clause 5 contains specific requirements for power supply and generation at unmanned offshore units.

Unmanned offshore units at fixed location are in general characterized by the following features:

- a) remote controlled without need of human presence for its operability;
- b) absence of fire-fighting pumps;
- c) maintenance works only require presence of operator with the limitation listed in the following two points:
 - 1) absence of living quarter and other permanent facilities to allow a manned control, both continuous and in periodic shift;
 - 2) possible presence of survival shelter to safely support maintenance operations carried out within a day.

5.2 Power sources

5.2.1 Sources to be evaluated

Electrical main power shall be available by at least one power source. Several power supply sources are to be evaluated:

- a) cable from other unit (a host unit) or from shore;
- b) local generator (gas or diesel);
- c) alternative sources.

NOTE Information regarding alternative sources of electric power is given in Annex F.

5.2.2 Cable from other unit or from shore

The cable can be part of the umbilical from another unit/shore. Design should then take into account possibility for corrosion in any isolated pipes in the umbilical due to the capacitive current caused by the voltage in the cable. The requirements in 4.8 can be used as a guideline.

This method of power supply (subsea cable) is preferable if power cannot be met by use of small alternative sources.

NOTE If there is no power cable from another unit, remote dead start from host unit cannot be performed.

5.2.3 Local generator (gas or diesel)

Main/emergency power with use of local generator only (no subsea cable) should be avoided if power from another location is within the range by use of subsea cable. This is because a diesel/gas engine requires maintenance, has less availability, and measures have to be taken to ensure control of the potential ignition source.

A local generator is an alternative to subsea cable in case of long distances or no available power in host unit (power export unit). A local generator may then replace the subsea cables mentioned in the different alternatives in Annex E.

5.2.4 Alternative sources of power

These may be used for power supply to units with very limited power demand.

The following renewable sources are relevant:

- a) photovoltaic cells;
- b) wind turbines;
- c) micro-turbines;
- d) CCVT;
- e) TEG.

Methods to fulfil requirements related to shutdown of these power sources should be considered.

5.2.5 UPS

A UPS shall be installed to guarantee power for a limited time to safety-critical consumers (like F&G, ESD) in case of loss of the main power source, according to the operation and safety requirements. The UPS location may be on another offshore unit.

Redundancy requirements shall be identified by the project.

In order to provide an optimized UPS network architecture, the UPS type and output voltage selection shall take into account the characteristics of the main power source and the power supply requirements of the various consumers. If escape route lighting is required, these fixtures should also be supplied from the UPS, to minimize maintenance.

The navigation aid system should have a separate UPS.

Battery back-up time shall be specified and/or approved by the owner of the unit. Special consideration shall be taken in relation to all modes with personnel on board, to ensure enough back-up time for safe process shutdown and evacuation of the personnel.

5.3 Factors affecting power supply requirements

Further information regarding factors affecting the power supply requirements and guidelines for defining power sources requirements is given in Annex E.

6 System earthing

6.1 General requirements

6.1.1 Clause 6 gives requirements and recommendations for system earthing, i.e. an intentional connection of the neutral point of the electrical power supply system to the hull or structure.

One of the following methods of treating the neutral shall be used:

- a) solidly earthed (TN system);
- b) impedance earthed (IT system);
- c) isolated (IT system).

The method selected shall be based on technical and operational factors.

NOTE 1 The principal features of these methods are presented in Table 1.

NOTE 2 For power distribution systems, the so-called "un-earthed" or "isolated" system design is capacitor earthed by distributed capacitances throughout the system, together with any interference suppression capacitors.