

Electronic portable and transportable apparatus designed to detect and measure carbon dioxide and/or carbon monoxide in indoor ambient air - Requirements and test methods

Matériels électroniques portables et transportables de détection et de mesure du dioxyde de carbone et/ou du monoxyde de carbone dans l'air ambiant intérieur des locaux - Exigences et méthodes d'essai

Tragbare und transportable elektrische Geräte für die Detektion und Messung von Kohlendioxid und/oder Kohlenmonoxid in Innenraumluft - Anforderungen und Prüfverfahren

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 216, Gas detectors.

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

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1 Scope

This European Standard specifies requirements for the construction, testing and performance of electronic portable and transportable apparatus for the detection and measurement of carbon dioxide (CO₂) and/or carbon monoxide (CO) in indoor ambient air, which includes air entering mechanical ventilation systems in domestic residential, commercial and industrial premises and public buildings.

This European Standard includes indoor air quality apparatus with CO and CO₂ measuring capabilities.

This European Standard excludes:

- apparatus used in workplace atmospheres for the direct detection and direct concentration measurement of toxic gases and vapours (i.e. conforming to EN 45544 series);
- electronic portable combustion gas analysers (i.e. conforming to EN 50379 series);
- apparatus for the detection of carbon monoxide in domestic premises (i.e. conforming to EN 50291 series).

NOTE 1 Examples of applications are monitoring indoor air quality, measuring CO and/or CO₂ concentrations in commercial laundry and kitchen environments, assessing the safe operation of appliances installed in compartments.

NOTE 2 When this apparatus is used in industrial premises national regulations may apply.

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.

EN 50270:2006, *Electromagnetic compatibility – Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen*

EN 50271:2010, *Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen – Requirements and tests for apparatus using software and/or digital technologies*

EN 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal) (IEC 60068-2-6)*

EN 60335-1:2002 + corr. Jul. 2009 + corr. May 2010, *Household and similar electrical appliances – Safety – Part 1: General requirements (IEC 60335-1:2001, mod.)*

EN 60529:1991 + corr. May. 1993, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

3 Terms and definitions

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

3.1

ambient air

normal atmosphere surrounding the apparatus

NOTE The concentration of CO₂ in ambient air is typically different from the concentration in outdoor air.

3.2

clean air

air that contains CO₂ at outdoor air concentrations but is free of CO and other gases and vapours to which the sensor is sensitive or which influence the performance of the sensor

3.3

battery-powered

apparatus designed to be energized from batteries alone, whether disposable or rechargeable

3.4

mains powered apparatus

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

3.5

calibration

process of determining the deviation of a measuring apparatus relative to a certified calibration gas cylinder

3.6

adjustment

process of tuning the apparatus, in order to return the deviation found in calibration to within the admissible error

3.7

aspirated apparatus

gas detection apparatus that obtains the gas by drawing it through a sample line to the gas sensor, for example, by means of a hand-operated or electric pump

3.8

diffusion apparatus

apparatus in which the transfer of gas from the atmosphere to the gas sensor takes place by random molecular movement, i.e. under conditions in which there is no aspirated flow

3.9

domestic residential premises

unit of residential accommodation including residential park homes, flats, bed-sits, maisonettes, terraced, semi-detached and detached houses (including all such residential accommodation situated within or forming part of commercial or industrial or agricultural premises), leisure accommodation vehicles and recreational craft

NOTE It is recognized that the guidance can be applied to premises other than dwellings, such as those supplying a small number of clients on a bed and breakfast basis.

3.10

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

NOTE For the purposes of this European Standard the word 'boat' should be taken to mean 'recreational craft'.

3.11

leisure accommodation vehicles

unit of living accommodation for temporary or seasonal occupation that may meet requirements for construction and use of road vehicles

3.12

probe

part of the measuring system that is placed in ambient air (including air entering a mechanical ventilation system) for the purpose of sampling the gas

3.13

gas concentration

amount of CO₂ and/or CO present expressed as parts per million or percent by volume

NOTE Parts per million (ppm) measurements can be expressed as parts per million (volume) (ppm_v).

3.14

test gas

synthetic air or nitrogen containing a known concentration of CO₂ and/or CO

3.15**portable apparatus**

apparatus that has been designed to be carried readily from place to place and to be used while it is being carried

3.16**transportable apparatus**

apparatus not intended to be portable but which can be readily moved from place to place

3.17**response time**

t_{90}
time interval with the apparatus in a warmed-up condition, between the time when an instantaneous variation of the parameter to be measured is produced at the apparatus inlet, and the time when the response reaches and remains beyond 90 % of the final indication

3.18**sensor**

assembly in which the sensing element is housed, and which can contain associated electronic components

3.19**indoor air quality apparatus**

apparatus used to determine the condition of the air inside buildings, often used for analysing the efficiency of air filtration and ventilation systems

NOTE The apparatus can be designed to measure a number of different parameters such as gaseous composition, temperature, relative humidity and airborne contaminant levels.

3.20**electronic portable combustion gas analyser**

electronic apparatus that will detect and measure the presence of combustion gases and display the result

3.21**warm up period**

time taken for the apparatus to reach the manufacturer's specified operating performance from switch on, or following power failure in the case of mains powered equipment

4 General requirements**4.1 Construction****4.1.1 General**

All parts of the apparatus, including the sensors and probe, shall be constructed of materials that will not be affected by vapours and gases or chemical substances typically found in the environment in which it is intended to be used [see 4.2.2 c)].

The apparatus shall conform to IP40, in accordance with EN 60529:1991, Clauses 12 and 14.

Adjustments that might affect the performance of the apparatus shall be suitably protected against unauthorized changes, such as through the use of passwords, tamper-evident seals or special tools.

4.1.2 Power supplies

Apparatus which derives its power from internal batteries may give a visual warning before the battery capacity falls to a point where either the apparatus sensitivity or the stated display accuracy falls outside the requirements. When this point is actually reached, a clear indication shall be given to alert the user and the display shall switch out of normal operational mode.

Apparatus provided with the means of connection to the mains supply shall conform to relevant EN standards.

NOTE This area is covered by various statutory regulations.

4.1.3 Indicators

4.1.3.1 Indicators shall be provided to show:

- a) measured parameter, values and units of measurement;
- b) low battery warning for battery-powered apparatus;
- c) for aspirated apparatus with an integrated flow indicator, a warning when a blockage occurs (see 5.3.14);
- d) mode of operation or apparatus status (e.g. warm-up and measurement);
- e) when values lie outside the indicating range.

All values shall be indicated on a display with characters not less than 8 mm high, unless adequate provision is made for enhancing the legibility (e.g. backlighting), in which case the minimum character height shall be 4 mm.

For each separate parameter measured the apparatus shall display the value, the physical unit and parameter description. For a combination of parameters the display may switch automatically from one indication to another. If the display switches between information of simultaneous parameters it shall be clear and understandable. Displayed measured values shall be refreshed at intervals no greater than 3 s. If the apparatus is equipped with seven-segment displays it shall have a device or self testing function for checking the displays.

4.1.3.2 For aspirated apparatus, a means shall be provided to recognise and/or indicate the working mode of the pump (or a blockage of the gas path) by, for example:

- audible warning;
- visual indication; or
- flow measurement.

4.1.4 Range, resolution, accuracy and response time

4.1.4.1 Table 1 lists the different parameters covered by this European Standard. For each parameter given it specifies the:

- minimum indication range;
- maximum display resolution;
- accuracy of the apparatus;
- maximum response time.

4.1.4.2 The indication ranges are the minimum ranges for the apparatus. Higher ranges are allowed, but will not change the values for accuracy, resolution or response time.

Table 1 – Requirements for range, resolution, accuracy and response time

Parameter	Indication range ppm	Resolution	Accuracy	Response time (t_{90})
CO	0 to 100	1 ppm	± 3 ppm (≤ 20 ppm) ± 5 ppm (> 20 ppm)	≤ 50 s (aspirated apparatus) ≤ 120 s (diffusion apparatus)
CO ₂ (low)	0 to 6 000	50 ppm	± 10 % of reading or ± 5 % of range, whichever is the greater	≤ 50 s (aspirated apparatus) ≤ 120 s (diffusion apparatus)
CO ₂ (high)	$> 6 000$	100 ppm	± 10 % of reading or ± 5 % of range, whichever is the lesser	≤ 50 s (aspirated apparatus) ≤ 120 s (diffusion apparatus)

4.1.5 Printer or data transfer facility

When the apparatus is provided with a printer or data transfer facility, it shall print or communicate the date, time, measured parameter, values and units of measurement specified in 4.1.3 taken at the time of the measurement.

4.2 Labelling and instructions

4.2.1 Labelling

4.2.1.1 Durable labels shall be carried on the apparatus, or moulded into the casing, giving:

- a) the manufacturer's or supplier's name, trademark or other means of identification;
- b) the type of apparatus, e.g. "CO₂ and CO gas analyser", and model name or number;
- c) the number and year of this European Standard;
- d) the manufacturer's serial number or other unique apparatus identification;
- e) the replacement battery and mains power requirements if relevant.

4.2.1.2 Item 4.2.1.1 b) shall be clearly visible during normal operation.

4.2.1.3 Item 4.2.1.1 e) shall be clearly visible if the batteries are being changed.

4.2.1.4 The durability of any external label shall be tested in accordance with EN 60335-1:2002, 7.6 and 7.14, after which the label shall not be removable and shall be legible with no curling.

4.2.2 Instructions

The apparatus shall be provided with an instruction booklet or leaflet. This shall give complete, clear and accurate instructions for the safe and proper operation, handling and regular checking of the apparatus, and shall include:

- a) the correct battery types and method of replacing or recharging batteries for battery powered units, details of mains voltage, frequency and fuse rating, if relevant, and warning of the possible hazards of electric shock or malfunction, if tampered with;
- b) an explanation of all warning and other indications;
- c) a list of commonly occurring materials, vapours or gases (e.g. cleaning fluids, polishes, paints and cooking operations) that might affect the operation or reliability of the apparatus in the short or long term;
- d) guidance on the life expectancy of the apparatus and batteries;
- e) details of the operational limitations including temperature, humidity and pressure ranges;
- f) a warning of potential error due to CO₂ solubility in water if the apparatus contains a water trap or filter;
- g) a warning of potential error if the apparatus is susceptible to changes in ambient light levels;
- h) details of the storage limitations including temperature and humidity ranges;
- i) details of procedure for switch on, including warm-up period;
- j) instructions for the disposal of the apparatus at the end of its working life;
- k) instructions for checking, testing and/or calibration and adjustment of the apparatus on a routine basis;
- l) instructions for checking, testing and/or replacing sensors, dust filters and water traps (where applicable).

NOTE This area is covered by various statutory regulations.

5 Testing

5.1 General

5.1.1 Sample, sequence and requirements of tests

5.1.1.1 For the purposes of type testing, three samples of the apparatus shall be subjected to the tests given in 5.3.2 to 5.3.18 and the apparatus shall meet the performance requirements in Table 1 of 4.1.4 (excluding 5.3.15).

NOTE The tests in 5.3.2 to 5.3.18 may be performed in a sequence chosen at the discretion of the test laboratory. If agreed by the manufacturer and the test laboratory, it is permissible for one gas test to be performed after the impact, vibration and drop tests 5.3.8, 5.3.9 and 5.3.10, rather than a gas test after each individual test.

5.1.1.2 If the apparatus consists of separate measuring and display elements they shall be considered as a single unit for the purposes of these tests.

5.1.2 Preparation of sample apparatus

5.1.2.1 The sample apparatus shall be prepared in accordance with the manufacturer's instructions (see 4.2.2).

5.1.2.2 If the apparatus has the facility to calibrate in ambient air, the apparatus shall be calibrated in clean air with a known CO₂ concentration before each test.

5.1.3 Test facility

The apparatus shall be tested in a suitable test chamber and/or gas delivery system to present test gases to the sensor. The construction of the test chamber and/or gas delivery system shall be such as to ensure that the gas sensor is exposed to a specific concentration of test gas in a reproducible manner.

5.2 Conditions for tests

5.2.1 Test gas

The apparatus shall be tested using the test gases given in Table 2 and/or Table 3.

Table 2 – CO₂ test gases

Level	CO ₂ concentration ppm
1	450 to 500
2	1 500 to 3 000
3	4 500 to 6 000
4	> 15 000 (only where the apparatus covers this range)
Total uncertainty of test gas concentrations shall be within ± 2 % relative.	

Table 3 – CO test gases

Level	CO concentration ppm
1	0
2	15 to 20
3	80 to 100
Total uncertainty of test gas concentrations shall be within ± 2 % relative, except Level 1 which shall be less than 2 ppm.	

5.2.2 Speed of test gas

The speed of air or test gas in the test chamber shall be between 0,1 m/s and 0,5 m/s.

NOTE In the case of a mask or direct gas connection to the apparatus, the requirements of 5.1.3 apply, in accordance with manufacturers' instructions.

5.2.3 Power supply

Unless otherwise specified for the particular test, the mains voltage shall be within either ± 2 % of the nominal value or the range of values quoted by the manufacturer. Battery powered apparatus shall be fitted with new or fully charged battery/batteries at the start of each test.

5.2.4 Temperature

Unless specified for a given test, the apparatus shall be held at a constant temperature ± 2 °C within the range of 15 °C to 25 °C throughout the duration of the test.

5.2.5 Humidity

5.2.5.1 Unless otherwise specified for the particular test, the ambient air shall be at a constant relative humidity ± 10 % r.h., within the range 30 % r.h. to 70 % r.h. for the duration of each test.

5.2.5.2 The test gas applied to the apparatus shall be at a constant relative humidity of less than 10 % r.h., except during the humidity test in 5.3.5.

5.2.6 Atmospheric pressure

The test shall be performed at any ambient atmospheric pressure between 86 kPa and 108 kPa and shall be recorded during each test with a total uncertainty of not greater than ± 1 kPa.

5.3 Test methods

5.3.1 Procedure

5.3.1.1 Each test condition shall be varied separately, while the other conditions remain as defined in 5.2, unless otherwise stated.

5.3.1.2 The test procedure to be used for 5.3.2 to 5.3.18 shall be as follows:

- a) Switch on the apparatus and its pump (if fitted) and allow it to stabilize for the warm-up period recommended by the manufacturer.
- b) If intended for CO₂ expose the apparatus to:
 - 1) test gas 1, Table 2, for (180 ± 10) s;
 - 2) clean air for at least 180 s to purge the apparatus;
 - 3) all other relevant levels of test gases in Table 2 in turn, each followed by 2) above.
- c) If intended for CO expose the apparatus to:
 - 1) test gas 1, Table 3, for (180 ± 10) s;
 - 2) test gas 2, Table 3, for (180 ± 10) s;
 - 3) clean air for at least 180 s to purge the apparatus;
 - 4) test gas 3, Table 3, for (180 ± 10) s.

5.3.2 Unpowered storage

Expose the apparatus (including the battery, if the manufacturer supplies this item with the product) sequentially to a temperature of (-10 ± 2) °C for 24 h, (20 ± 2) °C for 24 h, (40 ± 2) °C for 24 h and (20 ± 2) °C for 24 h. Energize the apparatus and test in accordance with 5.3.1, using all test gases as appropriate for CO₂ and/or CO.

5.3.3 Supply voltage

For mains powered apparatus, stabilize with a power supply voltage of 207 V r.m.s. and test in accordance with 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3. Repeat with a power supply voltage of 253 V r.m.s.

5.3.4 Temperature

5.3.4.1 Steady-state

Stabilize the apparatus at (5 ± 2) °C for at least 1,5 h, then test in accordance with 5.3.1, using all test gases. Stabilize the apparatus at (20 ± 2) °C for at least 1,5 h, but do not apply test gases. Stabilize the apparatus at (40 ± 2) °C for at least 1,5 h, then test again in accordance with 5.3.1, using all test gases as appropriate for CO₂ and/or CO.

5.3.4.2 Transient

Switch on and stabilize the apparatus in clean air at (20 ± 2) °C for the warm up period. Transfer the apparatus, within 5 s, into a test chamber at (40 ± 2) °C. Apply test gas 2 of Table 2 and/or test gas 3 of Table 3. Take a reading at 3 min and 10 min after application of the test gas.

5.3.5 Humidity

5.3.5.1 Steady-state

Stabilize the apparatus at (90 ± 5) % r.h. and (40 ± 2) °C for at least 1 h. Test the apparatus in accordance with 5.3.1, using test gas 1 and the highest suitable concentration of test gas of Table 2 and/or Table 3.

NOTE Low temperature, low humidity tests are a part of 5.3.4.1.

5.3.5.2 Transient

Switch on and stabilize the apparatus in clean air at (40 ± 10) % r.h. and (20 ± 2) °C for the warm up period. Transfer the apparatus, within 5 s, into a test chamber at 90 % r.h. to 95 % r.h. and (40 ± 2) °C. Apply test gas 2 of Table 2 and/or test gas 3 of Table 3. Take a reading at 10 min and 20 min after application of the test gas.

5.3.6 Atmospheric pressure variation

Switch on and stabilize the apparatus in the test chamber at ambient conditions as specified in 5.2 for the warm up period. Apply test gas 2 of Table 2 and/or Table 3 for sufficient time to flush the chamber and stabilize the displayed reading. Increase the pressure in the test chamber by (10 ± 1) kPa within 30 s. Take a reading at 3 min after pressure is stable.

5.3.7 Low battery warning

For battery powered apparatus, remove the battery and connect the apparatus to a stabilised power supply and set to the rated battery voltage. Decrease the supply voltage in steps of 0,1 V at intervals of at least 1 min, until the low battery warning is given. Record the supply voltage at which the low battery warning is given as U_e . Set the supply voltage one step above U_e and test in accordance with 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3.

5.3.8 Impact strength

The apparatus shall be tested in accordance with the test specified in EN 60335-1:2002, Clause 21 with the following modification to the third paragraph:

“The apparatus is rigidly supported, and three blows are applied to every point of the enclosure that is likely to be weak with an impact energy of $(1,0 \pm 0,2)$ J”.

The apparatus shall be subjected to this test in a case intended to provide protection during normal operation, if one is supplied with the apparatus. Subject the apparatus to test gas 2 of Table 2 and/or test gas 3 of Table 3.

5.3.9 Vibration

The appropriate test, as defined in EN 60068-2-6, shall be applied with the following parameters:

- a) 10 Hz to 60 Hz, 0,35 mm vibration amplitude;
- b) 61 Hz to 150 Hz, 5 g peak acceleration;
- c) ten sweep cycles on all three mutually perpendicular axes.

After return to normal test conditions, test in accordance with 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3.

5.3.10 Drop

Drop the apparatus, including the probe and any interconnecting wiring and tubing, in its normal orientation from a fall height of 0,5 m onto concrete. The apparatus shall be subjected to this test in a case intended to provide protection during normal operation, if one is supplied with the apparatus. After return to normal test conditions, test in accordance with 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3.

5.3.11 EMC

Subject the apparatus, including the probe and any interconnecting wiring and tubing, in clean air for electromagnetic compatibility as specified in EN 50270:2006, Table 5, 5.10.

5.3.12 Battery reversal

For apparatus containing user-replaceable batteries, attempt to insert the battery/batteries the wrong way around. Switch the apparatus on for 1 min. Afterwards, remove the battery/batteries and re-insert with the correct polarity and then power the apparatus and test in accordance with 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3.

5.3.13 Operational stability

5.3.13.1 Continuous operation

If the apparatus is intended to be operated without adjustments for periods in excess of 24 h, then it shall be subjected to a stability test. Repeat the procedure given in 5.3.1, using test gas 2 of Table 2 and/or test gas 3 of Table 3, at 24 h intervals during continuously powered operation for a period of five days, and then carry out a subsequent test one week later, with the apparatus switched on during this period.

5.3.13.2 Intermittent operation

If the apparatus is intended for intermittent monitoring (i.e. for periods of less than 24 h), turn it on and off in clean air 50 times. The duration of each operation shall be equal to the manufacturer's stated warm-up period; 1 min shall elapse after each operation. At the end of the 50 operations, expose the apparatus to test gas 2 of Table 2 and/or test gas 3 of Table 3, in accordance with 5.3.1.

NOTE Batteries may be recharged or replaced as necessary.

5.3.14 Sample flow

5.3.14.1 For aspirated apparatus, block the sample line. Check the apparatus to ensure that a warning of the blockage is given.

5.3.14.2 For continuously pumped apparatus, reduce the flow of sample through the apparatus to the minimum specified in the instruction manual. Expose the apparatus to test gas 1 and the highest concentration of test gas of Table 2 and/or Table 3, in accordance with 5.3.1.

5.3.15 Response to other gases

5.3.15.1 If intended for CO₂, expose the apparatus to test gas 3 of Table 3 for 3 min. The CO₂ reading shall not change.

5.3.15.2 If intended for CO, expose the apparatus to ethanol at a volume ratio of (200 ± 20) ppm for 3 min. The CO reading shall not change by greater than 10 ppm.

5.3.16 Response time

If the manufacturer supplies different types of accessories or optional filters, water traps and/or probes, then test the apparatus under the conditions which give the longest response time.

Expose the apparatus to a step change from ambient air to the test gas with the highest concentration of Table 2 and/or Table 3 used in 5.3.1.

5.3.17 Air velocity

Test apparatus with sensors that operate by diffusion in a flow chamber under conditions of no forced ventilation and at a speed of 2 m/s, using:

- a) ambient air with a known concentration of CO₂, free from CO; and
- b) the test gas with the highest concentration of Table 2 and/or Table 3 used in 5.3.1.

Position the sensor in relation to the direction of the flow such that the flow reaches the apparatus from each of three mutually perpendicular directions.

Do not test directions of flow which are not likely to occur in practice, due to the design of the apparatus, or which are expressly prohibited by the manufacturer.

5.3.18 Sensor replacement

If the manufacturer allows the replacement of sensing elements by the user, replace the sensing elements after the final test by new elements, in accordance with the instructions in the manual. After replacement, switch on the apparatus, allow the device to warm up and test in accordance with 5.3.1, using all test gases in Table 2 and/or Table 3 as appropriate.

5.3.19 Software and digital techniques

Software and digital components shall comply with the following clauses of EN 50271:2010: 4.1.1 to 4.1.3, 4.4, 5.1 and 5.2 including 5.1 c) requiring a software documentation according to 4.3.4.

Bibliography

EN 45544 series, *Workplace atmospheres – Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours*

EN 50291 series, *Electrical apparatus for the detection of carbon monoxide in domestic premises*

EN 50379 series, *Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances*

Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft, OJ L 164, 30.6.1994, p. 15-38
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