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BSI Standards Publication

Electrical apparatus for the detection of carbon monoxide in domestic premises, caravans and boats — Guide on the selection, installation, use and maintenance

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National foreword

This British Standard is the UK implementation of EN 50292:2013. It supersedes BS EN 50292:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EXL/31/1, Gas detectors.

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This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Electrical apparatus for the detection of carbon monoxide in domestic premises, caravans and boats - Guide on the selection, installation, use and maintenance

Appareils électriques pour la détection de monoxyde de carbone dans les locaux à usage domestique, caravanes et bateaux - Guide de sélection, d'installation, d'utilisation et de maintenance

Elektrische Geräte für die Detektion von Kohlenmonoxid in Wohnhäusern, Caravans und Booten - Leitfaden für Auswahl, Installation, Benutzung und Instandhaltung

CENELEC

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Foreword

This document (EN 50292:2013) has been prepared by CLC/TC 216, "Gas detectors".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2014-07-15
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2016-07-15

This document supersedes EN 50292:2001.

EN 50292:2013 includes the following significant technical changes with respect to EN 50292:2001 (various minor changes have also been made).

– Title and definitions are revised to be more general, i.e. to cover domestic premises, boats and caravans. This is a result of the splitting of EN 50291 into EN 50291-1 and EN 50291-2.

– In 4.3.1 of EN 50292:2001, incorrect terminology "warm air systems" is replaced by "ducted air heaters" (in 4.3.2 of EN 50292:2013).

– In 4.7, a more general title replaces the previous one as CO migration applies not only to multi-occupancy and multi-storey buildings but also to any premises connected to other premises, such as semi-detached and terrace premises, where the migration of CO is possible.

– In 5.2.1 and 5.2.2, the use of caravans and boats is included in installation/location information.

– In 5.3, an additional type of apparatus is added, capable of identifying lower concentrations of CO than would be needed to trigger an alarm. Such features are available in certain products, and may be useful to some at-risk groups, especially people who have respiratory health issues.

– In 6.2, the text is modified so that triggering a shut-off valve should be on the main gas supply, ideally at the gas meter/cylinder outlet, so that the entire installation is isolated (and not only individual appliances as stated in the previous version), as the source may not be that appliance.

– In 6.4, the text is modified to state that it is more important that the gas supply is isolated rather than the electrical supply. There is no need to make an exception for a gas appliance with an electrical connection. The carbon monoxide detection apparatus should not be used to operate the mains electrical switch, since such action may create unnecessary hazard for occupants of the premises.

– A new subclause 7.1 "Use of alarm" is added. It includes the requirement to advise the user that a CO alarm does not replace the correct installation, commissioning and regular maintenance by a competent person. This is required in the instruction booklet by EN 50291-1:2010, 4.7.4, item 'n'.

NOTE This was already stated in the introduction to EN 50292 but it is emphasised in the new 7.1.

– In 7.5, text relating to hydrogen interference is added.

– In Clause 8, recommendation to isolate the emergency control valve for gas installations is added.

– In Clause 8, text advising that the Gas Emergency Service Provider should be contacted in the first instance is added.

– A new Figure A.1 is added, showing CO-concentration and exposure time curves for various COHb levels including 2,5 % COHb (the protection level recommended by WHO).

– In A.2, text about health effects on vulnerable groups, derived from WHO, is added.

– Figure B.1 is modified to illustrate how alarm set points in EN 50291-1 align with the 2,5 % and 5 % COHb curves, providing a more practical rationale rather than the previous theoretical one.

Introduction

This European Standard is intended to be a guide for people who, in the course of their professional activities, are required to install apparatus for the detection of carbon monoxide (CO) in domestic premises. It is also aimed at anyone who might supply such detectors to members of the public for subsequent installation according to national regulations, so that advice may be given based on good engineering practice.

Apparatus for the detection of carbon monoxide are not a substitute for good installation and regular servicing of fuel burning appliances or regular cleaning of chimneys, although they may provide an added margin of reassurance for users. Domestic carbon monoxide detectors with or without some form of executive function may overcome fears of fuel safety and may be particularly beneficial in certain circumstances.

It is necessary to understand that carbon monoxide toxicity may have different consequences according to the physical condition of the individual. Thus, a carbon monoxide detector designed according to EN 50291 series may not fully safeguard individuals with specific medical conditions.

Carbon monoxide detectors are not intended to be used as an alternative to a smoke alarm.

1 Scope

This European Standard serves as a guide on the selection, installation, use and maintenance of apparatus for the detection of carbon monoxide, intended for continuous operation in a fixed installation in domestic premises, caravans and boats. This guide is intended to cover any type of domestic or residential accommodation, including leisure accommodation vehicles such as touring and static caravans, and motor homes; and recreational craft such as canal barges. Some static caravans are used as permanent dwellings, in such cases EN 50291-1 is appropriate. For all other types of caravan, EN 50291-2 is appropriate. This guide should be read in conjunction with EN 50291-1 and EN 50291-2 together with any additional relevant national or local regulations.

This European Standard refers to the installation of two types of apparatus:

a) Type A apparatus, to provide a visual and audible alarm and an executive action in the form of an output signal that can be used to actuate directly or indirectly a ventilation or other ancillary device;

b) Type B apparatus, to provide a visual and audible alarm only.

This European Standard excludes apparatus for the detection of combustible gases (see EN 50244) and for industrial installations or commercial premises.

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.

EN 1775, *Gas supply – Gas pipework for buildings – Maximum operating pressure less than or equal to 5 bar – Functional recommendations*

3 Terms and definitions

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

3.1
domestic premises
any house or building, or part thereof, residential park homes, or non-recreational boats such as canal barges, being the place of residence or home of a household, family or person

3.2
fixed installation
apparatus which is intended to have all parts except replaceable batteries permanently installed

3.3
sensor
assembly in which the sensing element is housed that may contain associated circuit component

3.4
sensing element
device, the output of which will change in the presence of carbon monoxide

3.5
continuous operation
apparatus that is continuously powered with continuous or intermittent automatic sensing

3.6
apparatus
carbon monoxide detection device, comprising the sensor, remote sensor if applicable, alarm indicators and any other circuit components, power supply and, for type A apparatus, a means of providing an output signal

Note 1 to entry: Carbon monoxide detection devices may also be generically termed “gas detectors” or “CO alarms”,

3.7
volume ratio
V/V
ratio of the volume of carbon monoxide to the volume of the gas mixture

Note 1 to entry: Volume ratio (V/V) is often expressed in units of parts per million (ppm); it is commonly referred to as concentration.

3.8
output signal
signal characterised by a standby and an activation state, by which action may be initiated

Note 1 to entry: In many cases, such action will entail triggering an ancillary device.

3.9
warm-up time
time interval between the time when the apparatus is switched on and the time when the apparatus is fully operational

3.10
alarm set point
fixed setting of the apparatus that determines the volume ratio and duration of exposure at which the apparatus will automatically initiate an alarm and, for type A apparatus, an output signal

3.11
fault signal
visual, audible or other type of output indicating a faulty or failed apparatus

3.12
mains-powered apparatus
apparatus designed to be powered by the normal domestic mains electrical supply, with or without an additional power source

3.13
battery-powered apparatus
apparatus designed to be powered by batteries only

3.14
leisure accommodation vehicle
vehicles including caravans, caravan holiday homes and motor caravans (EN 13878), also known as touring and static caravans and motor homes

Note 1 to entry: Other motorised vehicles like trucks are known to have residential accommodation. They are not leisure accommodation vehicles but are considered as similar vehicles in this European Standard.

3.15
recreational craft
boat of a minimum length of 2,5 m and a maximum length of 24 m as specified in Directive 94/25/EC, which is intended for sports or leisure purposes

4 Sources of carbon monoxide

4.1 General information

Carbon monoxide is a colourless, odourless, non-irritating gas which is classified as a chemical asphyxiant, whose toxic action is a direct result of the hypoxia produced by a given exposure (see Annex A and Annex B).

4.2 Normal exposure levels

Carbon monoxide can be generated within the home or enter from outside. The normal average background levels of carbon monoxide in domestic premises, measured over periods of 1 h to 24 h, are less than 10 ppm. In cases of climatic inversion, higher levels of carbon monoxide are possible.

4.3 Burning of carbonaceous materials for heating and cooking

4.3.1 General

Most of the carbon monoxide in the environment is produced during combustion of carbonaceous material, e.g. solid fuels (such as coal, coke and wood), liquid fuels (such as oil and petrol) and gaseous fuels (such as natural gas, town gas and liquefied petroleum gas (LPG)).

It should be noted that town gas is still used in some EU countries and it can contain a significant proportion of carbon monoxide prior to combustion.

The proportion and constituents of the combustion products from carbonaceous fuels will depend on the particular fuel and the combustion conditions.

Varying concentrations of carbon monoxide are produced from most combustion processes. Exhaust gases from burning solid and liquid fuels may contain significant concentrations of carbon monoxide: levels of 20 000 ppm to 50 000 ppm (2 % to 5 %) are not unexpected. For example, burning coal, wood or peat can produce concentrations of 20 000 ppm, 40 000 ppm and 50 000 ppm respectively. Efficient burning of natural gas and LPG in well-designed burners in an excess of air will not produce significant flue concentrations of carbon monoxide, usually in the range 10 ppm to 200 ppm. However, poorly maintained and inefficient burners can produce considerably higher levels of carbon monoxide.

Flue reversal may occur under certain climatic conditions with appliances using combustion air taken from within the premises. This is normally a temporary phenomenon that may occur with certain types of appliance, even when correctly maintained.

4.3.2 Space and water heating

Solid, liquid and gaseous fuels may be used for space and water heating. They are used in a variety of ways, either as a local heat source or as a remote central heat source, including

– appliance with flue using room air,

– appliance without flue using room air,

– appliance with flue using external air.

In the case of a defective ducted air heater, carbon monoxide can be distributed into remote rooms.

4.3.3 Cooking

Natural gas, town gas or LPG are the main fuels for cooking, typically using flueless appliances including cooking ranges. In some cases, solid fuels or oil are used in cooking appliances that are generally fitted with flues.

It should be emphasised that barbecue grills using charcoal, emit very high amounts of carbon monoxide and should only be used outdoors and should not be used as air heaters in any leisure accommodation, including tents.

4.4 Uncontrolled burning

Carbon monoxide is a major gaseous product from fires resulting from uncontrolled burning of carbonaceous material. Varying concentrations of carbon monoxide are produced, depending on the material, burning conditions, etc.

4.5 Tobacco smoking

Smoking produces a significant concentration of carbon monoxide.

4.6 Internal combustion engines

A major source of carbon monoxide in the non-industrial environment is the combustion engine. The concentration of carbon monoxide in exhaust gas is normally in the range 1 % to 3 % (10 000 ppm to 30 000 ppm) but may reach 7 % (70 000 ppm) in a badly maintained or badly tuned engine.

The exhaust gases from internal combustion engines (vehicles or electricity generators for example) running in an enclosed space will quickly produce dangerous levels of carbon monoxide.

4.7 Migration of CO

Carbon monoxide produced in one area within an individual dwelling or in connected premises such as semi-detached and terraced premises, maisonettes, and particularly multi-occupancy and multi-storey buildings, can be transported to and leak into another part of the building, e.g. across roof spaces, between floors, along ducting, in shared flues, chimneys and other re-entry points such as air vents.

5 Installation

5.1 General

The manufacturer is required to provide suitable instructions for the correct and safe installation of the apparatus and to indicate on the apparatus and its packaging that these instructions should be read carefully before installing or operating the apparatus.

Generally, the same considerations apply to both type A and type B apparatus.

5.2 Location of the apparatus

5.2.1 General

The design and layout of domestic premises, caravans and boats and the number, type and position of carbon monoxide sources vary widely. General guidance is given in the following clauses on where and where not to locate the apparatus in order to minimise the risk of misleading indications.

5.2.2 Which room?

5.2.2.1 General

Ideally, an apparatus should be installed in every room containing a fuel-burning appliance and additional apparatus should be installed to ensure that adequate warning is given for occupants in other rooms, by locating apparatus

– in remote rooms in which the occupant(s) spend considerable time whilst awake and from which they may not be able hear an alarm from apparatus in another part of the premises, and

– in every sleeping room.

If there is a fuel-burning appliance in more than one room and the number of apparatus is limited, the following points should be considered when deciding where best to position the apparatus:

a) locate the apparatus in a room containing a flueless or open-flued appliance, and

b) locate apparatus in a room where the occupant(s) spend most time.

If the domestic premises are a bedsit (a single room serving as both sitting and bedroom), then the apparatus should be positioned as far from the cooking appliances as possible but near to where the person sleeps.

If the appliance is in a room not normally frequented (for example a boiler room), the apparatus should be positioned so that the alarm may be heard more easily. Alternatively, an interlinked apparatus or a remote alarm siren may be connected to a type A apparatus located in a room(s) containing a fuel-burning appliance.

Where a fuel-burning appliance has an extended and/or concealed flue, an apparatus should be installed in each room through which the flue passes.

5.2.2.2 Caravans and boats

Caravans and boats may have additional risks of carbon monoxide ingress through air vents due to the nearby presence of other vehicles, engines, generators or barbecues; however, this does not change the basic guidance on location of the alarm. Caravans and boats should be fitted with an alarm in the same room as any combustion appliance(s), located in accordance with 5.2.3.3. If the caravan or boat has a single living space which incorporates the sleeping accommodation, it can be considered to be equivalent to a bedsit, and a single alarm is sufficient. However, any sleeping accommodation that is in a separate room from the combustion appliance(s) should also contain an alarm, located in accordance with 5.2.3.4.

5.2.3 Where in the room?

5.2.3.1 General

It should be possible to view all the light indicators when in the vicinity of the chosen location for the apparatus.

It is not possible to give specific guidance on the exact location of a detector that suits all types of room and their usage. The guidance in 5.2.3.2, 5.2.3.3, 5.2.3.4 and 5.2.3.5 should be taken into consideration when determining an optimum location for any appropriate situation.

5.2.3.2 Where not to install the apparatus

The apparatus should not be installed

– in an enclosed space (for example in a cupboard or behind a curtain),
– where it can be obstructed (for example by furniture),
– directly above a sink,

– next to a door or window,
– next to an extractor fan,
– next to an air vent or other similar ventilation openings,
– in an area where the temperature may drop below -10 °C or exceed 40 °C, unless it is designed to do so,
– where dirt and dust may block the sensor,
– in a damp or humid location, or
– in the immediate vicinity of a cooking appliance.

5.2.3.3 Apparatus located in the same room as a fuel-burning appliance

Although carbon monoxide has a similar density to that of ambient air, it will normally be emitted as part of a warm gas mixture and will therefore tend to rise until it cools. If the apparatus is located on a wall, it should be located:

a) close to the ceiling;

b) at a height greater than the height of any door or window.

Where an apparatus is ceiling mounted, it should be at least 300 mm from any wall, and where an apparatus is wall-mounted, it should be at least 150 mm from the ceiling.

The apparatus should be at a horizontal distance of between 1 m and 3 m from the nearest edge of the potential source.

If there is a partition in a room, the apparatus should be located on the same side of the partition as the potential source.

Carbon monoxide alarms in rooms with sloped ceilings should be located at the high side of the room.

5.2.3.4 Apparatus located in sleeping rooms and in rooms remote from a fuel burning appliance

Apparatus located in sleeping rooms and in rooms/areas, e.g. hallways, landings, remote from the fuel-burning appliance should be located relatively close to the breathing zone of the occupants.

5.2.3.5 Apparatus located in caravans and boats

It is not always possible to find an optimum location for an apparatus, for example, a small caravan or boat may not have suitable vertical surfaces available. Nevertheless, when fitting an apparatus in such situations, the two most important considerations when selecting an appropriate location are:

– not mounting the apparatus directly above a source of heat or steam; and
– mounting the apparatus at a distance of 1 m to 3 m from the nearest edge of the potential source.

5.3 Types of apparatus

Various options may be available to the person selecting the apparatus to be installed. For example, some models may include a data logging facility, which could be useful for identifying the conditions under which measurable carbon monoxide concentrations are actually present. Some systems may incorporate sensors other than for carbon monoxide, and care should be taken to avoid confusion between different signals that may require conflicting actions by the user. Such problems might best be overcome by integrating individual apparatus, together with a centralised control and alarm annunciator. However, the main choice is probably between type A or type B apparatus (that is, with or without an executive function, see Clause 6) either of which may involve further considerations as follows:

a) Type A

May be particularly useful for people with some physical disability that might delay a manual response to an alarm. They are more likely to be used in a fixed (rather than portable or transportable) installation, because of the need to transmit an output signal for activation of the ancillary device(s). However, this is not necessarily the case, and future development in communication technologies may allow even greater flexibility, so long as the overall reliability is not compromised.

b) Type B

Intended for either fixed or portable installation, with portable apparatus almost certainly powered from internal batteries alone. Besides the usual siting considerations, special care should be taken with portable units to ensure that they are always properly positioned in relation to the ambient air being sampled. In addition, the user should be cautioned against intermittent operation of the apparatus and dropping or damaging it whilst being re-located.

Apparatus is available, especially for vulnerable/at-risk groups, which has a digital display (in ppm units) allowing identification of lower concentrations of CO than the lowest alarm level specified in EN 50291-1 (50 ppm). Such apparatus will only display the CO concentration after a preset minimum level has been exceeded.

6 Executive functions (type A apparatus only)

6.1 General

Type A apparatus are fitted with an output function for triggering different ancillary devices, as described in 6.2 to 6.7.

6.2 Shut-off valve

If the apparatus is installed in homes equipped with gas appliances, the output signal may be used for triggering a shut-off valve on the incoming mains gas pipe. Such a valve should require a manual action for resetting to the open position. The installation and use shall be in accordance with EN 1775 and national regulations.

6.3 Ventilation fan

Exhaust gases from fuel burning appliances installed in the home may be drawn back from the flue system, if the action of an extractor fan (airflow from inside to outside) is stronger than the flue draught. In the event of a partially or fully blocked flue, the extraction fan may increase the release of exhaust gases into the room, and also the subsequent increased production of carbon monoxide.

A ventilation fan can increase the ventilation rate, provided that the airflow it creates is from outside to inside. It is essential to establish that any fan used to increase ventilation is correctly installed to ensure that the air supply inside the premises is not impaired by airflow from inside to outside.

6.4 Mains electrical switch

The carbon monoxide detection apparatus should not be used to operate the mains electrical switch, since such action may create unnecessary hazard for occupants of the premises.

6.5 Remote alarm

The output signal may be used to activate remote alarm(s). This is particularly recommended for individuals with specific medical conditions and for old or disabled persons.

6.6 Additional visual alarm

Those with impaired hearing should choose a type A apparatus connected to one or more visual indicators. Any delay time between alarm and the triggering output signal should in this case be as short as possible.

6.7 Link between detector and ancillary device

If the detector is linked to an ancillary device, it should be installed in accordance with the manufacturer's instructions. It is recommended that disconnection of the ancillary device should give rise to some kind of indication.

7 Advice to the user

7.1 Use of alarm

The installer should warn the user that installation of the apparatus should not be used as a substitute for proper installation, use and maintenance of fuel burning appliances including appropriate ventilation and exhaust systems.

7.2 Manufacturer’s instructions

Once the carbon monoxide detector has been correctly installed, and tested as necessary, the manufacturer’s instructions on routine operation should be studied thoroughly. The installer should carefully explain all these instructions to the user, paying special attention to 7.2 to 7.7.

NOTE The user may also be the installer.

7.3 Location

The reasons for the location of the apparatus and any special care required, particularly with apparatus mounted near cooking or heating appliances, should be explained to the user, see 5.2. Particular emphasis should be given to the difference between the optimum location for a carbon monoxide detector and that for a combustible gas detector (see also EN 50244).

Some CO alarms may have additional detection capability, for example combined CO and smoke alarms for warning of toxic and fire hazards respectively. It is particularly important that the manufacturer’s instructions on siting should be followed as the optimum location for smoke detection may not be the same as for CO detection. Interlinked alarms are available and may be useful where CO could be present in different locations (see 5.2.2.1 and 6.7).

7.4 Power supply

The installer should emphasise that the apparatus should be powered continuously for maximum safety. It should also be explained that if the home is uninhabited for a long time, or if there is no potential source of carbon monoxide present, the apparatus may be switched off during this period.

7.5 Indicators

All visual and audible indications that may be produced by the apparatus, including differences during initial warm-up and normal operation, should be explained to the user. The meaning of all fault warning signals, including low-battery indication, if relevant, should be described together with the subsequent action that should be taken. The alarm state signal and any reset facilities are of particular importance and should be fully explained, together with recommended actions (see Clause 8). The user should be advised of any in-built delays in the operation of the apparatus, whether between visual and audible indication, or between audible alarm and executive action.

7.6 Alarms

The user's attention should be drawn to the list of possible interfering substances given in the manufacturer's instructions, together with their likely effects on the sensor, either in the short or long term. However, a warning should be given that there could be other compounds occurring within a particular household which could cause similar effects.

It should be pointed out that high concentrations of tobacco smoke may give rise to alarms. The user should be advised that the apparatus may also respond to brief exhaust gas emissions, for example during the initial start-up of an appliance. Also, hydrogen acts as an interferent and can arise from some battery charging activities and the curing of concrete or cement under certain circumstances. Volatile Organic Compounds (VOCs), e.g. alcohols, which may eventually activate the alarm, can be generated from use of damp-proofing materials or other coatings containing alkylalkoxysilanes.

7.7 Maintenance

All routine procedures recommended by the manufacturer (including testing) should be explained to the user. The user should be advised that apparatus failing a routine test should be returned to the installer or supplier, or be replaced.

7.8 Lifetimes

The user should be advised of the manufacturer's recommendations of sensor and/or apparatus lifetime, by means of an indication on the apparatus, visible in the installed position, of the date when the replacement indicated by the manufacturer will be due. For battery-powered apparatus, the user should be advised of the expected battery life and the implication of the low-battery indication. The proper procedure for renewing the battery should be explained, including the battery size and type.

Apparatus may have an automatic end-of-life feature that raises a fault-warning signal when it is necessary to replace the apparatus; the user should be advised of the nature of this indication.

8 Emergency actions

If a carbon monoxide apparatus initiates an alarm signal it is recommended that the following actions are taken in the order given:

1) keep calm and open all doors and windows to increase the rate of ventilation, but see also item a) below. Stop using all fuel-burning appliances and ensure, if possible, that they are turned off, e.g. for gas appliances, isolate the emergency control valve;

2) if the alarm continues to be activated, then evacuate the premises. Leave the doors and windows open, and only re-enter the building when the alarm has stopped. In multi-occupancy and multi-storey premises, ensure that all the occupants are alerted to the risk;

3) get medical help for anyone suffering the effects of carbon monoxide poisoning, see Table A.1, and advise that carbon monoxide inhalation is suspected;

4) telephone the appropriate appliance servicing and/or maintenance agency or, when necessary, the relevant fuel supplier on their emergency number or the national Gas Emergency Service Provider, if appropriate, so that the source of carbon monoxide emissions can be identified and corrected. Unless the reason for the alarm is obviously spurious (see item c) below), do not use the fuel-burning appliances again, until they have been checked and cleared for use by a competent person according to national regulations.

In addition, the following items may modify the actions recommended above and, where appropriate, should be taken into consideration at the time of installing the apparatus.

a) It should be recognised that increasing ventilation rates may actually lead to higher levels of indoor carbon monoxide concentration under certain circumstances. Examples of such an occasion would be from a nearby vehicle exhaust or during extremely bad traffic pollution, especially in cold weather. It is therefore possible that outdoor conditions could be a factor in triggering domestic carbon monoxide alarms.

b) There may be another source of carbon monoxide emission inducing the alarm, for example

   – a large amount of tobacco smoke,

   – town gas,

   – emission from a smouldering fire.

c) The alarm may be induced by other substances. Some sensors may respond to common household substances, such as solvents. The instructions provided by the manufacturer should indicate which substances might give rise to alarms.

d) Particular situations could result in exposure to emissions from neighbouring premises, especially in multi-occupancy and multi-storey properties. There may be special problems with shared or poorly-sited flues, for example, which could lead to ingress of carbon monoxide from elsewhere in the same building. Such possibilities should be fully investigated when installing the apparatus.

e) Type A apparatus provides an output signal which may be used to activate an ancillary device, such as a ventilation fan or gas shut-off valve, see Clause 7. Once triggered, these devices may need to be manually reset, but this should not be done until the source of carbon monoxide has been identified and the fault corrected. In all other respects, the same emergency procedure should be followed as for type B apparatus.

f) Care should be taken with battery-powered apparatus, since the cessation of an alarm may be due to the battery being discharged, rather than a lowering of ambient carbon monoxide level. The premises should be re-entered with care and only after checking carbon monoxide concentrations to confirm the absence of the hazard.

Annex A
(informative)

Health effects

A.1 Toxic effects

Carbon monoxide (CO) is a colourless, odourless, non-irritating gas classified as a chemical asphyxiant and whose toxic action is a direct result of the hypoxia produced by a given exposure.

CO is rapidly absorbed through the lungs, diffuses across the alveolar capillary membrane and is reversibly bound with haemoglobin as carboxyhaemoglobin (COHb), however, a minute amount is present in the plasma. The affinity of haemoglobin for CO is over 200 times its affinity for oxygen. This reduces the oxygen carrying capacity of the blood, and has an effect on the dissociation of oxyhaemoglobin, which further reduces the oxygen supply to the tissues. CO is chemically unchanged in the body, and is eliminated in expired air. The elimination is determined by the same factors that applied during absorption. The half-life while breathing room air is 2 h - 6,5 h depending on the initial COHb level [6].

If the CO level in the inhaled air is constant, the level of COHb in the blood will approach an equilibrium (saturation) state after several hours. However, the rate at which the equilibrium is reached depends on many factors, e.g. lung ventilation rate (physical activity) and alveolar capillary transfer, cardiac parameters, blood haemoglobin concentration, barometric pressure, oxygen and carbon dioxide concentration in the inhaled air, but the two most important factors in determining the COHb level are the CO concentration and the duration of exposure.

The effects of different saturation blood COHb levels on healthy adults are shown in Table A.1.

Table A.1 – Health effects of COHb blood levels on healthy adults

% COHb	Effects
0,3 – 0,7	Normal range in non-smokers due to endogenous CO production
0,7 – 2,9	No proven physiological changes
2,9 – 4,5	Cardio-vascular changes in cardiac patients
4 – 6	Usual values observed in smokers, impairment in psychomotor tests
7 – 10	Cardio-vascular changes in non-cardiac patients (increased cardiac output and coronary blood flow)
10 – 20	Slight headache, weakness, potential burden on foetus
20 – 30	Severe headache, nausea, impairment in limb movements
30 – 40	Severe headache, irritability, confusion, impairment in visual acuity, nausea, muscular weakness, dizziness
40 – 50	Convulsions and unconsciousness
60 – 70	Coma, collapse, death
Source: U.S. Environmental Protection Agency 1984	

The relationship between the CO concentration and the duration of exposure can be calculated for a given %COHb, by parameterising the above factors. Figure A.1 shows examples for a person undertaking light/moderate exercise.

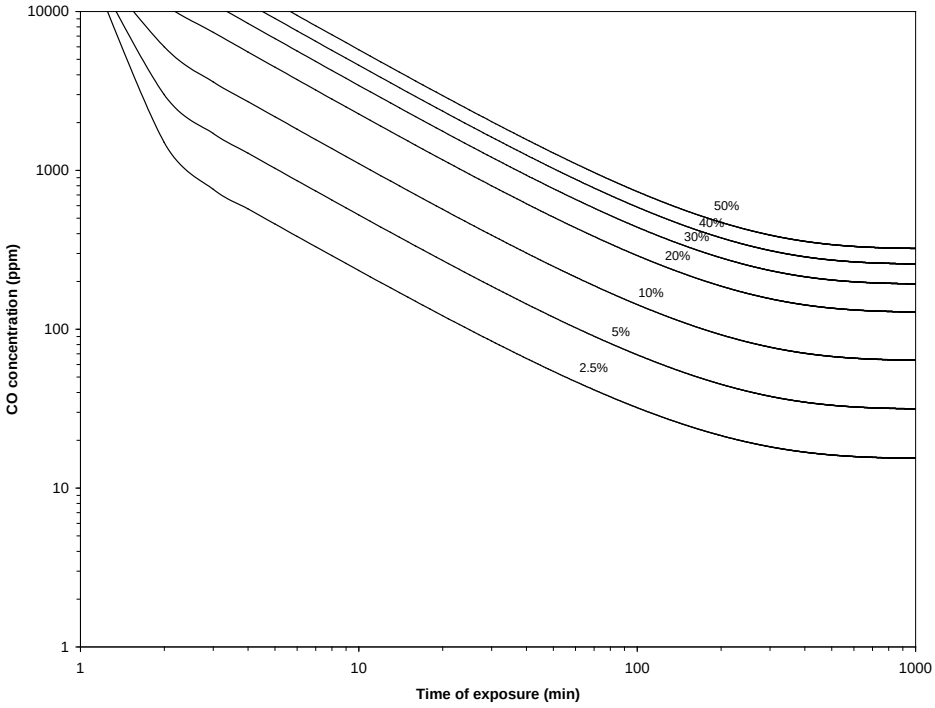


Figure A.1 – Relationship between CO concentration and exposure time for various %COHb (light/moderate exercise)

A.2 Chronic effects on high risk groups

Individuals with coronary artery disease exposed to low levels of CO show reduced ability to exercise and the time of onset of exercise-induced angina pectoris in such patients exposed to low levels of CO is reduced.

Carbon monoxide readily crosses the placental barrier and may endanger the normal development of the foetus.

A number of high-risk groups are particularly sensitive to the effects of CO because of various organ impairments or specific changes [6], mainly:

a) those whose oxygen carrying capacity is decreased due to anaemia or other haemoglobin disorders;

b) those with increased oxygen needs such as those encountered in fever, hyperthyroidism or pregnancy;

c) those with systemic hypoxia due to respiratory insufficiency;

d) those with heart disease and any vascular insufficiency.

WHO guidance [6] states that in order to protect non-smoking, middle-aged and elderly population groups with documented or latent coronary artery disease from acute ischaemic heart attacks, and to protect the foetuses of non-smoking pregnant women from untoward hypoxic effects, a COHb level of 2,5 % should not be exceeded. The following WHO guideline values and periods of time-weighted average exposures have been determined in such a way that the COHb level of 2,5 % is not exceeded, even when a normal subject engages in light or moderate exercise:

- 100 mg/m³ (90 ppm) for 15 min;
- 60 mg/m³ (50 ppm) for 30 min;
- 30 mg/m³ (25 ppm) for 1 h;
- 10 mg/m³ (10 ppm) for 8 h.

A.3 Normal COHb levels

Under normal conditions, humans typically have low levels of COHb of between 0,3 % and 0,7 % present within the body. These levels are considered neither beneficial nor harmful.

A.4 Tobacco smoking

Tobacco smokers are exposed to significant concentrations of CO. In cigarette smokers, the COHb concentration varies between 5 % - 9 %, while heavy cigar smokers may exceed 10 %.

Annex B
(informative)

Philosophy of setting alarm points

As stated in Annex A, the level of carboxyhaemoglobin (COHb) in the blood is a function of the carbon monoxide (CO) concentration in air, the duration of exposure and other parameters based, for example, on the activity levels of the person exposed.

It is necessary for the gas detection apparatus to give an alarm before the level of COHb in the blood reaches an unacceptable level, in order to prevent intoxication by carbon monoxide. Firstly, this maximum acceptable level of COHb shall be set, based on medical evidence. The relationship between carbon monoxide concentration in air and duration of exposure for a various levels of COHb, expressed as a percentage, is indicated in Figure B.1 as the solid curves.

All combinations of CO concentration and time above the curve are deemed unacceptable while those below the curve are deemed acceptable. Ideally, the response characteristics of the apparatus should mimic this curve profile, i.e. the apparatus response produces an alarm when combinations of CO concentration and exposure times are above the curve but does not produce an alarm when combinations of CO concentration and exposure times are below the curve. Setting appropriate alarm set points based on combinations of CO concentration and exposure time forms a basis of testing whether an apparatus is capable of providing adequate protection against unacceptable COHb levels. A number of alarm set points may be specified; Figure B.1 illustrates the principle using the combinations of concentration and time to produce the three alarm set points specified in EN 50291-1.

Ideally, a low concentration is chosen as the first alarm point so that the maximum acceptable level of COHb is never attained even at saturation (equilibrium). If this low, first alarm point is not achievable because of technological considerations (e.g. detection limit of apparatus not low enough), then a new, higher alarm point is chosen. In EN 50291-1, this first alarm point is specified as 50 ppm. In addition, a concentration is specified below which no alarm activation shall take place, so as to reduce false alarms caused, for example, by air pollution in the ambient air. In EN 50291-1, this concentration is set at 30 ppm and, for testing purposes, a sufficiently long but convenient minimum time (120 min) is specified, as shown in Figure B.1.

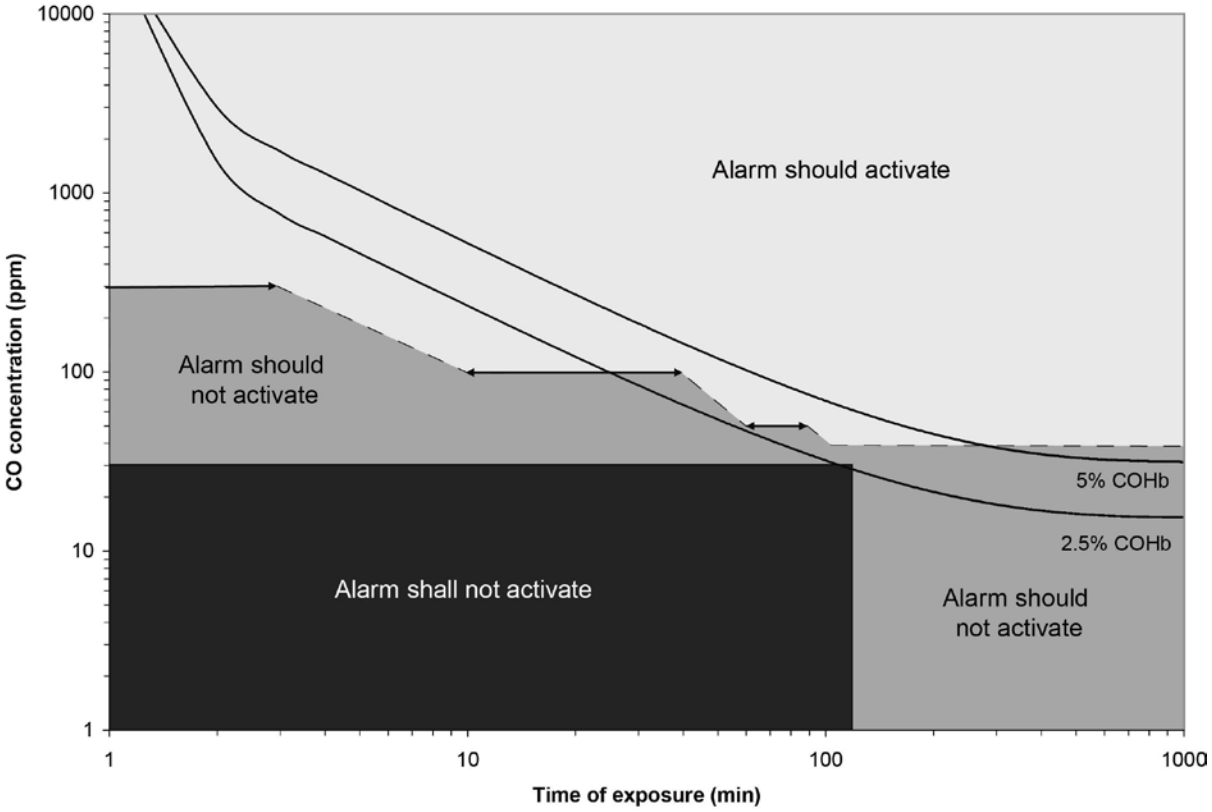
Values for the combinations of concentration and time for alarm set points are chosen such that they lie below the maximum acceptable COHb curve (see A.2 for guidance). Other considerations when choosing alarm set points include avoiding the activation of an alarm when high CO concentrations are present for short time periods caused by transient concentrations of CO arising from, for example, cold starting of a fuel burning appliance. For the situation shown in Figure B.1, the apparatus alarms according to EN 50291-1 at:

a) concentrations greater than or equal to 50 ppm within 60 min to 90 min; but

b) concentrations greater than or equal to 100 ppm within 10 min to 40 min; but

c) concentrations greater than or equal to 300 ppm before 3 min.

It is left to the alarm manufacturer to ensure that the response of the apparatus to CO and its response time characteristics allow the apparatus to be activated within the times specified above for various CO concentrations, so as to comply with EN 50291-1.



NOTE The dashed transition lines at the ends of the three-alarm set point ranges (at 50 ppm, 100 ppm and 300 ppm CO) are not defined by this European Standard, they are shown for diagrammatic purposes only.

Figure B.1 – CO alarm activation regions based on the requirements of EN 50291-1

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