SLOVENSKI STANDARD
SIST EN 14626:2005

01-september-2005

Kakovost zunanjega zraka ï Standardna metoda za doloļ anje koncentracije ogljikovega monoksida z nedisperzivno infrardeļ o spektroskopijo

Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy

Luftqualität - Messverfahren zur Bestimmung der Konzentration von Kohlenmonoxid mit nicht-dispersiver Infrarot-Photometrie

Qualité de l'air ambiant - Méthode de mesurage pour la détermination de la concentration du monoxyde de carbone dans l'air ambiant par la méthode a rayonnement infrarouge non dispersif

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English version

Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy

Qualité de l'air ambiant - Méthode normalisée de mesurage de la concentration en monoxyde de carbone par la méthode à rayonnement infrarouge non-dispersif

Luftqualität - Messverfahren zur Bestimmung von Kohlenmonoxid in Luft mit dem NDIR-Verfahren

This European Standard was approved by CEN on 10 December 2004.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This document (EN 14626:2005) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This document specifies a continuous measurement method for the determination of the concentration of carbon monoxide present in ambient air based on the non-dispersive infrared measuring principle (NDIR). This document describes the performance characteristics and sets the relevant minimum criteria required to select an appropriate non-dispersive infrared carbon monoxide analyser by means of type approval tests. It also includes the evaluation of the suitability of an anayser for use in a specific fixed site so as to meet the Directives data quality requirements and requirements during sampling, calibration and quality assurance.

The method is applicable to the determination of the mass concentration of carbon monoxide present in ambient air in the range from 0 mg/m^3 to 100 mg/m^3 carbon monoxide. This concentration range represents the certification range for the type approval test.

NOTE 1 0 mg/m^3 to 100 mg/m^3 of CO corresponds to 0 μmol/mol to 86 μmol/mol of CO.

The method covers the determination of ambient air concentrations of carbon monoxide in zones classified as rural areas, urban-background areas and traffic-orientated locations.

NOTE 2 Other ranges may be used for measurement systems applied at rural locations monitoring Ecosystems.

The results are expressed in mg/m^3 (at 293 K and 101,3 kPa).

When the standard is used for other purposes than the EU directive, the range and uncertainty requirements need not 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.

ENV 13005, *Guide to the expression of uncertainty in measurement*

EN ISO 14956:2002, *Air quality — Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty (ISO 14956:2002)*

ISO 6143, *Gas analysis — Comparison methods for determining and checking the composition of calibration gas mixtures*

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

ISO 6145 (all parts), *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods*

3 Terms and definitions

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

3.1
ambient air
outdoor air in the troposphere excluding workplace air[1)]

3.2
ambient temperature
temperature at the sample inlet outside the monitoring station (sample temperature, outdoor temperature)

3.3
availability of the analyser
fraction of the total time period for which usually valid measuring data of the ambient air concentration is available from an analyser

3.4
certification range
concentration range for which the analyser is type approved

3.5
calibration
comparison of the analyser response to a known gas concentration with a known uncertainty

3.6
combined standard uncertainty
calculation result of combining the uncertainties determined from all performance characteristics specified in this document according to the prescribed procedures given in this document

3.7
coverage factor
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

3.8
designated body
body which has been designated for a specific task (type approval tests and/or QA/QC activities in the field) by the competent authority in the Member States

NOTE It is recommended that the designated body is accredited for the specific task according to EN ISO/IEC 17025.

3.9
expanded uncertainty
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

NOTE for the purpose of this document the expanded uncertainty is the combined standard uncertainty multiplied by a coverage factor k = 2 resulting in an interval with a level of confidence of 95 %

3.10
fall time
difference between the response time (fall) and the lag time (fall)

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1) As stated in the relevant EU legislation.

3.11
independent measurement
individual measurement that is not influenced by a previous individual measurement by separating two individual measurements by at least four response times

3.12
individual measurement
measurement averaged over a time period equal to the response time of the analyser

3.13
influence quantity
quantity that is not the measurand but that affects the result of the measurement (VIM 2.7), either an interferent influence quantity (i.e. the concentration of a substance in the air under investigation that is not the measurand), or an external influence quantity (i.e. a quantity that is not the measurand nor the concentration of a substance in the air mass under investigation)

NOTE Examples are:
- presence of interfering gases in the flue gas matrix (interferent influence quantity);
- temperature of the surrounding air (external influence quantity);
- atmospheric pressure (external influence quantity);
- pressure of the gas sample (external influence quantity).

3.14
interference
response of the analyser to interferents

3.15
interferent
component of the air sample, excluding the measured constituent, that effects the output signal

3.16
lag time
time interval from the instant at which a step change of sample concentration occurs at the inlet of the analyser to the instant at which the output reading reaches a level corresponding to 10 % of the stable output reading

3.17
lag time (fall)
lag time for a negative step change

3.18
lag time (rise)
lag time for a positive step change

3.19
limit value
level fixed on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained

3.20
lack of fit
maximum deviation of the average of a series of measurements at the same concentration from the linear regression line

3.21
long-term drift
difference between zero or span readings over a determined period of time (e.g. period of unattended operation)

3.22
monitoring station
enclosure located in the field in which a CO analyser has been installed in such a way that its performance and operation comply with the prescribed requirements

3.23
parallel measurement
two measurements from different analysers, sampling from one and the same sampling manifold, starting at the same time and ending at the same time

3.24
performance characteristic
one of the parameters assigned to equipment in order to define its performance

3.25
performance criterion
limiting quantitative numerical value assigned to a performance characteristic, to which conformance is tested

3.26
period of unattended operation
time period over which the drift is within the performance criterion for long-term drift

3.27
repeatability (of results of measurement)
closeness of the agreement between results of successive individual measurements of the same measurand carried out under the same conditions of measurement [1]

NOTE These conditions are called laboratory repeatability conditions and include:

- the same measurement procedure;
- the same observer;
- the same analyser, used under the same conditions;
- at the same location;
- repetition over a short period of time.

3.28
reproducibility under field conditions
closeness of the agreement between the results of simultaneous measurements with two analysers in ambient air carried out under the same conditions of measurement

NOTE 1 These conditions are called laboratory repeatability conditions and include:

- the same measurement procedure;
- two identical analysers, used under the same conditions;
- at the same monitoring station;
- the period of unattended operation.

NOTE 2 In this document the reproducibility under field conditions is expressed as a value with a level of confidence of 95 %.

3.29
response time
time interval from the instant at which a step change of sample concentration occurs at the inlet of the analyser to the instant at which the output reading reaches a level corresponding to 90 % of the stable output reading

3.30
response time (fall)
response time at a negative step change

NOTE Response time (fall) is the sum of the lag time (fall) and the fall time.

3.31
response time (rise)
response time at a positive step change

NOTE Response time (rise) is the sum of the lag time (rise) and the rise time.

3.32
rise time
difference between the response time (rise) and the lag time (rise)

3.33
sampled air
ambient air that has been sampled through the sampling inlet and sampling system

3.34
sampling inlet
entrance to the sampling system where ambient air is collected from the atmosphere

3.35
short-term drift
difference between zero or span readings at the beginning and end of a 12 h period

3.36
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[ENV 13005]

3.37
surrounding temperature
temperature of the air directly surrounding the analyser (temperature inside the monitoring station or laboratory)

3.38
type approval
decision taken by a designated body that the pattern of an analyser conforms to the requirements as laid down in this document

3.39
type approval test
examination of two or more analysers of the same pattern which are submitted by a manufacturer to a designated body including the tests necessary for approval of the pattern

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply

A_a	availability of the analyser;
av	average concentration of the measurand during the field test;
b_{gp}	sensitivity coefficient of the analyser to sample gas pressure change expressed as a percentage of the measured value, obtained during the laboratory type approval test;
b_{gt}	sensitivity coefficient of the analyser to sample gas temperature change;
b_{st}	sensitivity coefficient of the analyser to surrounding air temperature change;
b_V	sensitivity coefficient of the analyser to electrical voltage change;
C	CO concentration of the applied gas;
C_{P1}	average concentration of the measurements at sampling gas pressure P_1;
C_{P2}	average concentration of the measurements at sampling gas pressure P_2;
C_R	concentration of the reference standard;
C_s	concentration of site standard;
$C_{s,1}$	average concentration of the measurements at span level at the beginning of the drift period;
$C_{s,2}$	average concentration of the measurements at span level at the end of the drift period;
c_t	test gas concentration;
C_{T1}	average concentration of the measurements at sample gas temperature T_1;
C_{T2}	average concentration of the measurements at sample gas temperature T_2;
C_{V1}	average concentration reading of the measurements at voltage V_1;
C_{V2}	average concentration reading of the measurements at voltage V_2;
$C_{z,1}$	average concentration of the measurements at zero at the beginning of the drift period;
$C_{z,2}$	average concentration of the measurements at zero at the end of the drift period;
$C_{\text{const}}^{\text{av}}$	average of at least four independent measurements during the constant concentration period (t_c);
$C_{\text{var}}^{\text{av}}$	average of at least four independent measurements during the variable concentration period (t_v);
$\overline{d_f}$	average difference of parallel measurements;
$d_{f,i}$	the ith difference in a parallel measurement;
$D_{l,s}$	long-term drift at span concentration c_t;
$D_{l,z}$	long-term drift at zero;

$D_{s,s}$ short-term drift at span level;

$D_{s,z}$ short-term drift at zero;

D_{sc} difference sample/calibration port;

E_{ss} sample system collection efficiency;

F_r response factor in concentration units per voltage output of the analyser;

P_1 sampling gas pressure P_1;

P_2 sampling gas pressure P_2;

R_d mean analyser response to the test gas directly sampled by the analyser;

R_m mean analyser response to the test gas via the sample manifold;

$s_{r,z}$ repeatability standard deviation at zero;

$s_{r,ct}$ repeatability standard deviation at concentration c_t;

$s_{r,f}$ reproducibility standard deviation under field conditions is the repeatability standard deviation;

s_l repeatability standard deviation;

T surrounding air temperature;

T_1 sample gas temperature T_1;

T_2 sample gas temperature T_2;

t_d relative difference between response time (rise) and response time fall;

t_f response time (fall);

T_l surrounding air temperature at the laboratory;

$t_{n-1,\ 0,05}$ two-sided Students t-factor at a confidence level of 0,05, with n-1 degrees of freedom;

t_r response time (rise);

t_t time period of the field test minus the time for calibration, conditioning and maintenance;

t_u total time period with validated measuring data;

t_V whole number of t_{S02} and t_{zero} pairs;

V_1 minimum voltage V_{min} (V) specified by the manufacturer;

V_2 maximum voltage V_{max} (V) specified by the manufacturer;

V_r voltage obtained when the reference standard is injected;

V_s voltage obtained when the site standard is injected;

V_z voltage obtained when zero gas is injected;

$\bar{x}$ average of measurements;

x_1 first average of the measurements at T_l just after calibration;

x_2 second average of the measurements at T_l just before calibration;

X_z difference between the readings of the recent zero check and the most recent calibration;

x_{ct} average of the measurements at concentration c_t;

X_{av} averaging effect;

x_c average of the measurements using the calibration port;

$X_{CO2,z,ct}$ influence quantity of CO_2 with concentration 500 µmol/mol;

$X_{H2O,z,ct}$ influence quantity of H_2O with concentration 19 mmol/mol;

x_i the *i*th measurement;

$X_{int,ct}$ influence quantity of the interferent at concentration c_t;

$X_{int,z}$ influence quantity of the interferent at zero;

X_l lack of fit (largest residual from the linear regression function);

$X_{NO,z,ct}$ influence quantity of NO with concentration 1 µmol/mol;

$X_{N2O,z,ct}$ influence quantity of N_2O with concentration 50 nmol/mol;

x_s average of the measurements using the sample port;

X_s difference between the readings of two consecutive span checks;

x_T average of the measurements at T_{min} or T_{max};

X_z difference between the readings of two consecutive zero checks;

$(x_{1,f})_i$ the *i*th measurement result of analyser 1;

$(x_{2,f})_i$ the *i*th measurement result of analyser 2 at the same time as the measurement of analyser 1;

Z_1 reading of the first zero check;

Z_2 reading of the second zero check;

ΔP_m measured pressure drop induced by the manifold pump;

ΔR_a change in the analyser's response due to the influence of the pressure drop induced by the manifold pump, expressed as a percentage;

5 Principle

5.1 General

This document describes the method for the measurement of the concentration of carbon monoxide in ambient air by means of the non-dispersive infrared spectrometry principle. The requirements, the specific components of the non-dispersive infrared analyser and its sampling system are described. For the analyser a number of performance characteristics with associated minimum performance criteria are given. The actual values of these performance characteristics for a specific type of analyser have to be determined in a so-called type approval test for which procedures have been described. The type approval test comprises a laboratory and a field test. The selection of a suitable analyser for a specific measuring task in the field is based on the calculation of the expanded uncertainty of the measuring method. In this expanded uncertainty calculation the actual values of the various performance characteristics of a type approved analyser and the site-specific conditions at the monitoring station are taken into account. The expanded uncertainty of the method shall meet the requirements of the (EU) legislation. Requirements and recommendations for quality assurance and quality control are given for the measurements in the field (see 9.4).

5.2 Measuring principle

Ambient CO concentration is measured with use of non-dispersive infrared methods. The attenuation of infrared light passing through a sample cell is a measure of the concentration of CO in the cell, according to the Lambert-Beer law. Not only CO but also most heteroatomic molecules will absorb infrared light, in particular water and CO_2 have broad bands that can interfere with the measurement of CO. Different technical solutions have been developed to suppress cross-sensitivity, instability and drift in order to design continuous monitoring systems with acceptable properties. For instance:

— measuring IR absorption of a specific wavelength (4,7 µm for CO);

— dual-cell monitors, using a reference cell filled with clean air (compensation for drift);

— gas filter correlation, “measuring” over a range of wavelengths.

Special attention has to be paid to infrared radiation absorbing gases such as water vapour, carbon dioxide, nitrous oxide and hydrocarbons.

The concentration of carbon monoxide is measured in volume/volume units (if the analyser is calibrated using a volume/volume standard). The final results for reporting are expressed in mg/m^3 using standard conversion factors (see Clause 10).

5.3 Type approval test

The type approval test is based on the evaluation of performance characteristics determined under a prescribed series of tests. In this document test procedures are described for the determination of the actual values of the performance characteristics for at least one analyser in a laboratory and two analysers in the field. These tests shall be performed by a designated body. The evaluation for type approval of an analyser is based on the calculation of the expanded uncertainty in the measurement result derived from the numerical values of the tested performance characteristics and compared with a prescribed maximum uncertainty.

The type approval of an analyser and subsequent OA and QC procedures provide evidence that the defined requirements concerning data quality laid out in relevant EU directives can be satisfied. Appropriate experimental evidence shall be provided by:

— type approval tests performed under conditions of intended use of the specified method of measurement, and

— calculation of expanded uncertainty of results of measurement by reference to ENV 13005.

Field operation and quality control: