INTERNATIONAL STANDARD

**ISO 13297**

Fifth edition
2020-12

# Small craft — Electrical systems — Alternating and direct current installations

*Petits navires — Installations électriques — Installations à courant alternatif et continu*



Reference number
ISO 13297:2020(E)



ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

 

# Contents

Page

# 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.



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 fifth edition of ISO 13297 cancels and replaces ISO 13297:2014 and ISO 10133:2012, which have been technically revised.

The main changes compared to the previous editions are as follows:

— combined the standard for alternating current (ISO 13297:2014) and the standard for direct current (ISO 10133:2012) into a single marine electrical standard.

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.

# Small craft — Electrical systems — Alternating and direct current installations

**IMPORTANT — The colours represented in the electronic file of this document can be neither viewed on screen nor printed as true representations. For the purposes of colour matching, see ISO 3864-4, which provides colorimetric and photometric properties together with, as a guideline, references from colour order systems.**

## 1 Scope

This document specifies the requirements for the design, construction and installation of the following types of DC and AC electrical systems, installed on small craft either individually or in combination:

a) extra-low-voltage direct current (DC) electrical systems that operate at nominal potentials of 50 V DC or less;

b) single-phase alternating current (AC) systems that operate at a nominal voltage not exceeding AC 250 V.

This document does not cover the following:



— electrical propulsion systems of direct current less than 1 500 V DC, single-phase alternating current up to 1 000 V AC, and three-phase alternating current up to 1 000 V AC, which are addressed by ISO 16315;

— any conductor that is part of an outboard engine assembly and that does not extend beyond the outboard engine manufacturer's supplied cowling;



— three-phase AC installations that operate at a nominal voltage not exceeding 500 V AC, which are addressed by IEC 60092-507.

## 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 7010:2019, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 8846:1990, *Small craft — Electrical devices — Protection against ignition of surrounding flammable gases*

ISO 10240:2019, *Small craft — Owner's manual*

IEC 60309-2:1999, *Plugs, socket-outlets and couplers for industrial purposes — Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*

## 3 Terms and definitions

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

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

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

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

**3.1**
**craft's ground/earth**
**protective grounding**
connection, provided for safety purposes, that is established by a conducting connection with the common ground/earth (potential of the earth's surface)

**3.2**
**equipotential bonding conductor**
normally non-current-carrying conductor used to put various *exposed conductive parts* (3.15) of direct current electrical devices and *extraneous conductive parts* (3.33) at a substantially equal potential

**3.3**
**engine negative terminal**
terminal on the engine, starter or solenoid to which the negative battery cable is connected

**3.4**
**main grounding**
**earthing point**
main point that provides connection for the DC negative conductor, AC *protective grounding conductor* (3.10) and bonding conductor to the craft's ground that is established by a conducting connection (intended or accidental) with the common ground (potential of the earth's surface)

Note 1 to entry: It can include any conductive part of the wetted surface of the hull in permanent contact with the water, depending on the overall system design.



**3.5**
**overcurrent protection device**
device designed to interrupt the circuit when the current flow exceeds a predetermined value for a predetermined time



EXAMPLE A *fuse* (3.29) or circuit breaker.

**3.6**
**residual current device**
**RCD**
electro-mechanical switching device or association of devices designed to make, carry and break currents under normal service conditions and to cause the opening of contacts when the residual current attains a given value under specified conditions

Note 1 to entry: RCDs serve to reduce the risk of injury to people from electrical shock hazard, and damage to equipment from leakage of stray currents to earth or to other circuits.

**3.7**
**polarization transformer**
transformer that automatically orientates the neutral and *active (phase) conductors* (3.12) in the system in the same polarity orientation as the *polarized system* (3.17) of the craft

**3.8**
**isolation transformer**
transformer installed in the shore power supply circuit on a craft to electrically isolate all the normally *live conductors* (3.11) and the *protective conductor* (3.10) on the craft from the AC system conductors of the shore power supply

**3.9**
**neutral conductor**
conductor intentionally maintained at ground potential and capable of contributing to the transmission of electrical energy

**3.10**
**protective conductor**
**protective grounding conductor**
conductor, not normally carrying current, used for some measure of protection against electric shock, for electrically connecting any of the following parts of electrical equipment to the craft's ground/earth and to the shore AC grounding conductor through the shore power cable:

a) *exposed conductive parts* (3.15) of electrical equipment;

b) *extraneous conductive parts* (3.33);

c) the main grounding (earthing) terminal;

d) earth electrode(s);

e) the earth point of a source, or an artificial neutral

**3.11**
**live conductor**
conductor or conductive part intended to be energized in normal use, including a *neutral conductor* (3.9)

**3.12**
**active (phase) conductor**
conductor that is maintained at a difference of potential from the *neutral conductor* (3.9) or *protective conductor* (3.10)

Note 1 to entry: In a system that does not include a neutral or protective conductor, all conductors are considered active conductors.



**3.13**
**ignition-protected**
<equipment> designed and constructed to give protection against ignition of surrounding flammable gases



Note 1 to entry: The protection against ignition of surrounding flammable gases is covered in ISO 8846:1990.

**3.14**
**system voltage**
nominal voltage supplied to the craft from a power source

**3.15**
**exposed conductive part**
conductive part of electrical equipment, which can be touched and which is not normally live, but which can become live under fault conditions

**3.16**
**panel board**
**switchboard**
assembly of devices for the purpose of controlling and/or distributing electrical power

Note 1 to entry: It can include devices such as circuit breakers, *fuses* (3.29), switches, instruments, and indicators.

**3.17**
**polarized system**
system in which the *live conductors* (3.11) (active and neutral) are connected in the same relation to all terminals on devices or receptacles (socket outlets) in a circuit

**3.18**
**fully insulated two-wire DC system**
system in which both positive and negative poles remain isolated from the ground (earth), e.g. not connected to the water through a metallic hull, the propulsion system or earthed through the AC *protective conductor* (3.10)

Note 1 to entry: Some systems can use a momentary ground connection for engine starting purposes and can remain isolated.

**3.19**
**self-limiting**
device whose maximum output is restricted to a specified value by its magnetic or electrical characteristics

**3.20**
**two-wire DC system with negative ground**
system in which the DC negative is connected to the ground

**3.21**
**shore power appliance inlet**
fitting designed for mounting on a craft, of a shrouded male type, to connect to the female connector on the craft end of the shore power cable in order to make the electrical connection for transmission of electrical energy

**3.22**
**trip-free 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 overload or short circuit, and which is designed so that the resetting means cannot be manually held in place to override the current-interrupting mechanism



**3.23**
**accessible**
capable of being reached for inspection, removal or maintenance without removal of permanent craft structure

**3.24**
**readily accessible**
capable of being reached for use, inspection, removal or maintenance without the use of tools

**3.25**
**sheath**
uniform and continuous tubular protective covering of metallic or non-metallic material around one or more insulated conductors

Note 1 to entry: Examples of appropriate materials include moulded rubber, moulded plastic, woven sleeving or flexible tubing.

**3.26**
**conduit**
part of a closed wiring system of circular or non-circular cross-section for insulated conductors and/or cables in electrical installations, allowing them to be drawn in and/or replaced

**3.27**
**cable trunking**
system of closed enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables, cords and for the accommodation of other electrical equipment

**3.28**
**double-pole circuit breaker**
device intended to interrupt both the *neutral conductor* (3.9) and *active (phase) conductors* (3.12) in a circuit simultaneously when a designated current is exceeded for a predetermined time

**3.29**
**fuse**
protective device that interrupts the circuit irreversibly when the current flow reaches a specified value for a specific time

[SOURCE: ISO 8820-1:2014, 3.2, modified – Note 1 to entry has been deleted.]

**3.30**
**galvanic isolator**
device which can be installed in series with the AC *protective conductor* (3.10) of the shore power cable to block low voltage DC galvanic current flow, but permits the passage of AC normally associated with the protective conductor

**3.31**
**inverter**
device powered by a DC source, designed primarily to provide AC power at a required voltage and frequency

**3.32**
**inverter/charger**
device designed to supply either AC power to a craft's electrical system or to utilize the craft's AC electrical distribution system to charge or maintain a battery or batteries supplying DC



**3.33**
**extraneous conductive part**
conductive part liable to introduce a potential, generally ground/earth potential, and not forming part of the electrical installation



**3.34**
**ground plate**
means to conduct the electrical current from a craft's conductive element to the water

**3.35**
**craft**
**small craft**
recreational boat, and other watercraft using similar equipment, of up to 24 m length of hull ($L_H$)

Note 1 to entry: The measurement methodology for the length of hull is defined in ISO 8666.

[SOURCE: ISO 8666:2020, 3.15, modified – Note 1 to entry has been added.]

## 4 General requirements, DC and AC systems

**4.1** The hull of a metallic hull craft shall not be used as a circuit conductor.

**4.2** Craft equipped with both DC and AC electrical systems shall have their distribution from either separate panel boards, or from a common one with a partition, or from other positive means to separate clearly the AC and DC sections from each other, and these shall be clearly identified.

**4.3** Wiring diagrams to identify circuits, components and conductors shall be included with the craft.

After completing an AC installation, it is recommended to perform a system test according to Annex C.

**4.4** Switches and controls shall be marked to indicate their function, unless the purpose of the switch is obvious and its operation cannot, under normal operating conditions, cause a hazardous condition.

## 5 General requirements, DC systems

**5.1** The system type shall be either a fully insulated two-wire DC system or a two-wire DC system with negative ground. Engine-mounted wiring systems can use the engine block as the grounded conductor.

For DC systems with a negative ground, the main grounding/earthing point shall be either:

a) the engine negative terminal; or

b) a main grounding bus of sufficient current carrying capacity.

Systems with multiple battery banks shall have a common negative connection. Exceptions to this are for dedicated power systems isolated from craft systems, e.g. propulsion systems that are clearly identified as part of the isolated system.

**5.2** An equipotential bonding conductor, if fitted, shall be connected to the craft's main grounding/earthing point.

**5.3** Protective devices such as trip free circuit breakers or fuses shall be provided at the source of power, e.g. the panel board (switchboard), to interrupt any overload current in the circuit conductors before heat can damage conductor insulation, connections or wiring system terminals.



**5.3.1** The selection, arrangement and performance characteristics shall allow:

a) maximum continuity of service to healthy circuits when fault conditions exist in other circuits, through selective operation of the various protective devices; and



b) protection of electrical equipment and circuits from damage due to overcurrents, by coordination of the electrical characteristics of the circuit or apparatus and the tripping characteristics of the protective devices.

**5.4** All DC equipment shall be capable of function within a voltage range of 75 % to 133 % of nominal voltage at the battery terminals, e.g.:

— for a 12 V system: 9 V to 16 V;

— for a 24 V system: 18 V to 32 V;

— for a 48 V system: 36 V to 64 V.

EXCEPTION Where the circuit includes equipment requiring a higher minimum voltage, the specified minimum voltage shall be used in the calculation of the conductor size in accordance with Annex A.

**5.5** The length and cross sectional area of conductors in each circuit shall be such that the calculated voltage drop shall not exceed 10 % of the nominal voltage.

**5.6** Equipment vital to safety, where the voltage drop is critical, shall be supplied with the proper voltage to achieve the rated performance.

NOTE 1 See Annex A for voltage drop calculations.

NOTE 2 A 3 % voltage drop is acceptable for this equipment.

NOTE 3 Examples of circuits that can be dependent on a minimum voltage drop include:

a) panel board/switchboard main conductors;

 

b) navigation lights;

c) bilge blowers;

d) bilge pumps.

## 6 General requirements, AC systems

**6.1** The protective conductor insulation shall be green or green with a yellow stripe. Neither colour shall be used for current-carrying conductors.

NOTE The equipotential bonding conductor of the DC electrical system also uses green or green with a yellow stripe insulation and is connected to various exposed conductive parts of DC electrical devices, other extraneous conductive parts and the DC negative ground/earth.

**6.2** For craft having a fully insulated DC system, the AC protective conductor shall be connected to:

a) for metallic hulled craft, the hull;

b) for non-conductive hulls, the craft's external ground/earth or ground plate.

**6.3** The AC protective conductor(s) shall be provided with a final (single) connection to the hull of a metallic hull craft, or, if the craft has a non-metallic hull, to the main grounding/earthing point of the craft.

**6.4** On metallic hulls, the point of connection of the protective conductor shall be located above any anticipated water accumulation.



**6.5** Metallic housings or enclosures of permanently installed AC electrical appliances shall be connected to the protective conductor system in the craft.



**6.6** Individual circuits shall not be capable of being energized by more than one source of electrical power at a time. Each shore power inlet, generator or inverter is a separate source of electrical power. The transfer from one power source circuit to another shall be made by a means which opens all current-carrying conductors, active (phase) and neutral, before closing the alternate source circuit, to prevent arc-over between contacts, and should be interlocked by mechanical or electromechanical means. A device that simultaneously breaks both current carrying conductors, active (phase) and neutral, shall be used when changing power sources.

The requirements for overcurrent protection are found in Clause 13. A combination of power sources can be used provided that:

a) the device is constructed and tested to an applicable recognized standard;

b) the device includes protection to prevent backfeeding to shore power (anti-islanding protection);

c) the device includes personnel protection against backfeeding;

d) the installation is performed according to the manufacturer’s instructions.

**6.7** Energized parts of electrical equipment shall be guarded against accidental contact by the use of enclosures conforming to at least IEC 60529:1989-IP 2X or other protective means which shall not be used for non-electrical equipment. Access to energized parts of the electrical system shall require the use of hand tools or be at least IP 2X, unless otherwise specified. A suitable warning sign shall be displayed (see 7.2).

**6.8** The neutral conductor shall be grounded (earthed) only at the source of power, i.e. at the onboard generator, the secondary windings of the isolation or polarization transformer, the shore power

connection or inverter. The shore power neutral shall be grounded (earthed) through the shore power cable and shall not be grounded (earthed) on board the craft or:

a) for systems using an isolation transformer or polarization transformer, both the generator or inverter neutral and the transformer secondary neutrals may be grounded at the AC main grounding bus instead of at the generator, inverter, or transformer secondaries;

b) for systems using an isolation transformer or polarization transformer, or no shore power provision, both the generator or inverter neutral and the transformer secondary neutrals may be ungrounded provided double-pole protection and switching is installed.

**6.9** When a galvanic isolator is fitted in the protective conductor, failure of the isolator shall not result in an open circuit.

**6.10** If the polarity of the system must be maintained for the proper operation of the electrical devices in the system, reverse polarity indicating devices providing a continuous visible or audible signal shall be installed in shore power systems and shall respond to the reversal of the active (phase) and the neutral conductors. Otherwise, a branch circuit shall be provided with overcurrent protection in only the active (phase) conductor.

Reverse polarity indicating devices are not required on craft employing:

a) unpolarized systems using double-pole branch circuit protection;

b) polarization or isolation transformers that establish polarity on the craft.



NOTE 1 Reverse polarity indicating devices might not respond to reversals of a live conductor and the protective conductor.

NOTE 2 Reverse polarity indicating devices respond to the reversal of an active (phase) conductor or grounded conductor only when there is continuity of the protective conductor to shore.



## 7 Marking, AC systems

**7.1** Shore power inlets shall be marked to indicate voltage and current; they shall also be marked with the electricity warning symbol (ISO 7010:2019-W012) and the "refer to instruction manual/booklet" symbol (ISO 7010:2019-M002).

**7.2** A permanently mounted waterproof warning sign shall be located at the panel board on the craft. The sign shall include the information shown in Figure 1 a) or 1 b).

General warning sign
ISO 7010-W001

Warning; Electricity
ISO 7010-W012

Warning;
Flammable material
ISO 7010-W021

Refer to instruction
manual/booklet
ISO 7010-M002

**a) Suggested warning sign using symbols**

| **WARNING — To minimize shock and fire hazards:** |
|---|
| 1) **Turn off craft's shore power connection switch before connecting or disconnecting shore power cable.** |
| 2) **Connect shore power cable to craft's inlet before connecting to shore power source.** |
| 3) **If incorrect polarity is indicated, immediately disconnect cable.** |
| 4) **Disconnect shore power cable at shore power source first.** |
| 5) **Close shore power inlet cover tightly.** |
| **DO NOT ALTER SHORE POWER CABLE CONNECTORS** |



**b) Suggested warning sign with text in language appropriate to the country of use**

Item 3 is required only if a polarity indicator is installed in the system.

Items 2, 4 and 5 are not required for permanently connected shore power cable installations.

**Figure 1 — Suggested warning signs**

**7.3** Electrical equipment shall be marked or identified to indicate:

a) manufacturer's identification;

b) model number or designation;

c) electrical rating, in volts and amperes or volts and watts;

d) phase and frequency, if applicable;

e) ignition protection, if applicable, in accordance with ISO 8846:1990.

## 8 Batteries, DC systems

**8.1** Batteries shall be permanently installed in a dry, ventilated location above anticipated bilge water level.