INTERNATIONAL STANDARD

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Small craft — Electrical systems — Extra-low-voltage d.c. installations

Navires de plaisance — Systèmes électriques — Installations à très basse tension à courant continu

Reference number
ISO 10133:1994(E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10133 was prepared by Technical Committee ISO/TC 188, *Small craft*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.

International Organization for Standardization
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Small craft — Electrical systems — Extra-low-voltage d.c. installations

1 Scope

This International Standard establishes the requirements for the design, construction and installation of extra-low-voltage direct current (d.c.) electrical systems which operate at nominal potentials of 50 V d.c. or less on small craft of up to 24 m length of hull.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards

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

ISO 10239:—[1], *Small craft — Liquefied petroleum gas (LPG) systems.*

IEC 529:1989, *Degrees of protection provided by enclosures (IP Code).*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 d.c. equipotential bonding conductor: Normally non-current-carrying conductor used to connect metallic non-current-carrying parts of direct current electrical devices.

3.2 engine negative terminal: Terminal on the engine to which the negative battery cable is connected.

3.3 craft's ground: Ground which is established by a conducting connection (intended or accidental) with the common ground (potential of the earth's surface), including any conductive part of the wetted surface of the hull.

3.4 ignition-protected equipment: Equipment designed and constructed in accordance with ISO 8846.

3.5 overcurrent protection device: Device, such as a fuse or circuit-breaker, designed to interrupt the circuit when the current flow exceeds a predetermined value.

3.6 panel-board: Assembly of devices for the purposes of controlling and/or distributing power on a craft, such as circuit-breakers, fuses, switches, instruments and indicators.

3.7 sheath: Continuous protective covering, such as overlapping electrical tape, moulded rubber, moulded plastics, or flexible tubing, around one or more insulated conductors.

3.8 trip-free circuit-breaker: Thermal and/or magnetically operated overcurrent protection device, designed so that the resetting means cannot be manually held in place to override the current-interrupting mechanism.

3.9 accessible: Capable of being reached for inspection, removal or maintenance without removal of permanent structure of the craft.

1) To be published.

3.10 readily accessible: Capable of being reached quickly and safely for effective use without the use of tools.

3.11 conduit: Part of a closed wiring system for protection of conductors or cables in electrical installations, allowing them to be drawn in and/or replaced, but not inserted laterally.

3.12 cable trunking: Enclosure manufactured for the protection of conductors or cables, normally of rectangular cross-section, of which one side is removable or hinged.

3.13 system voltage: Nominal voltage supplied to the direct current distribution panel-board from the battery or a group of batteries connected together.

4 General requirements

4.1 The system type shall be either an insulated two-wire system or a two-wire system with negative ground. The hull shall not be used as a current-carrying conductor. Engine-mounted wiring systems may use the engine block as the grounded conductor.

4.2 A d.c. equipotential bonding conductor shall be connected to the boat's ground to minimize stray current corrosion.

4.3 If earthing (grounding) of the system is required, the engine negative terminal shall be grounded.

4.4 Switches and controls shall be marked to indicate their use, 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 Batteries

5.1 Batteries shall be installed in a dry, ventilated location above bilge water level.

5.2 Batteries shall be installed in a manner to restrict their movement horizontally and vertically considering the intended use of the craft, including trailering if applicable. A battery, as installed, shall not move more than 10 mm in any direction when exposed to a force corresponding to twice the battery weight.

5.3 Batteries as installed in the craft shall be capable of inclinations of up to 45° without leakage of electrolyte. Means shall be provided for containment of any spilled electrolyte, with the battery in its normal operating position.

5.4 Batteries shall be installed, designed or protected so that metallic objects cannot come in unintentional contact with any positive battery terminal.

5.5 Batteries, as installed, shall be protected against mechanical damage by their location or enclosure.

5.6 Batteries shall not be installed directly above or below a fuel tank or fuel filter.

5.7 Any metallic component of the fuel system within 300 mm and above the battery top, as installed, shall be insulated with dielectric material.

5.8 Battery cable terminals shall not depend on spring tension for mechanical connection to the battery terminals.

6 Battery-disconnect switch

6.1 A battery-disconnect switch shall be installed in the positive conductor from the battery or group of batteries connected to supply system voltage in a readily accessible location as close as practical to the battery(ies).

The following constitute exceptions:

a) outboard-powered craft with engine starting and navigation lighting circuits only;

b) bilge pumps and alarms if separately fused at the source of power;

c) engine/fuel tank compartment ventilation exhaust blower if separately fused at the source of power.

6.2 Battery-disconnect switches shall be capable of carrying the maximum current of the system including the intermittent load of the starter motor circuit.

6.3 Remote controlled battery-disconnect switches, if used, shall also permit safe manual operation at the switch.

7 Conductors

7.1 Electrical distribution shall use insulated stranded copper conductors. Conductor insulation shall be of fire-retardant material, e.g. not supporting combustion in the absence of flame.

7.2 Single conductors not sheathed shall be supported at maximum intervals of 250 mm unless run in conduits or trunking, or supported by trays.

7.3 Sheathed conductors and battery conductors shall be supported at maximum intervals of 450 mm with the first support not more than 1 m from the terminal.

Starter motor conductors constitute an exception to this requirement.

7.4 Conductors shall be protected against damage by chafing or exposure to heat sources capable of damaging the insulation.

7.5 Conductors shall be sized as a minimum in accordance with table A.1 based on the load to be supplied and allowable voltage drop for the load to be carried. Conductors in voltage-critical circuits, such as starter motor circuits, navigation light and ventilation blower circuits, whose output may vary with system voltage, shall be sized in compliance with the component manufacturer's requirements.

7.6 Each conductor longer than 200 mm installed separately shall have at least 1 mm^2 area. Each conductor in a multi-conductor sheath shall have at least 0,75 mm^2 area and may extend out of the sheath a distance not to exceed 800 mm.

7.7 Both a.c. and d.c. conductors or multiconductors shall be separately sheathed, in conduits or cable trunking, or bundled or otherwise kept separated from each other.

7.8 Each electrical conductor that is part of the electrical system shall have a means to identify its function in the system, except for conductors integral with engines as supplied by their manufacturers.

7.8.1 All d.c. equipotential bonding conductors shall be identified by green with yellow stripe insulation, or may be uninsulated. Conductors with green or green with yellow stripe insulation shall not be used for current-carrying conductors.

7.8.2 All d.c. negative conductors shall be identified by black insulation. Black insulation shall not be used for d.c. positive conductors.

7.8.3 Means of identification other than colour may be used providing a wiring diagram of the system indicating the method of identification is supplied with the craft.

8 Overcurrent protection

8.1 A manually reset trip-free circuit-breaker or a fuse shall be installed within 200 mm of the source of power for each circuit or conductor.

The main power feed circuit from the battery to an engine-cranking motor, if sheathed or supported to protect against abrasion and contact with conductive surfaces, is an exception to this requirement.

NOTE 1 If the fuse or circuit-breaker at the source of the supply conductor is sized to protect the smallest conductor in the circuit, only the fuse or circuit-breaker at the source is required.

8.2 If it is impractical to place the fuse or circuit-breaker within 200 mm of the source of power, the conductor may instead be contained within an enclosure such as a junction box, control box, enclosed panel-board or within the conduit or cable trunking.

8.3 The voltage rating of each fuse or circuit-breaker shall not be less than the nominal circuit voltage; the current rating shall not exceed the value for the smallest size conductor in the circuit.

8.4 Output circuits of self-limiting generators do not require fuses or circuit-breakers.

9 Panel-boards

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

9.2 The front side of panel-boards and of their components shall meet the following requirements, which are in conformity with IEC 529:

— min. IP 56 if exposed to short-term immersion;

— min. IP 44 if exposed to splashing water;

— min. IP 20 if located in protected locations inside the craft.

9.3 Craft equipped with both direct current (d.c.) and alternating current (a.c.) electrical systems shall have their distribution from either separate panel-boards or a common one with a partition or other positive means provided to separate clearly the a.c. and d.c. sections from each other. Wiring diagrams to identify circuits, components and conductors shall be included.

10 Wiring connections and terminals

10.1 Conductor connections shall be in locations protected from the weather or in min. IP 44/IEC 529 enclosures. Connections above deck exposed to intermittent immersion shall be in min. IP 56/IEC 529 enclosures.

10.2 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.

10.3 Terminals shall be of the ring or captive spade type, not dependent on screw or nut tightness alone for retention on the stud or screw.

An exception is friction type connectors which may be used in circuits not exceeding 20 A if the connection does not separate when subjected to a force of 20 N.

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

10.5 Exposed shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves, except for those in the grounding system.

11 Receptacles

11.1 Receptacles and matching plugs used on d.c. systems shall not be interchangeable with those used on a.c. systems on the craft.

11.2 Receptacles installed in locations subject to rain, spray or splash shall be protected to min. IP 44/IEC 529 when not in use, e.g. protected by a cover with an effective weatherproof seal.

11.3 Receptacles installed in areas subject to flooding or momentary submersion shall be protected to min. IP 56/IEC 529, including when in use with connecting plugs.

12 Ignition protection

12.1 Electrical components installed in compartments which may contain explosive gases shall be ignition-protected in accordance with ISO 8846.

Compartments which may contain explosive gases are those containing or which have open connections with compartments containing such items as

a) spark-ignition engines or their fuel tanks;

b) joints or fittings in fuel lines connecting spark-ignition engines with their fuel tanks.

Open compartments having 0,34 m^2 of open area per cubic metre of compartment volume exposed to the open atmosphere outside the craft constitute an exception to this requirement.

12.2 Craft with LPG systems shall have ignition-protected electrical components installed in accordance with ISO 10239.

Annex A
(normative)

Conductor requirements

A.1 Table A.1 gives allowable continuous current ratings in amperes determined for 30 °C ambient temperature.

For conductors in engine rooms (60 °C ambient), the maximum current rating in table A.1 shall be derated by the factors below:

Temperature rating of conductor insulation: °C	Multiply maximum current from table A.1 by:
70	0,75
85 to 90	0,82
105	0,86
125	0,89
200	1

A.2 For information, the voltage drop E at load, in volts, may be calculated by the following formula:

$$E = \frac{0{,}016\ 4 \times I \times L}{S}$$

where

S is the conductor cross-sectional area, in square millimetres;

I is the load current, in amperes;

L is the length, in metres, of conductor from the positive power source to the electrical device and back to the negative source connection.

Table A.1 — Conductor cross-sectional area, allowable continuous current and stranding

Cross-sectional area	Maximum current, in amperes, for single conductors at insulation temperature ratings						Minimum number of strands	
mm²	60 °C	70 °C	85 °C to 90 °C	105 °C	125 °C	200 °C	Type 1*)	Type 2*)
0,75	8	10	12	16	20	25	16	—
1	12	14	18	20	25	35	16	—
1,5	16	18	21	25	30	40	19	26
2,5	20	25	30	35	40	45	19	41
4	30	35	40	45	50	55	19	65
6	40	45	50	60	70	75	19	105
10	60	65	70	90	100	120	19	168
16	80	90	100	130	150	170	37	266
25	110	120	140	170	185	200	49	420
35	140	160	185	210	225	240	127	665
50	180	210	230	270	300	325	127	1 064
70	220	265	285	330	360	375	127	1 323
95	260	310	330	390	410	430	259	1 666
120	300	360	400	450	480	520	418	2 107
150	350	380	430	475	520	560	418	2 107

*) Conductors with at least type 1 stranding shall be used for general craft wiring. Conductors with type 2 stranding shall be used for any wiring where frequent flexing is involved in use.

Annex B
(informative)

Information and instructions to be included with owner's manual

B.1 The following information should be included with the owner's manual:

a) complete wiring diagram identifying the electrical circuits of the craft with the locations of electrical devices in the craft and identification of conductors by colour or other means;

b) location and description of functions of electrical controls, dials, switches, fuses and also circuit-breakers installed on the panel-board;

c) explanation or description of symbols used for the d.c. electrical installation.

B.2 The following advisory instructions should be provided for the owner.

B.2.1 Always

a) check battery and charging system condition before going to sea;

b) check engine compartment for fumes and run engine compartment blower for the designated time before starting the engine;

c) disconnect and remove the battery when the craft is in winter storage (cold weather areas) or long-term storage;

d) check the function of navigation lights before embarking on night passages and carry replacement bulbs for all navigation lights.

B.2.2 Never

a) work on the electrical installation while the system is energized;

b) modify the electrical installation and the relevant drawings, except by a qualified marine electrical technician;

c) alter or modify the rated current amperage of overcurrent protective devices;

d) install and replace electrical appliances or devices with components exceeding the rated current amperage of the circuit;

e) leave the craft unattended with the electrical system energized, except automatic bilge pump, fire protection and alarm circuits.

Annex C
(informative)

Bibliography

This International Standard is intended to provide protection against explosion and fires. It is important to realize that this Standard by itself is not intended to achieve this purpose. The manufacturer also needs to comply with additional Standards related to protection against the same possible hazards. These additional Standards are listed below, with a brief description of their contents. For complete understanding of the requirements, the manufacturer needs to refer to the actual Standard. Compliance with all these International Standards will ensure a high level of safety in all craft, particularly in those using petrol or LPG.

[1] ISO 10088:1992, *Small craft — Permanently installed fuel systems and fixed fuel tanks*

Individual fuel tanks, 100 % pressure-tested
Non-metallic fuel tanks, fire-tested
Fire-resistant flexible fuel hoses
Fire test for non-metallic fuel system components
Corrosion-resistant fuel tank materials
Galvanically compatible metallic parts
Anti-siphon protection requirements
Double clamping of fuel fill hoses
Electrically ground major metallic parts
100 % pressure test of entire fuel system

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

All components in petrol engines, petrol and LPG tank compartments to 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.

The Standard further 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.

[3] ISO 7840:—[1], *Small craft — Fire-resistant fuel hoses*

Only fire-resistant fuel hoses may be used in petrol engine and petrol fuel tank compartments. A flexible hose to be used between the engine and any solidly mounted metallic line to eliminate vibration failure. The hose to withstand fire, pressure, vacuum collapse, ozone and other environments, and have minimal fuel permeation.

[4] ISO 9097:1991, *Small craft — Electric fans*

[5] ISO 8849:1990, *Small craft — Electrically operated bilge-pumps.*

All components, if installed in a petrol engine, petrol or LPG tank compartment to be ignition-protected, have all wiring insulated, be suitable for marine environment, and not create a hazard when the motor is overloaded or stalled.

[6] ISO 10239:—[2], *Small craft — Liquefied petroleum gas (LPG) systems*

System to withstand temperature extremes
Appliances approved and installed only in ventilated compartments, tanks and pressure regulators in lockers identified and vented with overboard drains
Meet specifications for fuel lines and their supports
Appliance well secured with flame failure shutoff control device for each appliance
Warning labels on appliances
Pressure test on installed system
Any electrical device in lockers, designated for LPG storage, ignition-protected

1) To be published. (Revision of ISO 7840:1985)

2) To be published.