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STANDARD

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**Small craft — Electrical systems —  
Alternating current installations**

*Petits navires — Systèmes électriques — Installations à courant alternatif*

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## 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](http://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](http://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 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*.

This fourth edition cancels and replaces the third edition (ISO 13297:2012), of which it constitutes a minor revision. The main changes are:

- deletion of Annex E;
- replacement of [Annex D](#);
- correction of references in [14.1](#) indent e) by replacing 4.8 with [4.7](#) and in [14.3](#) by replacing 4.6 with [4.7](#);
- update of reference to ISO 10133.

# Small craft — Electrical systems — Alternating current installations

**IMPORTANT** — The colours represented in the electronic file of this document can be neither viewed on screen nor printed as true representations. Although the copies of this document printed by ISO have been produced to correspond (with an acceptable tolerance as judged by the naked eye) to the requirements of ISO 3864-4, it is not intended that these printed copies be used for colour matching. Instead, consult ISO 3864-4, which provides colorimetric and photometric properties together with, as a guideline, references from colour order systems.

## 1 Scope

This International Standard specifies the requirements for the design, construction and installation of low-voltage alternating current electrical systems which operate at nominal voltages of less than 250 V single phase on small craft of hull length up to 24 m.

Additional information to be included in the owner's manual is listed in [Annex B](#).

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

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

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

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

IEC 60079-0, *Explosive atmospheres — Part 0: General requirements*

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

IEC 60446, *Basic and safety principles for man-machine interface marking and identification — Identification of conductors by colours or numerals*

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.

### 3.1

#### craft's earth

#### protective ground

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 of direct current electrical devices and extraneous conductive parts at a substantially equal potential

**3.3**

**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.

**3.4**

**polarization transformer**

transformer which automatically orientates the neutral and active (phase) conductors in the system in the same polarity orientation as the polarized system of the craft

**3.5**

**isolation transformer**

transformer with protective separation between the input and output windings and the protective conductor

**3.6**

**neutral conductor**

conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy

**3.7**

**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 a.c. grounding conductor through the shore power cable:

- a) exposed conductive parts of electrical equipment;
- b) extraneous conductive parts;
- c) the main grounding (earthing) terminal;
- d) earth electrode(s);
- e) the earth point of a source, or an artificial neutral

**3.8**

**live conductor**

conductor or conductive part intended to be energized in normal use, including a neutral conductor

**3.9**

**active (phase) conductor**

any conductor that is maintained at a difference of potential from the neutral or protective conductor

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

**3.10**

**ignition-protected equipment**

equipment designed and constructed to give protection against ignition of surrounding flammable gases

Note 1 to entry: See ISO 8846.

**3.11****overcurrent protection device**

device designed to interrupt the circuit when the current flow exceeds a predetermined value for a predetermined time

EXAMPLE A fuse or circuit breaker.

**3.12****panel board  
switchboard**

assembly of devices 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.

**3.13****polarized system**

system in which the live conductors are connected in the same relation to all terminals on devices or receptacles (socket outlets) in a circuit

**3.14****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

**3.15****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

**3.16****accessible**

capable of being reached for inspection, removal or maintenance without removing the craft's permanent structure

**3.17****readily accessible**

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

**3.18****sheath**

uniform and continuous protective tubular 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.

**3.19****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

**3.20****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

**3.21**

**double-pole circuit breaker**

device intended to interrupt both the neutral and active (phase) conductors in a circuit simultaneously when a designated current is exceeded for a predetermined time

**3.22**

**captive spade terminal**

conductor terminal component which is maintained in the connection to the screw or stud even when the threaded terminal fastener is loose

**3.23**

**exposed conductive part**

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

**3.24**

**fuse**

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

[SOURCE: ISO 8820-1:2008, 3.1]

**3.25**

**galvanic isolator**

device which can be installed in series with the a.c. protective conductor of the shore power cable to block low voltage d.c. galvanic current flow, but permit the passage of a.c. normally associated with the protective conductor

**3.26**

**inverter**

device powered by d.c. current (batteries), designed primarily to provide a.c. at a required voltage and frequency

**3.27**

**inverter/charger**

device designed to supply either a.c. power to a craft's electrical system or to utilize the craft's a.c. electrical distribution system to charge or maintain a battery or batteries supplying d.c.

**3.28**

**extraneous conductive part**

conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation

## 4 General requirements

**4.1** 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 d.c. electrical system (see ISO 10133) also uses green or green with a yellow stripe insulation and is connected to various exposed conductive parts of d.c. electrical devices, other extraneous conductive parts and the d.c. negative ground/earth.

**4.2** For crafts having a fully insulated d.c. system in accordance with ISO 10133, the a.c. protective conductor shall be connected to:

- a) the hull of a metallic hulled craft;
- b) the craft's external ground/earth or ground plate for non-conductive hulls.

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

**4.4** The a.c. 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.

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

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

**4.7** 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 live 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. The conductors of both circuits-carrying conductors, active (phase) and neutral, shall be broken simultaneously when changing power sources.

The requirements for overcurrent protection and sizing of the switch are found in [Clause 7](#). A combination of power sources may be used provided that:

- the device is constructed and tested to an applicable recognized standard;
- the device includes anti-islanding protection;
- the device includes personnel protection against backfeeding; and
- the installation is performed according to the manufacturer's instructions.

**4.8** Energized parts of electrical equipment shall be guarded against accidental contact by the use of enclosures of at least IEC 60529-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 [5.2](#)).

**4.9** The neutral conductor shall be grounded (earthed) only at the source of power, i.e. at the onboard generator, the secondary 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 a.c. 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.

**4.10** When an optional galvanic isolator is fitted in the protective conductor to resist imported stray galvanic current flow while permitting the passage of a.c. current, failure of the isolator shall not result in an open circuit.

**4.11** 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, if the polarity of the system has to be maintained for the proper operation of the electrical devices in

the system. Otherwise, a branch circuit shall be provided with overcurrent protection in only the active (phase) conductors. This does not apply for the systems indicated below in a) and b).

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.

**4.12** Craft equipped with both d.c and a.c. electrical systems shall have their distribution from either separate panel boards or from a common one with a partition or other positive means provided to separate clearly the a.c. and d.c. sections from each other, and shall be clearly identified. Wiring diagrams to identify circuits, components and conductors shall be included with the craft.

NOTE After completing an a.c. installation it is recommended to perform a system test according to [Annex C](#).

## 5 Marking

**5.1** Shore power inlets shall be marked to indicate voltage and current; they shall also be marked with the electricity warning symbol (ISO 7010 — W012) and the “refer to instruction manual/booklet” symbol (ISO 7010 — M002).

**5.2** 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 1a](#)) or [Figure 1b](#)).



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

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

NOTE 1 Item 3 is required only if a polarity indicator is installed in the system

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

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

**Figure 1 — Suggested warning signs**

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

**5.4** 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 protected, if applicable, by ISO 8846.

## **6 Ignition sources**

Electrical components installed in compartments which in normal operation can contain LPG gases or petrol vapor, e.g. petrol tank, engine compartment and LPG lockers, shall be designed to be compliant with ISO 8846 or designed according to IEC 60079-0.

NOTE ISO 10088 requires that all components in petrol engines, petrol and LPG tank compartments be ignition-protected to prevent open sparks. This applies to the entire engine, as well as all electrical contacts, commutators, brushes, collector rings, switches, relays, generators, fuses, distributors, engine-cranking motors, propulsion trim motors, etc. ISO 8846 requires components to withstand any operating conditions of the device, including the maximum achievable overload up to 400 % of the rated current (circuit-breakers, switches and the like) and a stalled rotor condition for any motor with the circuit protected in an overcurrent protective device specified by the product manufacturer.

## **7 Overcurrent protection**

### **7.1 General**

**7.1.1** In unpolarized systems double-pole circuit breakers opening both active (phase) and neutral conductors are required.

**7.1.2** Fuses shall not be installed in unpolarized systems. If used in polarized systems, fuses shall be located to interrupt the active (phase) conductor.

**7.1.3** Overcurrent protection devices for motor loads shall have a predetermined value of amperage consistent with electrical demand of the protected circuit.

**7.1.4** All a.c. motor installations and each motor of a motor-operated device shall be individually protected in accordance with [7.1.3](#) or by an integral overcurrent or thermal protection device unless the motors will not overheat under continuous locked rotor conditions.

**7.1.5** The rating of the overcurrent protection device shall not exceed the maximum current-carrying capacity of the conductor being protected. See [Table A.1](#).

## 7.2 Supply circuits

**7.2.1** Double-pole circuit breakers shall be installed in conductors to all supply circuits.

**7.2.2** A manually reset trip-free circuit breaker shall be installed within 0.5 m of the source of power or, if impractical, the conductor from the source of power to the panel-board circuit breaker shall be contained within a protective covering, such as a junction box, control box, enclosed panel board or within conduit or cable trunking or equivalent protective covering. If the location of the main shore power inlet circuit breaker exceeds 3 m from the shore power inlet connection or the electrical attachment point of a permanently installed shore power cord, additional circuit breakers shall be provided within 3 m of the inlet or attachment point to the electrical system in the craft, measured along the conductor.

**7.2.3** Overcurrent protection shall be provided for isolation and polarization transformers, including a bank of transformers operating as a unit. Each transformer shall be protected by an individual overcurrent device on the primary side, rated at not more than 125 % of the rated primary current of the transformer.

## 7.3 Branch circuits

**7.3.1** The active (phase) conductor of each branch circuit in a polarized system shall be provided with overcurrent protection, i.e. fuse or circuit breaker, at the point of connection to the main panel board bus.

**7.3.2** Both current-carrying conductors of each branch circuit in unpolarized systems shall be provided with overcurrent protection by double-pole circuit breakers and double-pole switches, at the point of connection to the main panel board bus.

NOTE Use of a reverse polarity indicator presumes compliance with [7.3.1](#).

## 8 Ground fault protection/earth-leakage protection

**8.1** RCDs shall be of the trip-free type.

**8.2** The craft shall be provided with earth-leakage protection in all a.c. sources by one or more double-pole RCDs having a maximum nominal trip sensitivity of 30 mA and 100 ms maximum trip time.

NOTE Common standards for RCD construction are IEC 60898-2[\[10\]](#), IEC 61009-1[\[12\]](#) and IEC 61543[\[13\]](#).

**8.3** The RCD device shall have an internal circuit for manually testing the trip function.

## 9 Appliances and equipment

**9.1** Appliances and fixed a.c. electrical equipment installed on a craft shall have exposed conductive parts connected to the craft protective conductor, unless the appliance is of double-insulated construction.

**9.2** Integral or external overcurrent protection shall be provided.

## 10 System wiring

**10.1** Conductors, including flexible cords, shall have a minimum rating of 300/500 V.

**10.2** Conductors and flexible cords shall be multi-strand copper, with cross-sectional areas no smaller than those determined using [Table A.1](#).

NOTE A conductor used for equipment grounding is not considered a current-carrying conductor when referencing [Table A.1](#).

**10.3** The insulation temperature rating of conductors and flexible cords outside engine spaces shall be at least 60 °C.

**10.4** Conductors shall be at least 1 mm<sup>2</sup> in area. An exception may be made for conductors of minimum 0,75 mm<sup>2</sup> area which can be used as internal wiring in panel boards.

**10.5** Conductor insulation temperature ratings in engine spaces shall be 70 °C minimum, and the conductor insulation shall be oil-resistant, or shall be protected by insulating conduit or sleeving. The conductors shall be derated in an allowable current-carrying capacity in accordance with [Annex A](#).

**10.6** The protective conductor shall have a cross-sectional area equal to that of the live conductors.

a) For earth continuity conductors (protective conductors) in flexible cables or flexible cords:

- 1) a cross-section equal to that of the current-carrying conductor if the latter is less than or equal to 16 mm<sup>2</sup>; or
- 2) a cross-section equal to 50 % of that of the current-carrying conductor if the latter is greater than 16 mm<sup>2</sup>, subject to a minimum of 16 mm<sup>2</sup>;

b) for earth continuity conductors (protective conductors) incorporated in fixed multicore cables:

- 1) a cross-section equal to that of the main conductors if the latter is less than or equal to 16 mm<sup>2</sup> subject to a minimum of 1,5 mm<sup>2</sup>; or
- 2) a cross-section of not less than 50 % of the cross-section of the main conductor if the latter is more than 16 mm<sup>2</sup>, subject to a minimum of 16 mm<sup>2</sup>.

**10.7** Active (phase) and neutral conductors of the a.c. system shall be identified. Identification may be made by insulation colour, by numbering or by other means on the wiring diagram for the system supplied with the craft. Insulation colours used shall be in conformance with IEC 60446. For single-phase systems:

- active (phase) conductors shall be black or brown;
- neutral conductors shall be white or light blue;
- protective conductors shall be green or green with a yellow stripe (see [4.1](#)).

NOTE A coloured stripe may be added to active (phase) and neutral conductor insulations for identification in the system.

Yellow, green or green with a yellow stripe insulation colour shall not be used for active (phase) or neutral conductors of the a.c. system.

## 11 Conductor and cable installation

**11.1** Conductor connections shall be in locations protected from the weather or in enclosures in accordance with IEC 60529-IP 55 as a minimum. Connections above deck exposed to intermittent immersion shall be in IEC 60529-IP 67 enclosures as a minimum.

**11.2** Conductors and cables shall be supported throughout their length in conduits, cable trunking or trays, or by individual supports at maximum intervals of 450 mm.

**11.3** An a.c. circuit shall not be contained in the same wiring system as a d.c. circuit, unless one of the following methods of separation is used:

- a) for a multicore cable or cord, the cores of the a.c. circuit are separated from the cores of the d.c. circuit by an earthed metal screen of equivalent amperage rating to that of the largest core of the a.c. circuit;
- b) the cables are insulated for their system voltage and installed in a separate compartment of a cable ducting or trunking system;
- c) the cables are installed on a tray or ladder where physical separation is provided by a partition;
- d) a separate conduit, sheath or trunking system is used;
- e) the a.c. and d.c. conductors are fixed directly to a surface and separated by at least 100 mm.

**11.4** Current-carrying conductors of the a.c. system shall either be routed above foreseeable levels of bilge water and in other areas where water can accumulate, or at least 25 mm above the water level at which the automatic bilge pump switch activates.

If conductors have to be routed in the bilge area, the wiring and connections shall be in enclosures in accordance with IEC 60529-IP 67, such as continuous conduit, as a minimum, and there shall be no connections below the foreseeable water level.

**11.5** Metals used for terminal studs, nuts and washers shall be corrosion-resistant and galvanically compatible with the conductor and terminal. Aluminium and unplated steel shall not be used for studs, nuts or washers in electrical circuits.

**11.6** Solderless crimp-on terminals and connectors shall be used on conductors and connectors, and shall be attached with the type of crimping tool designed for the termination used and for producing a connection meeting the requirements of [11.14](#).

**11.7** All conductors shall have suitable terminals installed, i.e. no bare wires to stud or screw connections.

**11.8** Screw-clamp terminals or screwless terminal blocks shall clamp conductors to ensure reliable mechanical linkage and electrical contact is properly maintained without bearing directly on conductor strands. Other terminals shall be of the ring or captive spade type not dependent on screw or nut tightness alone for retention on the screw or stud. Captive spade terminals shall be of the self-locking type.

**11.9** Friction type connectors on conductors may be used in circuits not exceeding 20 A if the connection does not separate when subjected to a force of 20 N.

**11.10** Twist-on connectors (wire nuts) shall not be used.

**11.11** Exposed shanks of terminals shall be protected against accidental shorting by insulating barriers or sleeves, except those in the protective conductor system.

**11.12** Conductors shall be routed away from exhaust pipes and other heat sources which can damage the insulation. The minimum clearance is 50 mm from water-cooled exhaust components and 250 mm from dry exhaust components, unless an equivalent thermal barrier is provided.

**11.13** Conductors which can be exposed to physical damage shall be protected by sheaths, conduits or other equivalent means. Conductors passing through bulkheads or structural members shall be protected against insulation damage by chafing.

**11.14** Each conductor-to-connector and conductor-to-terminal connection shall be capable of withstanding a tensile force equal to at least the value shown in [Table 1](#) for the smallest conductor in the connection for 1 min, without separating.

**Table 1 — Tensile values for connectors**

Conductor size mm <sup>2</sup>	Tensile force N	Conductor size mm <sup>2</sup>	Tensile force N	Conductor size mm <sup>2</sup>	Tensile force N
0,75	40	6	200	50	400
1	60	10	220	70	440
1,5	130	16	260	95	550
2,5	150	25	310	120	660
4	170	35	350	150	770

**11.15** No more than four conductor connectors shall be secured to one terminal stud.

## 12 Panel boards (switchboards)

**12.1** An a.c. system panel board with a means of indicating system on/off status shall be installed.

**12.2** A system voltmeter shall be installed on the panel board if the system is designed to supply motor circuits or if an onboard generator is installed.

**12.3** Panel boards shall be permanently marked with the system voltage and frequency.

EXAMPLE 230 V, 50 Hz; 115 V, 60 Hz.

**12.4** The front side of panel boards, i.e. the switch and circuit breaker operating face, shall be readily accessible, and the rear side, i.e. the terminal and connection side, accessible.

NOTE Electrical controls required for proper operation of the craft (e.g. horns, navigation lights) should be apparent to the operator when in normal use.

**12.5** Connections and components on panel boards shall be in locations protected from the weather in conformity with IEC 60529:

- IP 67 as a minimum, if exposed to short-term immersion;
- IP 55 as a minimum, if exposed to splashing water;
- IP 20 as a minimum, if located in protected locations inside the craft.

**12.6** A visible means, i.e. voltmeter or lamp, indicating that the inverter is active on line and/or in standby mode, shall be provided at the a.c. panel board.

**12.7** A warning label shall be placed at the panel board to indicate that the electrical system includes an inverter. For example:

**WARNING – ELECTRICAL SHOCK HAZARD**

Craft is equipped with a d.c. to a.c. power inverter.

To avoid serious injury or death from electrical shock:

disconnect a.c. shore power and d.c. battery power to inverter before opening panel or servicing electrical systems.

## 13 Socket outlets

**13.1** Shore power appliance inlets shall conform to IEC 60309-2 with a minimum rating of IP 44 when mated with the appropriate plug.

**13.2** Socket outlets and matching plugs used on a.c. systems shall not be interchangeable with those used in the d.c. system on the craft.

**13.3** Socket outlets installed in locations subject to rain, spray or splash shall be in enclosures conforming to IEC 60529-IP55 as a minimum, when not in use. Socket outlets mated with the appropriate plug shall also remain sealed in accordance with IEC 60529, IP55.

**13.4** Socket outlets installed in areas subject to flooding or momentary submersion shall be in enclosures in accordance with IEC 60529-IP67 as a minimum, and shall also meet these requirements when mated with the appropriate plug.

**13.5** Socket outlets shall be of the earthing type with a terminal provided for the protective conductor.

**13.6** Socket outlets provided for the galley area shall be located so that appliance cords can be plugged in without crossing above a galley stove or sink or across a traffic area.

**13.7** Socket outlets shall have a voltage rating in accordance with the voltage supplied by the power sources.

## 14 Power source options

**14.1** Power for the a.c. system shall be supplied by one of the following means:

- a) single shore power cable, power inlet, wiring and components with a capacity to supply the required design system load;
- b) separate shore power cables, power inlets, wiring and components with a capacity to supply the required design system loads;
- c) inverter supplying a.c. power from the craft's d.c. system;
- d) onboard a.c. generator(s) supplying the required system load;
- e) combination of shore power cable(s), onboard generator(s), inverters or inverter/chargers used simultaneously if the craft's circuitry is arranged such that the load connected to each source is isolated from the other sources or supplies are combined in accordance with [4.7](#).

**14.2** The shore power cable(s) alone or with onboard generator(s) capacity in addition shall be at least as large as the required system load(s).

**14.3** Where a.c. generators are installed, they shall be connected to the electrical distribution system as required in [4.7](#) and/or protected in accordance with [14.1 e\)](#).

**14.4** Except for the system indicated in the Note below, the power feeder conductor from the a.c. generator shall be protected at the generator with overcurrent protection devices with a rating such that 120 % of the generator nominal output is not exceeded.

NOTE Self-limiting (self-adjusting) generators whose maximum overload current does not exceed 120 % of its rated current output do not require additional external overcurrent protection.

See [Annex D](#) for examples of a.c. system diagrams.

## 15 Inverters and inverter/chargers

**15.1** Permanently installed inverters and inverter/chargers shall be non-rotating power inverters supplying less than 250 V rms a.c. at a frequency of 50 Hz or 60 Hz, and shall

- a) be designed to operate up to an ambient temperature of 50 °C and withstand an ambient temperature of 70 °C without damage;
- b) be automatically controlled;
- c) provide isolation of the a.c. output from the d.c. supply circuit;
- d) have controls which are readily accessible;
- e) be located in a ventilated, dry, readily accessible site where ambient temperatures will not exceed 50 °C;

NOTE Inverters may be located in an accessible location if the controls are mounted in a readily accessible location.

- f) be mounted away from heat sources such as engine exhaust system components and other heat-producing devices;
- g) be mounted not less than 500 mm above foreseeable levels of bilge water.

**15.2** Inverter outlet circuits shall be protected in accordance with [Clauses 7](#) and [8](#).

**15.3** Inverters and inverter/chargers shall be ignition protected in accordance with [Clause 6](#) and shall be marked as such by the manufacturer, i.e. IGNITION PROTECTED ISO 8846.

**15.4** d.c. conductor terminals or conductors shall be labelled as follows:

- a) d.c.+, or POS, or +
- b) d.c.-, or NEG, or -

**15.5** A separate d.c. equipotential conductor shall be connected from the metallic case or chassis of the inverter or inverter/charger to the engine negative terminal, or its bus, and be of an amperage rating equal to the d.c positive conductor. This conductor shall not be connected to the d.c. negative at the inverter or inverter/charger.

NOTE If the craft is fitted with an insulated d.c. system as per ISO 10133, or if the inverter a.c./d.c. power terminal enclosure is of double-insulated construction, this requirement will not necessarily apply.

**15.6** Provision shall be made within the inverter or inverter/charger to permit the ready connection of three or more conductors with connectors meeting the requirements of [11.8](#) and [11.13](#). The terminals or conductors shall be labelled, e.g. L1, G, N.

**15.7** Inverter or inverter/charger integral switching shall switch all live conductors. Integral switching will also disconnect the grounded (neutral) conductor from ground when an external supply is used, e.g. from a shore power source circuit unless an ungrounded system or a common neutral bus is used.

**15.8** Access panels to compartments containing a.c. connections shall be provided with a label containing a warning about electrical shock hazards. For example:

**WARNING – ELECTRICAL SHOCK HAZARD**

To avoid electrical shock hazard:

disconnect a.c. shore power and d.c battery power to inverter before opening panel

**15.9** All inverter/chargers shall include the following information for the charging system:

- a) input voltage, amperage and frequency;
- b) nominal output voltage and current;
- c) d.c. output voltage at float or shut off, if applicable;
- d) continuous output current at 12 V (24 or 32) at specified input voltage at 25 °C;
- e) battery type;
- f) warning concerning internal charged capacitor hazard when servicing.

**15.10** All inverters shall also include the following information:

- a) input voltage and amperage;
- b) continuous output current at rated voltage;
- c) nominal output voltage and frequency;
- d) surge capability and duration.

## Annex A

(normative)

### Conductor requirements

[Table A.1](#) gives allowable continuous current ratings, in amperes, at different temperature ratings and the minimum number of strands for conductors. These values have been determined for an ambient temperature of 30 °C and apply to single conductors and stranding when no more than three conductors are bundled together.

For conductors in engine rooms (60 °C ambient) or when more than three conductors are bundled together, the maximum current rating in [Table A.1](#) shall be derated by the factors given in [Table A.2](#).

**Table A.1 — Cross-sectional area conductor, allowable permanent current and stranding**

Cross-sectional area mm <sup>2</sup>	Maximum continuous amperage capacity for single conductors at insulation temperature ratings						Minimum number of strands	
	60 °C	70 °C	85 °C to 90 °C	105 °C	125 °C	200 °C	Type A <sup>a</sup>	Type B <sup>b</sup>
0,75	6	10	12	16	20	25	16	-
1	8	14	18	20	25	35	16	-
1,5	12	18	21	25	30	40	19	26
2,5	17	25	30	35	40	45	19	41
4	22	35	40	45	50	55	19	65
6	29	45	50	60	70	75	19	105
10	40	65	70	90	100	120	19	168
16	54	90	100	130	150	170	37	266
25	71	120	140	170	185	200	49	420
35	87	160	185	210	225	240	127	665
50	105	210	230	270	300	325	127	1 064
70	135	265	285	330	360	375	127	1 323
95	165	310	330	390	410	430	259	1 666
120	190	360	400	450	480	520	418	2 107
150	220	380	430	475	520	560	418	2 107

<sup>a</sup> Conductors with Type B stranding shall be used for any wiring where frequent flexing is involved during use.

<sup>b</sup> Conductor current ratings may be interpolated for cross-sectional areas between those shown above.

**Table A.2 — Derating of maximum current rating in [Table A.1](#)**

Temperature rating of conductor insulation:	Multiply maximum current from <a href="#">Table A.1</a> by:
70 °C	0,75
85 °C to 90 °C	0,82
105 °C	0,86
125 °C	0,89
200 °C	1
Number of conductors bundled:	Multiply maximum amperage from <a href="#">Table A.1</a> by:
4 to 6	0,7
7 to 24	0,6
25 or more	0,5

NOTE Derating reductions for temperature and bundling are cumulative.

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## Annex B

(normative)

### Instructions to be included with owner's manual

There shall be an owner's manual in accordance with ISO 10240.

The owner's manual shall include instructions for the operation and maintenance of the system, including a wiring diagram with conductor identification, and at least the following instructions:

- a) Do not modify the craft's electrical system or relevant drawings. Installation, alterations and maintenance should be performed by a competent marine electrical technician. Inspect system at least biennially.
- b) Disconnect shore power connections when system is not in use.
- c) Connect metallic housings or enclosures of installed electrical appliances to the protective conductor system in the craft (green or green with a yellow stripe conductor).
- d) Use double-insulated or grounded (earthed) electrical appliances.
- e) If reverse polarity indicator is activated, do not use electrical system. Correct polarity fault before activating the electrical system on the craft.
- f) **WARNING — Do not allow shore power cable end to hang in the water. An electrical field can result which can cause injury or death to nearby swimmers.**
- g) **WARNING — To minimize shock and fire hazards:**
  - Turn off craft's shore power connection switch before connecting or disconnecting shore power cable.
  - Connect shore power cable to craft's inlet before connecting to shore power source.
  - If reverse polarity indicator is activated, turn off craft's shore power connection switch immediately (if fitted).
  - Disconnect shore power cable at shore power source first.
  - Close shore power inlet cover tightly.
- h) Do not alter shore power cable connectors, use only compatible cable connectors and shore power receptacles.
- i) Instructions on monthly testing of the RCD.

Instruction e) is required for polarized systems with polarity indicator.

Instruction g), second list item is not required for permanently connected shore power cable installations.

Instruction g), third list item is required only if reverse polarity indicator is required in the system.

## Annex C (informative)

### Recommended system tests

The following system tests should be performed upon completion of the a.c. installation:

- residual current device (RCD) testing;
- polarity test at distribution and at each outlet.

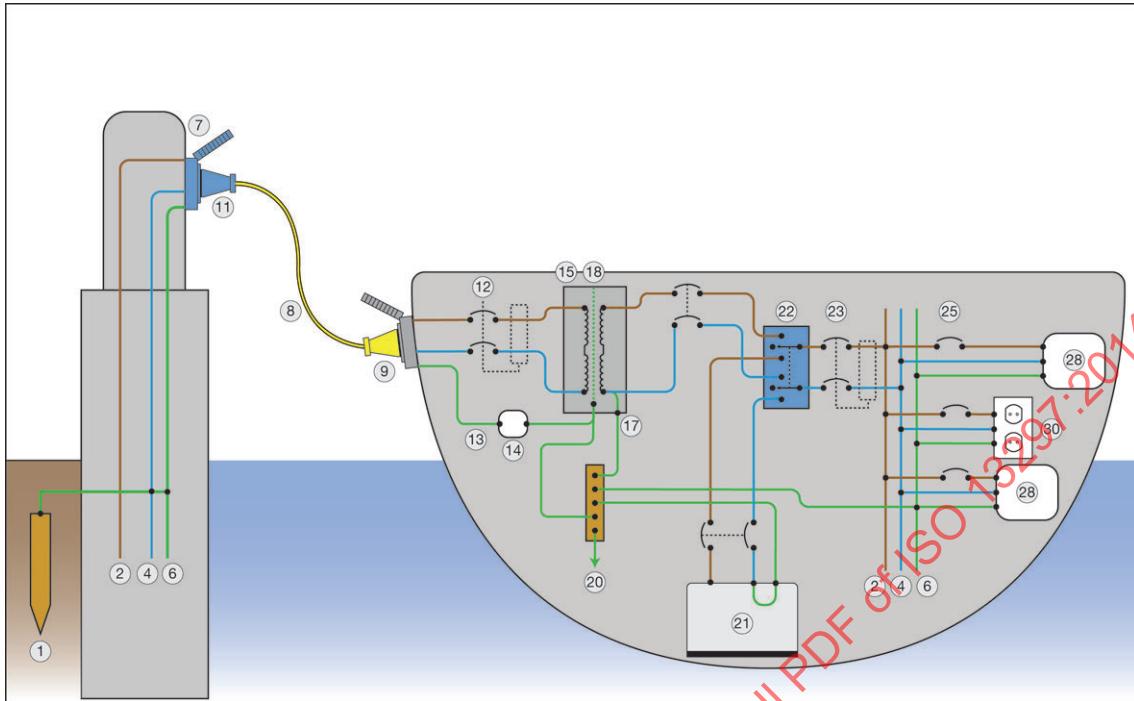
**CAUTION — Some electronic equipment can be damaged by high d.c. voltages.**

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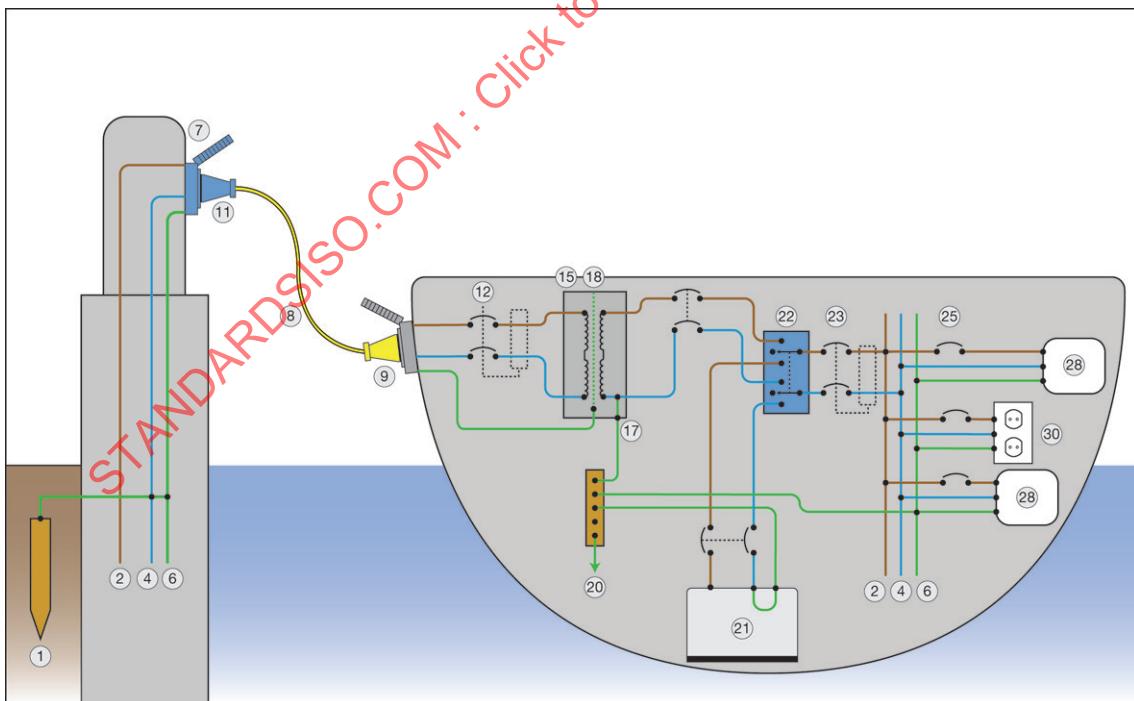
**Annex D**  
(informative)

**Typical a.c. system diagrams**

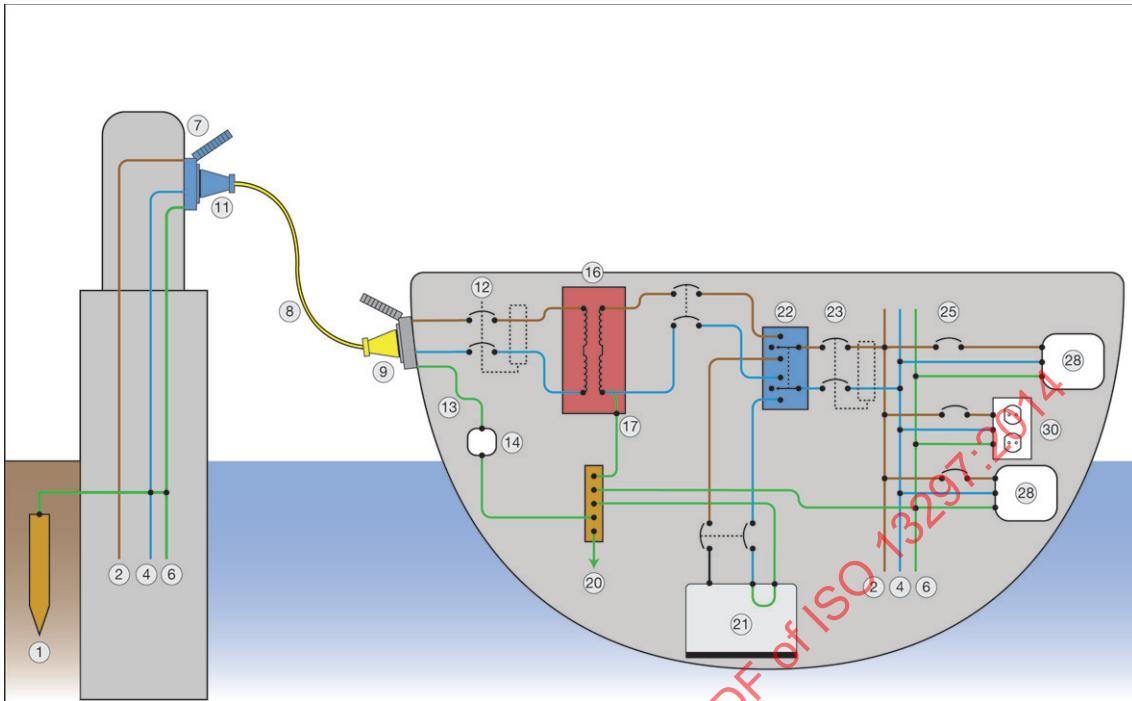
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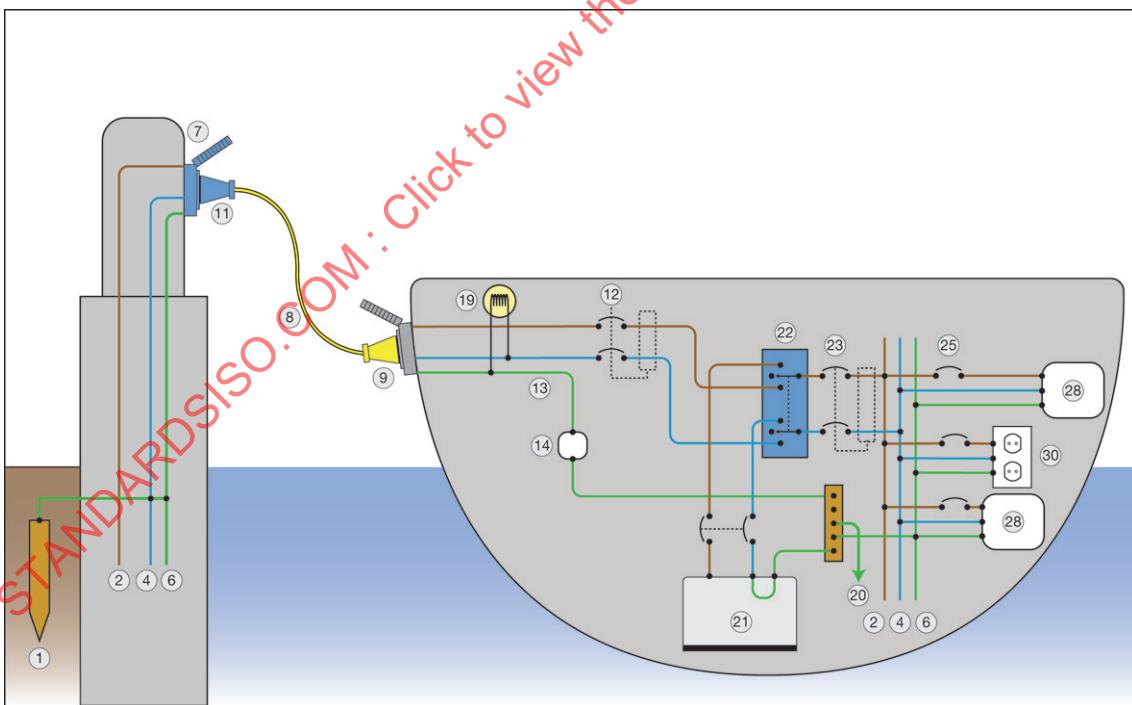
a) Isolation transformer system with a single phase 230 V input and a 230 V output and generator illustrating the use of main AC grounding bus and RCD/shore power disconnect breaker – Shown with input ground connected to ship's ground (via optional galvanic isolator), converting the isolation transformer into a polarizing transformer



b) Isolation transformer system with a single phase 230 V input and a 230 V output, and generator illustrating the use of main AC grounding bus and RCD/shore power disconnect breaker



c) Polarization transformer system with a single phase 230 V input and a 230 V output, and generator illustrating the use of main AC grounding bus and RCD/shore power disconnect breaker



d) Single phase 230 V system with shore grounded (blue) neutral and grounding (green) conductors, and combined RCD/ MCB – A typical European system