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Small craft — Electric propulsion system

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Contents

Page

Foreword v
Introduction vi
1 Scope 1
2 Normative references 1
3 Terms and definitions 2
4 General requirements 5
4.1 General 5
4.2 Components of an electric propulsion system 6
4.3 Electric propulsion systems 6
4.4 Arrangements for other electrical equipment and circuits on-board a small craft connected to a common energy source for both propulsion and general electrical installation 8
4.4.1 DC systems 8
4.4.2 AC systems 8
4.5 Environmental factors 9
4.6 Electrical ratings 9
4.7 Equipment 10
4.7.1 Transformers 10
4.7.2 Converters 10
4.7.3 Motors 10
4.8 Enclosures 10
4.9 Identification of equipment and conductors 10
4.10 Segregation of DC and AC systems 11
4.11 Steering and throttle controls 11
4.12 Electromagnetic compatibility (EMC) 11
4.13 Electrical equipment in the vicinity of battery banks 11
4.14 Hazardous areas 11
5 Controls, monitoring, system alerts and trips alarms 12
5.1 Electrical/electronic controls for electric propulsion systems 12
5.1.1 Controls 12
5.1.2 Emergency stop 13
5.1.3 Fault trip reset 13
5.1.4 “Get you home” mode 13
5.2 Instruments, alerts and trip alarms 13
5.2.1 General 13
5.2.2 Operating mode and status 13
5.2.3 System alerts 14
5.2.4 Fault trip alarms 14
6 Protection against electric shock 14
6.1 Protection against direct contact 14
6.2 Automatic disconnection of supply to the electric propulsion system under fault-to-earth conditions (earthed two wire DC systems and earthed neutral AC systems) 14
6.3 Fault-to-earth monitoring and tripping arrangements for DC fully insulated systems, DC 3-wire systems 15
6.4 Fault-to-earth tripping in AC non-neutral earthed systems (IT-type system) 16
7 Protection against over-current 16
7.1 General 16
7.2 Characteristics of protective devices 16
7.3 Overcurrent devices in the outgoing circuit(s) from a battery 17
8 Battery monitoring and installation 17
8.1 General arrangements 17

8.2 Isolation of battery packs or battery banks ... 17
8.3 Operational switching of battery pack(s) or battery bank(s) ... 18
8.4 Permanently energized circuits ... 18
8.5 Ventilation ... 19
8.6 Electrical apparatus for explosive gas atmospheres ... 19

9 Electrical installation ... 19
9.1 General ... 19
9.2 Segregation of electrical propulsion system cables ... 19

10 Testing ... 20
10.1 General ... 20
10.2 Earthing and bonding ... 20
10.3 Insulation resistance ... 20
10.3.1 General ... 20
10.3.2 DC electrical propulsion systems ... 20
10.3.3 AC electrical propulsion systems ... 20
10.3.4 Switchboards, panel boards and distribution boards ... 20
10.3.5 Power and lighting final circuits ... 21
10.3.6 Generators and motors ... 21
10.3.7 Transformers ... 21
10.4 Electrical/electronic controls systems for propulsion motor control ... 21
10.5 On load test and inspection of electrical propulsion systems, and associated switch gear and control gear ... 21
10.6 Voltage drop ... 21

Annex A (normative) **Information and instructions to be included in the owner's manual ... 22**

Annex B (normative) **Installation documentation ... 23**

Bibliography ... 24

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 188, *Small craft*, together with CEN/BT/WG 69, *Small craft* and IEC/TC 18, *Electrical installations of ships and of mobile and fixed offshore units*.

Introduction

Electrical propulsion systems are becoming more common in recreational craft and other small craft and propulsion system voltages of up to AC 1 000 V and DC 1 500 V are possible together with variable speed drives operating at frequencies which differ from 50/60 Hz or DC.

Electric propulsion systems for small craft are generally designed and constructed from a number of component parts many of which can be of proprietary origin and all of the electrical and control items are interconnected by cables and operated as a system.

There are a significant number of electrical propulsion system architectures for small craft and the main types are the following.

— DC sourced. The main power source is a propulsion battery which is either recharged from on-board DC generators, or on-board AC generators/an AC shore supply through battery chargers. The electric propulsion system(s) may be variable speed through a DC motor controller or AC through a Variable Frequency Drive (VFD) or be fixed speed with a variable pitch propeller or other mechanical means of providing thrust. The electric propulsion system may be electrically separate from other electrical systems on board (e.g. be fully insulated via the motor controller, or be an AC IT system via a VFD or motor starter). Or the electrical propulsion system may be integrated with the whole craft DC electrical system using converters DC/DC, DC/AC to provide for different services/consumers.

— AC sourced. The main power source is AC generator(s) generally configured as TT, TN-C or TN-S. The electric propulsion system(s) may be DC variable speed through a AC/DC converter and DC motor controller, or AC through a VFD, or be fixed speed with a variable pitch propeller or other mechanical means of providing thrust. The electric propulsion system may be DC fully insulated system or be an AC IT system via a galvanically isolated VFD or via an isolating transformer. A DC propulsion system(s) may be supported by propulsion battery.

— Also possible are hybrid systems similar to the types being introduced for road vehicles where the source is an internal combustion engine providing, for example, energy to a relatively lightweight energy storage system with power take-off via converters to propulsion motor(s) and other electrical consumers.

It is essential that the electric propulsion system designer/installer be competent with all aspects of the equipment included in the design of a particular system such that the component parts of the propulsion system are integrated in a coherent and safe manner.

Current electrical standards for small craft of less than 24 m LH are the following:

a) ISO 10133 which is limited to recommendation for the design, construction and installation of direct current systems that operate at a voltage of DC 50 V or less; and

b) ISO 13297 which is limited to single phase alternating current electrical systems less than AC 250 V.

Neither of these standards includes requirements for electrical propulsion systems.

c) IEC 60092-507 is applicable to small craft up to 50 m/500 GT and includes requirements for three-phase systems not exceeding AC 500 V and single-phase systems not exceeding AC 250 V and for DC systems and sub-systems not exceeding DC 50 V nominal, and includes a section on electric propulsion systems.

Small craft — Electric propulsion system

1 Scope

This International Standard addresses the design and installation of alternating current (AC) and direct current (DC) electrical systems used for the purpose of electrical propulsion and/or electrical hybrid (system with both a rechargeable battery and a fuelled power source) propulsion.

This International Standard applies to electrical propulsion systems operated in the following ranges either individually or in combination:

— direct current of less than 1 500 V DC;

— single-phase alternating current up to AC 1 000 V;

— three-phase alternating current up to AC 1 000 V.

This International Standard applies to electrical propulsion systems installed in small craft up to 24 m length of the hull (L_H according to ISO 8666).

This International Standard also lists in Annex A additional information to be included in the owner's manual as well as Annex B additional information to be provided to the installer.

2 Normative references

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

ISO 8846, *Small craft — Electrical devices — Protection against ignition of surrounding flammable gases*

ISO 9094, *Small craft — Fire protection*

ISO 10133:2012, *Small craft — Electrical systems — Extra-low-voltage d.c. installations*

ISO 10239, *Small craft — Liquefied petroleum gas (LPG) systems*

ISO 10240, *Small craft — Owner's manual*

ISO 11105, *Small craft — Ventilation of petrol engine and/or petrol tank compartments*

ISO 13297:2014, *Small craft — Electrical systems — Alternating current installations*

ISO 25197:2012, *Small craft — Electrical/electronic control systems for steering, shift and throttle*

IEC 60079-series, *Electrical apparatus for explosive gas atmospheres*

IEC 60092-202:1994/Amd 1:1996, *Electrical installation in ships — Part 202: System design — Protection*

IEC 60092-303, *Electrical installation in ships — Part 303: Equipment — Transformers for power and lighting*

IEC 60092-352, *Electrical installation in ships — Part 352: Choice and installation of electrical cables*

IEC 60092-507:2014, *Electrical installations in ships — Part 507: Small vessels*

IEC 60898-1, *Electrical accessories — Circuit-breakers for overcurrent protection for household and similar installations — Part 1: Circuit-breakers for a.c. operation*

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

IEC 60947-2, *Low voltage switchgear and control gear — Part 2: Circuit breakers*

IEC 61558-2-4, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1100 V — Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V — Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
safety voltage
<AC> voltage which does not exceed AC 50 V r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer, or converter with separate winding

<DC> voltage which does not exceed 50 DC V between conductors, or between any conductor and earth, in a circuit which is isolated from higher voltage circuits

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

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

[SOURCE: IEC 60092-101:1994, 1.3.19]

3.2
rated voltage
U_0
<TN systems> nominal AC r.m.s. line voltage to earth

<IT systems> nominal AC r.m.s. voltage between line conductor and neutral conductor

<DC systems> nominal DC voltage between poles

[SOURCE: IEC 60092-507:2014, 3.1.4]

3.3
live part
conductor or conductive part intended to be energized in normal operation including a neutral conductor, but by convention not a PEN conductor (a conductor combining the functions of both a protective conductor and a neutral conductor)

Note 1 to entry: This term does not necessarily imply risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19, modified as follows: The text “or a PEM conductor or PEL conductor” has been deleted. The text in brackets has been added]

3.4
earthed
grounded, en US
connected to the general mass of the hull of the craft in such a manner as will ensure at all times an immediate discharge of electrical energy without danger

[SOURCE: IEC 60092-101:1994, 1.3.9, modified as Note 1 to entry has been deleted]

3.5
readily accessible
capable of being reached quickly and safely for effective use without the use of tools

[SOURCE: ISO 13297:2014, 3.17]

3.6
final circuit
portion of a wiring system extending beyond the final overcurrent protection device for that circuit

[SOURCE: IEC 60092-101:1994, 1.3.17, modified – The words "overcurrent protective device of a board" have been replaced with "overcurrent protection device for that circuit"]

3.7
overcurrent protection device
device provided to interrupt an electric circuit in case the conductor current in the electric circuit exceeds a predetermined value for a specified duration

3.8
fuse
device that by the fusing of one or more of its specifically designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time

Note 1 to entry: The fuse comprises all the parts that form the complete device.

[SOURCE: IEC 60050-441:1984, 441-18-01, modified]

3.9
circuit-breaker
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of a short circuit

[SOURCE: IEC 60050-441:1984, 441-14-20]

3.10
residual current device
RCD
mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

[SOURCE: IEC 60050-442:1994, 442-05-02, modified as Note has been omitted]

3.11
protective conductor
PE (identification)
conductor provided for purposes of safety, for example, protection against electric shock

Note 1 to entry: In an electrical installation, the conductor identified PE is normally also considered as protective earthing conductor.

[SOURCE: IEC 60050-195:1998, 195-02-09]

3.12
bond
connection of non-current-carrying parts to ensure continuity of electrical connection, or to equalize the potential between parts comprising, for example, the armour or lead sheath of adjacent length of cable, the bulkhead, etc.

[SOURCE: IEC 60092-101:1994, 1.3.7, modified – Last part concerning "cables in a radio-receiving room" has been deleted.]

3.13
conductor
conductive part intended to carry a specified electric current

[SOURCE: IEC 60050-195:1998, 195-01-07]

3.14
neutral conductor
conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[SOURCE: IEC 60050-195:1998, 195-02-06]

3.15
line conductor
phase conductor (in AC systems) (deprecated) pole conductor (in DC systems) (deprecated)

conductor which is energized in normal operation and capable of contributing to the transmission or distribution of electric energy but which is not a neutral conductor

[SOURCE: IEC 60050-195:1998, 195-02-08]

3.16
transformer
energy converter with isolating separation between the input and output windings and the protective conductor

3.17
switch
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit

Note 1 to entry: A switch may be capable of making but not breaking short-circuit currents.

3.18
panel board
assembly of devices, such as circuit breakers, fuses, switches, instruments and indicators, for the purpose of controlling and/or distributing electrical power

Note 1 to entry: Examples of devices include circuit breakers, fuses, switches, instruments and indicators.

3.19
disconnector
mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements

[SOURCE: IEC 60050-441:1994, 441-14-05]

3.20
battery pack
mechanical assembly comprising battery cells and retaining frames or trays and possibly components for battery management

Note 1 to entry: Note1 to entry: Typical battery packs will be a single assembly, voltage and connection in an enclosure.

Note 2 to entry: Several connected battery packs form a battery bank.

[SOURCE: ISO 12405-2:2012, 3.2, modified by additional Note 1 and 2 to entry]

4 General requirements

4.1 General

Electric propulsion systems for small craft are generally designed and constructed from a number of component parts many of which can be of proprietary origin and all of the electrical and control items are interconnected by cables and operated as a system.

It is essential that the propulsion system designer/installer shall be competent with all aspects of the equipment included in the design of a particular system such that the component parts of the propulsion system are integrated in a coherent and safe manner.

The rated power output of each electric propulsion system at the motor shaft shall be designed to match the propeller characteristics and the required rotational speed range or thrust range of variable pitch propellers/thrusters.

The electric propulsion system may be electrically separate from other electrical systems on board a small craft.

Different types of AC electrical system include four-wire with neutral earthed, but without hull return (TN-C), five-wire with neutral earthed, but without hull return (TN-S), and IT systems with their particular requirements for earth leakage current monitoring, alarm and tripping systems.

DC systems may be either earthed, or be fully insulated with particular requirements for insulation resistance monitoring, alarm and tripping systems. For DC propulsion systems operating at voltages greater than safety voltage, a three-wire system (e.g. DC +48 V/0/−48V) may be considered with the mid-point conductor earthed to limit prospective touch voltage.

For DC electric propulsion systems and other electrical systems with rated nominal voltages in excess of safety voltage, the precautions against the risk of electric shock shall be observed.

DC electric propulsion systems may have large capacity battery bank(s) or pack(s) as the main power source, and particular attention is required for the following:

a) ventilation requirements necessary for battery bank or battery pack compartments;

b) requirements for an overcurrent device and an isolation switch for each propulsion battery bank or battery pack;

c) circuit protection requirements for permanently energised circuits supplied from a battery bank or battery pack.

Electric propulsion circuits shall be designed to protect against the following:

— fire by the use of overcurrent protection, grounding/earthing, terminal protection and conductor type and size;

— shock by the use of enclosures, conductor and terminal insulation, automatic disconnection and grounding/earthing system protection as appropriate.

Electric propulsion circuits shall not interact with other circuits in such a way that circuits would fail to operate as intended.

4.2 Components of an electric propulsion system

The electric propulsion system may include several sub-systems and components including, but not limited to, the following:

— batteries;

— battery management systems;

— AC or DC generators;

— AC/DC, DC/DC, DC/AC, AC/AC converters, Variable Frequency Drives;

— electric propulsion motors;

— propulsion panel board;

— propulsion motor controls, monitoring, system alerts and trip alarms;

— transformers;

— conductors and cables;

— isolation switches (disconnectors), circuit breakers, contactors, fuses.

Each of these propulsion system components shall conform to the relevant ISO/IEC standard.

4.3 Electric propulsion systems

4.3.1 An electrical propulsion system may be

a) DC, sourced from battery(s) or DC generator(s) or AC/DC converters from an AC source, or

b) AC, sourced from alternator(s) or a DC/AC converter from a DC source [e.g. battery(s)].

The energy source(s) of an electric propulsion system may be reserved for this purpose and be electrically separate from other electrical systems on board a craft, or all electrical systems on board a craft may be directly connected to a common source but propulsion system(s) may have specific requirements for electrical separation, earthing/bonding, conductor installation, etc. from the other items of electrical equipment and circuits included in the overall design.

The rated voltage of an electric propulsion may be different from other electrical systems on-board a craft and uses either AC or DC systems.

— For an AC propulsion system, it may be at variable frequency.

— For a DC propulsion system sourced from an AC system, the DC electrical propulsion system may be obtained from an AC/DC converter with galvanic separation between input and output and appropriate arrangements made at the output for fully insulated or negative earth propulsion systems. Similarly, an earthed two wires propulsion system may be supplied from an insulated two wires source via a DC/DC converter with galvanic separation and vice versa.

— For a DC propulsion system sourced from a DC system, the source shall have the same characteristics.

Systems may require attention to the treatment of the neutral earth, and also have specific requirements in respect of earthing and bonding relative to the requirements of other electrical systems on-board a craft.

