International Standard

ISO 16315

Small craft — Electrical systems used for electrical propulsion

Petits navires — Systèmes électriques utilisés pour la propulsion électrique

Second edition
2026-02

Reference number
ISO 16315:2026(en)

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Published in Switzerland

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 Configuration of electrical systems sharing a common energy source for propulsion and service power 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 Electromagnetic compatibility (EMC) 11
4.11 Electrical equipment in the vicinity of batteries 11
4.12 Hazardous areas 12
4.13 Fire protection 12

5 Controls, monitoring, system alerts and trip 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
5.2 Instruments, alerts and trip alarms 13
5.2.1 General 13
5.2.2 Operating mode and status 14
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) 15
6.3 Fault-to-earth monitoring for DC fully insulated systems and DC three-wire systems 15
6.4 Fault-to-earth tripping in AC non-neutral earthed systems (IT-type system) 16

7 Protection against overcurrent **16**
7.1 General 16
7.2 Characteristics of protective devices 16
7.3 Overcurrent protection devices in the outgoing circuit(s) from a battery 17
7.4 Overcurrent protection devices in fully insulated systems 17
7.4.1 Single pole overcurrent protection 17
7.4.2 Dual pole overcurrent protection 17

8 Battery monitoring and installation **17**
8.1 General arrangements 17
8.2 Isolation of batteries or battery banks 18
8.3 Operational switching of battery(s) or battery bank(s) 18

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8.4 Permanently energized circuits ... 18
8.5 Ventilation ... 19
9 Electrical installation ... 19
9.1 General ... 19
9.2 Segregation of electrical propulsion system cables ... 19
10 Testing ... 19
10.1 General ... 19
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 ... 20
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 for the owner's manual ... 22**
Annex B (normative) **Installation documentation ... 23**
Annex C (informative) **Electromagnetic compatibility documents ... 24**
Bibliography ... 25

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Foreword

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This document was prepared by Technical Committee ISO/TC 188, *Small craft*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 464, *Small Craft,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 16315:2016), which has been technically revised.

The main changes are as follows:

— the overcurrent protection requirements have been clarified;

— the fault monitoring requirements for isolated DC systems have been revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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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.

A propulsion system designer/installer should be competent with all components of the system addressed by this standard, as well as all aspects of any other equipment included in the design of a system such that the component parts of the propulsion system are integrated in a complete and safe manner.

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 or battery bank 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) can 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 can 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 can 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). The electric propulsion system(s) can be DC variable speed through an 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 can 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) can be supported by a propulsion battery or battery bank.

— 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 L_H are as follows:

a) ISO 13297, which covers extra-low-voltage direct current (DC) electrical systems that operate at nominal potentials of 50 V DC or less and single-phase alternating current (AC) systems that operate at a voltage not exceeding AC 250 V. It does not include requirements for electrical propulsion systems.

b) IEC 60092-507, which 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. It includes a section on electric propulsion systems.

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Small craft — Electrical systems used for electrical propulsion

1 Scope

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

This document is applicable 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 document is applicable to electrical propulsion systems installed in small craft up to 24 m length of the hull (L_H in accordance with ISO 8666).

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.

ISO 8665-2, *Small craft — Power measurements and declarations — Part 2: Electric marine propulsion*

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

ISO 13297, *Small craft — Electrical systems — Alternating and direct current installations*

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

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

IEC 60092-202, *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, *Electrical installations in ships — Part 507: Small vessels*

IEC 60146-1-1:2024, *Semiconductor converters — General requirements and line commutated converters — Part 1-1: Specification of basic requirements*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors*

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

IEC 60947-1, *Low-voltage switchgear and controlgear — Part 1: General rules*

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IEC 61558-2-4, *Safety of transformers, reactors, power supply units and combinations thereof — Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers for general applications*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
safety voltage
<alternating current (AC)> voltage which does not exceed AC 50 V root mean square (rms) between *conductors* (3.19), or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating *transformer* (3.22), or converter with separate winding

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* (3.9) 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.

3.2
safety voltage
<direct current (DC)> voltage which does not exceed 50 DC V between *conductors* (3.19), 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* (3.9) 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* (3.22) or converter is operated at its rated supply voltage.

3.3
rated voltage
U_{0_TN}
<TN systems> nominal alternating current (AC) root mean square (rms) line voltage to earth

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

3.4
rated voltage
U_{0_IT}
<IT systems> nominal alternating current (AC) root mean square (rms) voltage between *line conductor* (3.21) and *neutral conductor* (3.20)

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

3.5
rated voltage
U_{0_DC}
<direct current (DC) systems> nominal DC voltage between poles

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

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3.6
maximum voltage
U_{max_IT}
<IT systems> measured maximum alternating current (AC) root mean square (rms) voltage between *line conductor* (3.21) and *neutral conductor* (3.20)

3.7
maximum voltage
U_{max_DC}
<direct current (DC) systems> the measured maximum DC voltage between poles

3.8
maximum voltage
U_{max_TN}
<TN systems> measured maximum alternating current (AC) root mean square (rms) line voltage to earth

3.9
live part
conductor (3.19) or conductive part intended to be energized in normal operation including a *neutral conductor* (3.20), but by convention not a PEN conductor (a conductor combining the functions of both a *protective conductor* (3.17) and a neutral conductor)

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

[SOURCE: IEC 60050-195:2021, 195-02-19, modified — "or a PEM conductor or PEL conductor" deleted. Text in brackets added.]

3.10
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 60092-101:2018, 1.3.9]

3.11
readily accessible
capable of being reached quickly and safely for effective use without the use of tools

[SOURCE: ISO 13297:2020, 3.24]

3.12
final circuit
portion of a wiring system extending beyond the final *overcurrent protection device* (3.13) for that circuit

[SOURCE: IEC 60092-101:2018, 1.3.17, modified — "for that circuit" replaced "of a board".]

3.13
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

[SOURCE: IEC 60050-826:2004, 826-14-14]

3.14
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]

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3.15
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]

3.16
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 60050-442:1998, 442-05-02, modified — Note deleted.]

3.17
protective conductor
PE
conductor (3.19) 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 a protective earthing conductor.

[SOURCE: IEC 60050-195:2021, 195-02-09]

3.18
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 cable screen of adjacent length of cable or the bulkhead

[SOURCE: IEC 60092-101:2018, 1.3.7, modified — “cables in a radio-receiving room” deleted.]

3.19
conductor
conductive part intended to carry a specified electric current

[SOURCE: IEC 60050-195:2021, 195-01-07]

3.20
neutral conductor
conductor (3.19) electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[SOURCE: IEC 60050-195:2021, 195-02-06]

3.21
line conductor
DEPRECATED: phase conductor (in AC systems)
DEPRECATED: pole conductor (in DC systems)
conductor (3.19) 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* (3.20)

[SOURCE: IEC 60050-195:2021, 195-02-08]

3.22
transformer
energy converter with isolating separation between the input and output windings and the *protective conductor* (3.17)

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3.23
switch
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, which can include specified operating overload conditions, and also carrying for a specified time currents under specified abnormal circuit conditions such as those of a short circuit

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

3.24
panel board
assembly of devices, such as *circuit-breakers* (3.15), *fuses* (3.14), *switches* (3.23), 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.

3.25
disconnector
mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements

[SOURCE: IEC 60050-441:1984, 441-14-05]

3.26
battery
collection of cells wired in series (or series/parallel) and constituting a single physical unit

[SOURCE: ISO 23625:2025, 3.2]

3.27
battery bank
set of *batteries* (3.26) electrically connected (parallel/series) to increase capacity and/or voltage

[SOURCE: ISO 23625:2025, 3.3]

4 General requirements

4.1 General

4.1.1 The owner's manual shall include the information and instructions provided in Annex A. Installation documentation shall be in accordance with Annex B.

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

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

4.1.3 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);

— IT systems with the requirements for earth leakage current monitoring, alarm and tripping systems.

4.1.4 DC electric propulsion systems can have large capacity battery(s) or battery bank(s) as the main power source, provided that the following requirements are fulfilled:

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

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