# INTERNATIONAL STANDARD

# ISO 4224

First edition
2000-03-01

# Ambient air — Determination of carbon monoxide — Non-dispersive infrared spectrometry method

*Air ambiant — Dosage du monoxyde de carbone — Méthode par spectrométrie dans l'infrarouge selon un procédé de type non dispersif*



Reference number
ISO 4224:2000(E)

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 4224 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 3, *Ambient air*.

Annexes A, B and C form a normative part of this International Standard.

## Introduction

Determination of carbon monoxide (CO) is an essential component of the evaluation of many air pollution complexes. Carbon monoxide is formed in the process of incomplete combustion of hydrocarbon fuels, and is a constituent of the exhaust of gasoline engines. Various national air quality regulatory bodies have established air quality standards for CO that are designed to protect the public health and welfare.

# Ambient air — Determination of carbon monoxide — Non-dispersive infrared spectrometry method

## 1 Scope

This International Standard specifies a non-dispersive infrared spectrometry method for the continuous analysis and recording of the carbon monoxide (CO) content of the ambient air.

The method is applicable to the determination of carbon monoxide concentrations from 0,6 mg/m$^3$ (0,5 ppm volume fraction) to 115 mg/m$^3$ (100 ppm volume fraction).

The method has a lower limit of detection of about 0,06 mg/m$^3$ (0,05 ppm volume fraction) carbon monoxide in air.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.



ISO/TR 4227, *Planning of ambient air quality monitoring.*

ISO 6141, *Gas analysis — Requirements on certificates for gases and gas mixtures.*

ISO 6142, *Gas analysis — Preparation of calibration gas mixtures — Gravimetric method.*

ISO 6143, *Gas analysis — Determination of composition of calibration gas mixtures — Comparison methods.*

ISO 6144, *Gas analysis — Preparation of calibration gas mixtures —- Static volumetric method.*

ISO 6146, *Gas analysis — Preparation of calibration gas mixtures — Manometric method.*

ISO 6147, *Gas analysis — Preparation of calibration gas mixtures — Saturation method.*

ISO 6879, *Air quality — Performance characteristics and related concepts for air quality measuring methods.*

ISO 9169, *Air quality — Determination of performance characteristics of measurement methods.*

## 3 Principle

An atmospheric sample is introduced into a sample conditioning system and then into a non-dispersive infrared spectrometer (NDIR).

The spectrometer measures the absorption by CO at 4,7 µm [1] using two parallel infrared beams through a sample cell, a reference cell and a selective detector. The detector signal is fed to an amplifier control section and the analyser output measured on a meter and recording system.

Some instruments use gas filter correlation to compare the IR absorption spectrum between the measured gas and other gases present in the sample, in a single sample cell. These instruments utilize a highly concentrated sample of CO as a filter for the IR transmitted through the sample cell, to yield a beam that cannot be further attenuated by the CO in the sample and thus acts as a reference beam. The broadband radiation that passes through the sample cell and the CO filter is filtered again by a narrow-bandpass filter that allows only the CO-sensitive portion of the band to pass to the detector. The removal of wavelengths sensitive to other gases reduces interferences.

The concentration of CO in the sample is determined from a calibration curve [2].

## 4 Interferences

### 4.1 General

The degree of interference which occurs varies among individual NDIR instruments. Consult the manufacturer's specifications for the particular analyser to determine whether interferences render the instrument unsuitable for the proposed use.

### 4.2 Water vapour



The primary interferant is water vapour, and is a function of the water vapour content in the sample gas. With no correction, the error may be as high as 11 mg/m$^3$ (10 ppm volume fraction) [5].

Water vapour interference can be minimized by using one or more of the following procedures:



a) passing the air sample through a semi-permeable membrane or a similar drying agent;

b) maintaining a constant humidity in the sample and calibration gases by refrigeration;

c) saturating the air sample and calibration gases to maintain constant humidity;

d) using narrow-band optical filters in combination with some of the above measures;

e) making a volume correction, if the sample is dried or humidified.

NOTE Gas-correlation spectrometers facilitate rejection of interference by water vapour, carbon dioxide and organic compounds, therefore use of a narrow-band-pass filter ensures that only the CO-sensitive IR wavelengths are measured.

### 4.3 Carbon dioxide

Interference may be caused by carbon dioxide ($CO_2$). The effect of $CO_2$ interference at concentrations normally present in ambient air is minimal; that is, 600 mg/m$^3$ (340 ppm volume fraction) of $CO_2$ may give a response equivalent to 0,2 mg/m$^3$ (0,2 ppm volume fraction) [3]. If necessary, $CO_2$ may be scrubbed with soda lime.

### 4.4 Hydrocarbons

Hydrocarbons at concentrations normally found in the ambient air do not ordinarily interfere; that is, 325 mg/m$^3$ (500 ppm volume fraction) of methane may give a response equivalent to 0,6 mg/m$^3$ (0,5 ppm volume fraction) [3].

## 5 Apparatus

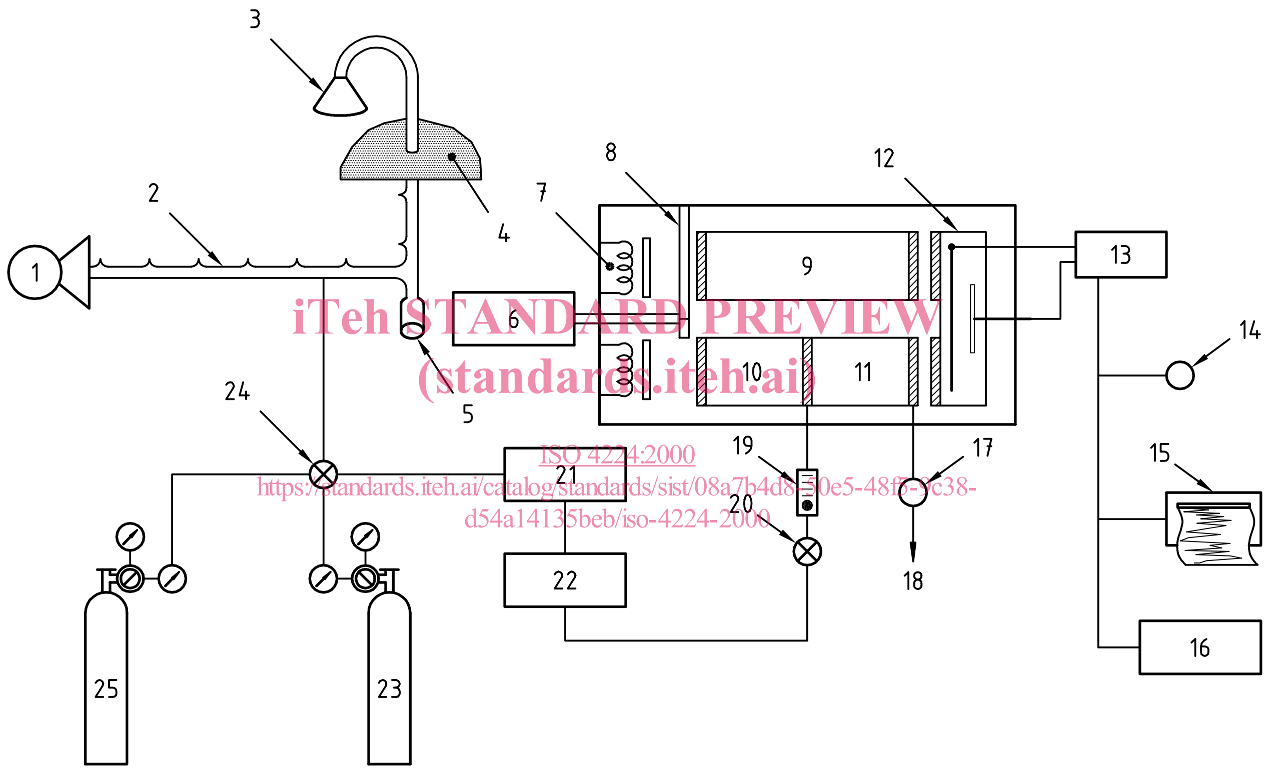
**5.1 NDIR analyser**, for analysis of carbon monoxide in air.

The analyser should be complete with analyser section, sample pump, amplifier/control section, meter, and recording system. The NDIR analyser shall meet the performance specifications described in annex A. See Figure 1.

**5.2 Sample conditioning system**, consisting of flow control valve, rotameter, particulate matter filter, and moisture controller.

**5.3 Thermometer**, capable of measuring atmospheric temperature to ± 0,5 °C.

**5.4 Barograph** or **barometer**, capable of measuring atmospheric pressure to ± 0,6 kPa.






**Key**

1 Blower
2 Sample manifold
3 Sample inlet port
4 Roof
5 Moisture trap
6 Motor
7 Infrared source
8 Beam chopper
9 Reference cell
10 Filter cell
11 Sample cell
12 Infrared detector
13 Amplifier
14 Analyser readout
15 Strip chart recorder
16 Data acquisition system
17 Pump
18 Exhaust
19 Rotameter
20 Flow control valve
21 Moisture controller
22 Particulate matter filter
23 Span gas
24 Four-way valve
25 Zero-air

**Figure 1 — Typical carbon monoxide analyser system**

### 5.5 Calibration equipment

The two acceptable methods for dynamic multipoint calibration of CO analysers are:

a) the use of individual certified standard cylinders of CO for each concentration needed;

b) the use of one certified standard cylinder of CO, diluted as necessary with zero-air, to obtain the various calibration concentrations needed.

Both methods require the following equipment.

#### 5.5.1 Pressure regulators for the CO cylinders

A two-stage regulator with inlet and delivery pressure gauges will be required for the CO calibration standard cylinder. Procure regulators for each cylinder if individual cylinders are to be used for individual calibration points. Ensure the cylinders have a non reactive diaphragm and suitable delivery pressure. Consult the supplier from whom the CO cylinders are to be obtained for the correct cylinder fitting size required for the regulator.

#### 5.5.2 Flow controller

The flow controller can be any device (valve) capable of adjusting and regulating the flow from the calibration standard: If the dilution method is to be used for calibration, a second device is required for the zero-air. For dilution, the controllers shall be capable of regulating the flow to ± 1 %.

#### 5.5.3 Flow meter



A calibrated flow meter capable of measuring and monitoring the calibration standard flowrate. If the dilution method is used, a second flow meter is required for the zero-air flow. For dilution, the flow meters shall be capable of measuring the flow with an accuracy of ± 2 %.



#### 5.5.4 Mixing chamber (dynamic dilution only)

A mixing chamber is required only if the calibrator concentrations are generated by dynamic dilution of a CO standard. Design the chamber to provide thorough mixing of CO and zero-air.

#### 5.5.5 Output manifold

The output manifold should be of sufficient diameter to ensure an insignificant pressure drop at the analyser connection. The system shall have a vent designed to ensure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

## 6 Regents and materials

### 6.1 Zero-air

Use a pressurized cylinder of pure air certified to contain less than 0,1 mg/m$^3$ (0,09 ppm volume fraction) of CO. Alternatively, a catalytic oxidizing agent to convert CO to $CO_2$ or a palladium filter may be used to obtain zero-air.

### 6.2 Up-scale span gas

Use a pressurized cylinder containing a span gas mixture consisting of CO in air corresponding to 80 % of full scale. Certify the cylinder in accordance with ISO 6142, ISO 6143, ISO 6144, ISO 6146 or ISO 6147.

### 6.3 Calibration gases

Use pressurized cylinders containing concentrations of CO in air corresponding to the instrument operating range, that is, 10 %, 20 %, 40 % and 80 % of full-scale range. They shall be certified to a national standard.

Alternatively, if a dilution calibration method is used, a single pressurized cylinder may be used. This may be in nitrogen if the zero-air dilution ratio is not less than 100:1.

Utilize high-pressure cylinders with inside surfaces of a chromium-molybdenum alloy with low iron content for the up-scale and calibration gases.

### 6.4 Calibration certificate

Certify the span and calibration gases to ± 2 % of the stated value. See ISO 6141.

## 7 Precautions

Operate the analyser system in non explosive areas unless the equipment is explosion-proof.

Follow standard safety practices for the handling and storage of compressed gas cylinders and the installation and use of the analyser. See ISO 6142.

Do not expose cylinders of compressed gases to direct sunlight or excessive heat.

Maintain the same sample cell flowrate during sampling and calibration. Use the same sample pump.

## 8 Sampling



When sampling the outside ambient atmosphere from an enclosure, utilize a sampling line or probe extending at least 1 m from the enclosure, and protected against the entry of precipitation. See ISO/TR 4227.

Place the analyser in an enclosure with atmospheric control so the temperature remains constant within ± 5 °C.



Record the temperature and pressure of the atmosphere sample.

## 9 Calibration and standardization

### 9.1 Calibration procedures

Calibration procedures shall be in accordance with annex B.

### 9.2 Frequency of calibration

#### 9.2.1 Multipoint calibration

Perform a multipoint calibration (see B.1) when:

a) the analyser is first purchased;

b) the analyser has had maintenance that could affect its response characteristics;

c) the analyser shows drift in excess of specifications as determined when the zero and span calibrations are performed (see 9.2.2).

#### 9.2.2 Zero and span calibration

Perform zero and span calibrations (see B.2) before and after each sampling period or, if the analyser is used continuously, daily.