
**Small craft — Carbon monoxide (CO)
detection systems**

Petits navires — Systèmes de détection du monoxyde de carbone (CO)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 12133 was prepared by Technical Committee ISO/TC 188, *Small craft*.

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Small craft — Carbon monoxide (CO) detection systems

1 Scope

This International Standard specifies requirements for the design, construction and installation of carbon monoxide detection and alarm systems in small craft.

Annex A provides educational material about carbon monoxide relative to boats and boating.

2 Normative references

The following referenced documents are indispensable for the application 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 7240-6, *Fire detection and alarm systems — Part 6: Carbon monoxide fire detectors using electro-chemical cells*

ISO 7240-8, *Fire detection and alarm systems — Part 8: Carbon monoxide fire detectors using an electro-chemical cell in combination with a heat sensor*

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

IEC 60529, *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

carbon monoxide

CO

gas formed by the combination of one atom of carbon and one atom of oxygen

NOTE In its chemical formula, C stands for carbon and O for oxygen. For the purposes of this International Standard, the CO level is always expressed in terms of mass fraction of CO in air.

3.2

carboxyhaemoglobin

COHb

stable combination of carbon monoxide and haemoglobin formed in the blood when carbon monoxide is inhaled

NOTE Also called carbonmonoxy-haemoglobin, CO-haemoglobin, blood-COHb, and blood-CO. It is the molecule formed when carbon monoxide, instead of oxygen, combines with blood.

3.3

% COHb

degree to which the oxygen carrying capacity of blood is impeded by the union of carbon monoxide to the haemoglobin in the blood

NOTE Expressed as a percentage.

3.4

enclosed accommodation compartment

contiguous space, surrounded by permanent structure that contains

- a) designated sleeping accommodation,
- b) a galley area with sink, and
- c) a head compartment

NOTE A cuddy intended for gear storage and open passenger cockpits, with or without canvas enclosures, are not considered to be enclosed accommodation compartments.

4 Symbols

β (Beta) An arbitrary variable name chosen to represent the mathematical calculation of the absolute worst case predicted %COHb levels in a typical individual exposed to the factors [mass fraction (mg/kg) of carbon monoxide level and minutes of exposure to that CO level]] used in that calculation.

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5 Requirements

5.1 Design and construction

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5.1.1 Detectors shall meet the requirements of ISO 7240-6 or ISO 7240-8, or relevant national standard (e.g. UL 2034 or EN 50291-2).

5.1.2 An audible alarm shall be provided.

If detectors employing a COHb level algorithm, or other integrating alarm structures, include a switch to mute only the audible alarm, then warnings or other means shall be provided to protect such a switch from casual use. The switch shall not reset the detector and shall not mute the alarm for more than 6 min.

5.1.3 There shall be no power switch on the detector.

5.1.4 A non-mechanical indicator, e.g. some type of visual electrical indicator (lamp, LED, LCD, etc.), shall be provided on the detector to indicate that it is in operation.

5.1.5 A circuit self-check shall be provided that will also give an alarm for an electrically defective sensor. A testing procedure or test switch shall be provided for checking the alarm circuitry.

5.1.6 Detectors shall be designed and marked as drip proof or watertight in accordance with IP rating 42, as defined in IEC 60529.

5.1.7 Detectors shall be powered by the boat's electrical system, or by a self-contained battery.

5.2 Performance specifications

5.2.1 The device shall be tested to the relevant national standard (e.g. UL 2034) including the following:

- β (Beta) = 10 % maximum;
- an alarm condition shall occur at some point within the shaded area of the curve shown in Figure 1.

5.2.2 β is calculated from the following expression:

$$\beta = 218 \times \left(0,000\,3 + \frac{w_{\text{CO}}}{1\,316} \right) \times \left(1 - e^{-t/96,879\,2} \right)$$

where

w_{CO} is the mass fraction of CO in mg/kg (ppm);

e is the base natural logarithm, approximately equal to 2,718 28;

t is the time of exposure in minutes.

NOTE For reference purposes, the β (Beta) equation solved for t or w_{CO} is as follows:

$$w_{\text{CO}} = \frac{6,036\,7\,\beta}{1 - e^{-t/96,879\,2}} - 0,394\,8 \quad \text{and} \quad t = -96,879\,2 \cdot \ln \left[1 - \frac{\beta}{0,065\,4 + 0,166\,w_{\text{CO}}} \right]$$

5.3 Installations

5.3.1 A carbon monoxide detection system shall be installed on all boats with an enclosed accommodation compartment(s) and a petrol generator set or an inboard petrol propulsion engine.

5.3.2 Detectors shall be located to monitor the atmosphere in the main cabin and each sleeping area.

The detector shall be mounted and located to avoid areas subject to physical damage, including harm from rain, water or sunlight, and dilution of sampled air (e.g. near hatches, ports or forced ventilation openings), and inadequate natural air circulation, (e.g. in corners).

The d.c. electrical system of the detector system shall be installed in accordance with ISO 10133, except for detectors powered by a self-contained battery.

5.3.3 If a circuit breaker is installed, it shall include a block or other multi-step means to prevent it from being inadvertently turned off.

The power source for the detector may be the continuously energized side of the battery switch.

5.3.4 The boat manufacturer shall provide instructions in the owner's manual as to what action should be taken when the CO alarm sounds.

5.4 Instructions

Instructions covering the installation and operation shall be provided with each detector. The following information shall be included in the instructions:

- mounting location requirements consistent with the requirements in 5.3;
- actions to be taken when the alarm system sounds, wherein the order of action is evacuate, ventilate, investigate, and take corrective action;

- the manufacturer's service policy;
- the manufacturer's recommendation for overcurrent protection shall specify the current rating and type of overcurrent protection device in the connected branch circuit;
- if a fuse is to be used, the fuse current rating shall be permanently marked where it will be visible if the fuse is replaced;
- the manufacturer's recommendation for operational testing and frequency for such testing in accordance with Clause 5;
- general educational material about carbon monoxide;
- the detector's performance specifications in accordance with this International Standard;
- information on the detector's ability to sense only the air in the vicinity of the detector's sensing element.

6 Markings

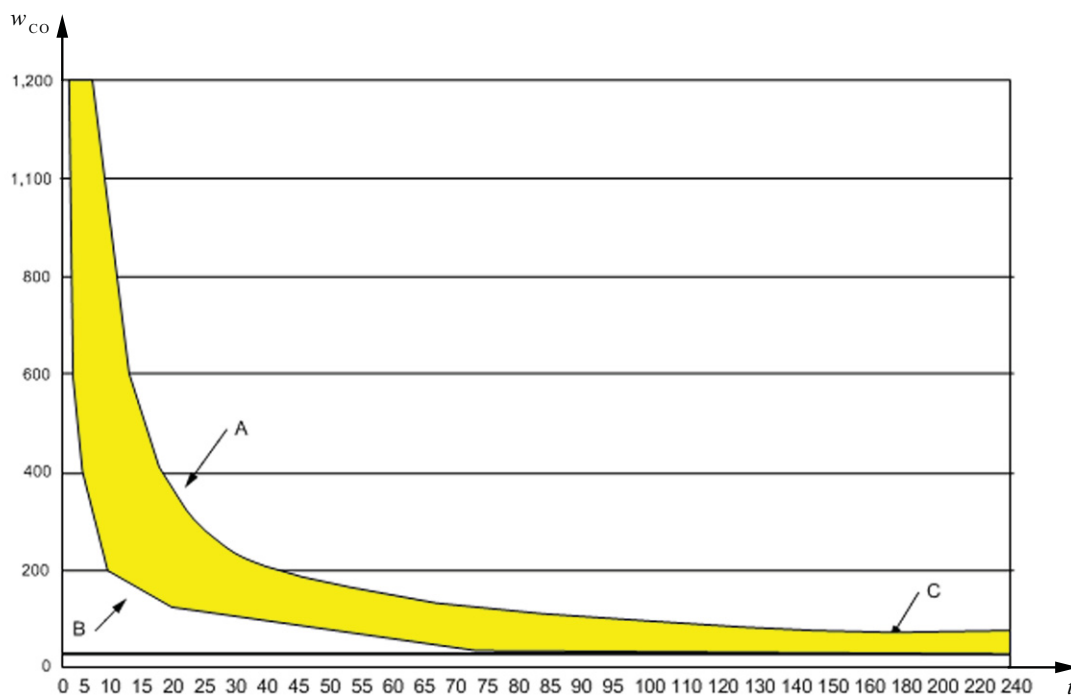
Detectors shall be marked with "Marine Carbon Monoxide Alarm" or equivalent, as tested to the relevant national standard.

Detectors that have been certified by a certification body shall be marked with the name of the certifying body.

The markings shall be clearly visible as installed.

NOTE These markings are in addition to markings required under the relevant national legislation.

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**Key** t time (min) w_{CO} mass fraction of CO in mg/kg (ppm)

A 10 % COHb curve

B 2,5 % COHb curve

C 30 mg/kg (ppm) <https://standards.iteh.ai/catalog/standards/sist/b08598b4-6f4f-40ce-a2fd-0a89c2f0552/iso-12133-2011>

NOTE 1 This figure is for illustrative purposes only.

NOTE 2 The β (Beta) formula given in 5.2.2 is used to determine β (Beta).

**Figure 1 — Beta curve for 2,5 % to 10 % COHb level —
CO mass fraction in mg/kg (ppm) vs. time in minutes**

Annex A **(informative)**

Educational information about carbon monoxide

NOTE The information in this annex concerns all boats.

A.1 General

Carbon monoxide can accumulate in interior spaces and exterior areas. Carbon monoxide accumulation is affected by a multitude of variables (e.g. boat geometry, hatches, window and door openings, ventilation openings, proximity to other structures, swim platforms, canvas enclosures, location of exhaust outlets, vessel attitude, wind direction, boat speed, boat engine performance and maintenance).

This annex discusses many of these variables and enables the user to better understand some of the more predictable effects. However, this annex is limited in that it cannot cover all conceivable variables, and the user is cautioned not to rely exclusively on it to prevent the accumulation of carbon monoxide.

A.2 Properties and characteristics of carbon monoxide

Carbon monoxide (CO) is a colourless, odourless and tasteless gas that weighs about the same as air. It cannot be expected to rise or fall like some other gases because it will distribute itself throughout the space. Do not rely on the sense of smell or sight of other gases to detect CO as it diffuses in the air much more rapidly than easily detectable vapours (i.e. visible and aromatic vapours).

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A.3 What makes carbon monoxide?

Carbon monoxide is produced any time a material containing carbon burns, such as gasoline, natural gas, oil, propane, coal or wood. Common sources of CO are internal combustion engines and open flame appliances such as but not limited to

- propulsion engines,
- auxiliary engines (gensets),
- cooking ranges,
- central heating plants,
- space heaters,
- water heaters,
- fireplaces, and
- charcoal grills.

The carbon monoxide component of diesel exhaust is extremely low relative to the carbon monoxide level found in gasoline engine exhaust.

A.4 How is a person affected by carbon monoxide?

A.4.1 General

Carbon monoxide is absorbed by the lungs and reacts with blood haemoglobin to form carboxyhaemoglobin, which reduces the oxygen carrying capacity of the blood. The result is a lack of oxygen for the tissues with the subsequent tissue death and, if exposure is prolonged, death of the individual. Altitude, certain health related problems, and age will increase the effects of CO. Persons who smoke or are exposed to high concentrations of cigarette smoke, consume alcohol or have lung disorders or heart problems are particularly susceptible to an increase in the effects from CO. However, all occupants' health should be considered. Physical exertion accelerates the rate at which the blood absorbs CO.

Carbon monoxide in high concentrations can be fatal in a matter of minutes. Lower concentrations should not be ignored because the effects of exposure to CO are cumulative and can be just as lethal.

A.4.2 Symptoms of CO poisoning

The sequence of symptoms listed generally reflects the order of occurrence in most people; however, there are many variables that affect this order of symptom manifestation. One or more of the following symptoms can signal the adverse effect of CO accumulation:

- a) watering and itchy eyes;
- b) flushed appearance;
- c) throbbing temples;
- d) inattentiveness;
- e) inability to think coherently;
- f) loss of physical coordination;
- g) ringing in the ears;
- h) tightness across the chest;
- i) headache;
- j) drowsiness;
- k) incoherence;
- l) slurred speech;
- m) nausea;
- n) dizziness;
- o) fatigue;
- p) vomiting;
- q) collapse;
- r) convulsions.

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