SLOVENSKI STANDARD
oSIST prEN 15058:2014

01-januar-2015

Emisije nepremičnih virov - Določevanje masne koncentracije ogljikovega monoksida - Standardna referenčna metoda: nedisperzna infrardeča spektrometrija

Stationary source emissions - Determination of the mass concentration of carbon monoxide - Standard reference method: non-dispersive infrared spectrometry

Emissionen aus stationären Quellen - Bestimmung der Massenkonzentration von Kohlenmonoxid - Standardreferenzverfahren: Nicht-dispersive Infrarotspektrometrie

Emissions de sources fixes - Détermination de la concentration massique de monoxyde de carbone - Méthode de référence normalisée : spectrométrie infra-rouge non dispersive

Ta slovenski standard je istoveten z: **prEN 15058**

ICS:

13.040.40 Emisije nepremičnih virov Stationary source emissions

oSIST prEN 15058:2014 **en,fr,de**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

DRAFT
prEN 15058

October 2014

ICS 13.040.40

Will supersede EN 15058:2006

English Version

Stationary source emissions - Determination of the mass concentration of carbon monoxide - Standard reference method: non-dispersive infrared spectrometry

Émissions de sources fixes - Détermination de la concentration massique de monoxyde de carbone - Méthode de référence normalisée : spectrométrie infrarouge non dispersive

Emissionen aus stationären Quellen - Bestimmung der Massenkonzentration von Kohlenmonoxid - Standardreferenzverfahren: Nicht-dispersive Infrarotspektrometrie

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COMITÉ EUROPÉEN DE NORMALISATION
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Ref. No. prEN 15058:2014 E

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Foreword

This document (prEN 15058:2014) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 15058:2006.

Annex F provides details of significant technical changes between this document and the previous edition.

1 Scope

This European Standard specifies the standard reference method (SRM) based on the infra-red (IR) absorption principle. It includes the sampling and the gas conditioning system, and allows the determination of the carbon monoxide CO in flue gases emitted to the atmosphere from ducts and stacks.

This European Standard specifies the characteristics to be determined and the performance criteria to be fulfilled by measuring systems using the IR measurement method. It applies for periodic monitoring and for the calibration or control of automatic measuring systems (AMS) permanently installed on a stack, for regulatory or other purposes.

This European Standard specifies criteria for demonstration of equivalence of an alternative method (AM) to the SRM by application of prEN 14793.

This European Standard has been validated during field tests on waste incineration, co-incineration and large combustion plants and on a recognized test bench. It has been validated for CO concentrations with sampling periods of 30 min in the range of 0 mg/m^3 to 400 mg/m^3 for large combustion plants and 0 mg/m^3 to 740 mg/m^3 for waste and co-incineration. Directive 2010/75/EC lays down emission values which are expressed in mg/m^3, on dry basis at a specified value of oxygen and at standard conditions of 273 K and 101,3 kPa.

NOTE The characteristics of installations, the conditions during field tests and the values of repeatability and reproducibility in the field are given in Annex A.

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.

prEN 14793:2014, *Stationary source emission – Demonstration of equivalence of an alternative method with a reference method*

EN 15259, *Air quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 15267-3, *Air quality – Certification of automated measuring systems – Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources*

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 5725-2, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of* repeatability and reproducibility *of a standard measurement method*

ISO 5725-6: *Accuracy (trueness and precision) of measurement methods and results – Part 6: Use in practice of accuracy values*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

3.1

adjustment of a measuring system

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

[SOURCE: JCGM 200:2012]

Note 1 to entry: The adjustment can be made directly on the instrument or using a suitable calculation procedure.

3.2

ambient temperature

temperature of the air around the measuring system

3.3

automated measuring system

AMS

measuring system permanently installed on site for continuous monitoring of emissions or measurement of peripheral parameters

Note 1 to entry: An AMS is a method which is traceable to a reference method.

Note 2 to entry: Apart from the analyser, an AMS includes facilities for taking samples (e.g. probe, sample gas lines, flow meters, regulators, delivery pumps) and for sample conditioning (e.g. dust filter, moisture removal devices, converters, diluters). This definition also includes testing and adjusting devices that are required for regular functional checks.

[SOURCE: FprEN 14181:2014]

3.4

calibration of an AMS

establishment of the statistical relationship between values of the measurand indicated by the automated measuring system (AMS) and the corresponding values given by the standard reference method (SRM) used during the same period of time and giving a representative measurement on the same measurement plane

Note 1 to entry: The result of calibration permits to establish the relationship between the values of the SRM and the AMS (calibration function).

3.5

zero drift

difference between two zero readings at the beginning and at the end of a measuring period

3.6

span drift

difference between two span readings at the beginning and at the end of a measuring period

3.7

emission limit value

ELV

emission limit value according to EU Directives on the basis of 30 min, 1 hour or 1 day

3.8
influence quantity
quantity that is not the measurand but that affects the result of the measurement

Note 1 to entry: Influence quantities are e.g. ambient temperature, atmospheric pressure, presence of interfering gases in the flue gas matrix or pressure of the gas sample.

3.9
interference
negative or positive effect upon the response of the measuring system, due to a component of the sample that is not the measurand

3.10
lack of fit
systematic deviation within the range of application between the measurement result obtained by applying the calibration function to the observed response of the measuring system measuring test gases and the corresponding accepted value of such test gases

Note 1 to entry: Lack of fit may be a function of the measurement result.

Note 2 to entry: The expression "lack of fit" is often replaced in everyday language by "linearity" or "deviation from linearity".

3.11
measurand
quantity intended to be measured

[SOURCE: JCGM 200:2012]

3.12
measurement plane
plane normal to the centreline of the duct at the sampling position

Note 1 to entry: Measurement plane is also known as sampling plane.

[SOURCE: EN 15259:2007]

3.13
measurement point
position in the measurement plane at which the sample stream is extracted or the measurement data are obtained directly

Note 1 to entry: Measurement point is also known as sampling point.

[SOURCE: EN 15259:2007]

3.14
measurement site
place on the waste gas duct in the area of the measurement plane(s) consisting of structures and technical equipment, for example working platforms, measurement ports, energy supply

Note 1 to entry: Measurement site is also known as sampling site.

[SOURCE: EN 15259:2007]

3.15
measuring system

set of one or more measuring instruments and often other devices, including any reagent and supply, assembled and adapted to give information used to generate measured quantity values within specified intervals for quantities of specified kinds

[SOURCE: JCGM 200:2012]

3.16
performance characteristic

one of the quantities (described by values, tolerances, range) assigned to equipment in order to define its performance

3.17
repeatability in the laboratory

closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement

Note 1 to entry: Repeatability conditions include:

- same measurement procedure;
- same laboratory;
- same measuring instrument, used under the same conditions;
- same location;
- repetition over a short period of time.

Note 2 to entry: Repeatability can be expressed quantitatively in terms of the dispersion characteristics of the results.

Note 3 to entry: In this European Standard the repeatability is expressed as a value with a level of confidence of 95 %.

3.18
repeatability in the field

closeness of the agreement between the results of simultaneous measurements of the same measurand carried out with two sets of equipment under the same conditions of measurement

Note 1 to entry: These conditions include:

- same measurement procedure;
- two sets of equipment, the performances of which are fulfilling the requirements of the reference method, used under the same conditions;
- same location;
- implemented by the same laboratory;
- typically calculated on short periods of time in order to avoid the effect of changes of influence parameters (e.g. 30 min).

Note 2 to entry: Repeatability can be expressed quantitatively in terms of the dispersion characteristics of the results.

Note 3 to entry: In this European Standard, the repeatability under field conditions is expressed as a value with a level of confidence of 95 %.

3.19
reproducibility in the field

closeness of the agreement between the results of simultaneous measurements of the same measurand carried out with several sets of equipment under the same conditions of measurement

Note 1 to entry: These conditions are called field reproducibility conditions and include:

- same measurement procedure;
- several sets of equipment, the performances of which fulfil the requirements of the reference method, used under the same conditions;
- same location;
- implemented by several laboratories.

Note 2 to entry: Reproducibility can be expressed quantitatively in terms of the dispersion characteristics of the results.

Note 3 to entry: In this European Standard, the reproducibility under field conditions is expressed as a value with a level of confidence of 95 %.

3.20
residence time in the measuring system

time period for the sampled gas to be transported from the inlet of the probe to the inlet of the measurement cell

3.21
response time

duration between the instant when an input quantity value of a measuring instrument or measuring system is subjected to an abrupt change between two specified constant quantity values and the instant when a corresponding indication settles within specified limits around its final steady value

Note 1 to entry: By convention time taken for the output signal to pass from 0 % to 90 % of the final change.

[SOURCE: JCGM 200:2012]

3.22
span gas

test gas used to adjust and check a specific point on the response line of the measuring system

Note 1 to entry: This concentration is often chosen around 80 % of the upper limit of the range.

3.23
reference method
RM

measurement method taken as a reference by convention, which gives the accepted reference value of the measurand

Note 1 to entry: A reference method is fully described.

Note 2 to entry: A reference method can be a manual or an automated method.

Note 3 to entry: Alternative methods can be used if equivalence to the reference method has been demonstrated.

[SOURCE: EN 15259:2007]

3.24
standard reference method
SRM
reference method prescribed by European or national legislation

[SOURCE: EN 15259:2007]

3.25
uncertainty
parameter associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

3.26
standard uncertainty
u
uncertainty of the result of a measurement expressed as a standard deviation

3.27
combined uncertainty
u_c
standard uncertainty attached to the measurement result calculated by combination of several standard uncertainties according to the principles laid down in ISO/IEC Guide 98-3 (GUM)

3.28
expanded uncertainty
U
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

$$U = k \times u$$

Note 1 to entry: In this European Standard, the expanded uncertainty is calculated with a coverage factor of $k = 2$, and with a level of confidence of 95 %.

Note 2 to entry: The expression overall uncertainty is sometimes used to express the expanded uncertainty.

3.29
uncertainty budget
calculation table combining all the sources of uncertainty according to EN ISO 14956 or ISO/IEC Guide 98-3 in order to calculate the combined uncertainty of the method at a specified value

4 Principle

4.1 General

This European Standard describes the standard reference method (SRM) for sampling, and determining the carbon monoxide (CO) concentration in ducts and stacks emitted to atmosphere by means of an automatic analyser using the IR absorption principle. The specific components and the requirements for the sampling system and the IR analyser are described in Clause 6. A number of performance characteristics with associated performance criteria are given for the analyser. These performance characteristics and the combined uncertainty of the method shall meet the performance criteria given in this European Standard. Requirements and recommendations for quality assurance and quality control are given for measurements in the field (see Clause 9).

4.2 Measuring principle

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 hetero-atomic molecules 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 in order to design automatic monitoring systems with acceptable performance.

For example, the Non Dispersive Infra-Red (NDIR) method is suitable for CO measurements**:** gas concentration is measured electro-optically by its absorption of a specific wavelength in the infrared (IR). The IR light is directed through the sample chamber towards the detector. In parallel there is another chamber with an enclosed reference gas, typically nitrogen. The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb. Ideally other gas molecules do not absorb light at this wavelength, and do not affect the amount of light reaching the detector to compensate for interfering components. For instance, CO_2 and H_2O often initiate cross sensitivity in the infrared spectrum. Different technical solutions have been developed to suppress, cross-sensitivity, instability and drift in order to design automatic monitoring systems with acceptable properties (e.g. Gas Filter Correlation technique).

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

IR analysers are combined with an extractive sampling system and a gas conditioning system. A sample of gas is taken from the stack with a sampling probe and conveyed to the analyser through the measurement line and gas conditioning system. The values from the analyser are recorded and/or stored by means of electronic data processing.

The concentration of CO is measured in volume/volume units (if the analyser is calibrated using a volume/volume standard). The final results for reporting are expressed in milligrams per cubic meter using standard conversion factors (see Clause 10).

5 Description of the measuring system

5.1 General on sampling and sample gas conditioning systems

A volume is extracted from the flue gas for a fixed period of time at a controlled flow rate. The sampling system consists of:

- a sampling probe;
- a filter;
- a sampling line;
- a conditioning system.

A filter removes the dust in the sampled volume before the sample is conditioned and passes to the analyser. Three different sampling and conditioning configurations can be used in order to avoid the water condensation in the measuring system. These configurations are:

- Configuration 1: removal of water vapour by condensation using a cooling system;
- Configuration 2: removal of water vapour through elimination using a permeation drier;
- Configuration 3: dilution with dry, clean, ambient air or nitrogen of the gas to be characterized;
- Configuration 4: maintaining the temperature of the measurement line up to the heated analyser.

It is important that all parts of the sampling equipment upstream of the analyser are made of materials that do not react with or absorb CO. The temperature of its components coming into contact with the gas shall be maintained at a sufficiently high temperature to avoid any condensation and alter the gas composition.

Conditions and layout of the sampling equipment contribute to the combined uncertainty of the measurement. In order to minimise this contribution to the combined measurement uncertainty, performance criteria for the sampling equipment and sampling conditions are given in 5.2 and in Clause 6.

Some other conditioning systems may exist and could be acceptable, provided they fulfil the requirements of this European Standard and have been validated with success during the certification process. For example, some systems put gas in depression using a simple Sonic nozzle in the collection probe in order to create a partial vacuum (between 50 hPa absolute and 100 hPa absolute) so that the head of collection and the measurement line does not need to be heated and water vapour condensation is avoided.

5.2 Sampling system

5.2.1 Sampling probe

In order to reach the measurement point(s) of the measurement plane, probes of different lengths and inner diameters may be used. The design and configuration of the probe used shall ensure the residence time of the sample gas within the probe is minimised in order to reduce the response time of the measuring system.

NOTE 1 The probe may be marked before sampling in order to demonstrate that the measurement point(s) in the measurement plane has (has) been reached.

NOTE 2 A seal-able connection may be installed on the probe in order to introduce test gases for adjustment.

5.2.2 Filter

The filter and filter holder shall be made of an inert material (e.g. ceramic or sinter metal filter with an appropriate pore size). It shall be heated above the sample dew point temperature. The particle filter shall be changed or cleaned periodically depending on the dust loading at the measurement site.

NOTE Overloading of the particle filter may increase the pressure drop in the measurement line.

5.2.3 Sampling line

The sampling line shall be heated up to the conditioning system. It shall be made of a suitable corrosion resistant material (e.g. stainless steel, borosilicate glass, ceramic or titanium could be used; PTFE is only suitable for flue gas temperature lower than 200 °C).

NOTE Excessive temperature should be avoided because it might alter the flue gas characteristics.

5.2.4 Conditioning system

5.2.4.1 Sample cooler (configuration 1)

A dew-point temperature of 4 °C shall not be exceeded at the outlet of the sample cooler.

NOTE The concentrations, provided by this sampling configuration, are considered to be given on dry basis. However, the results may be corrected for the remaining water vapour (refer to the table of Annex B in EN 14790).

5.2.4.2 Permeation drier (configuration 2)

The permeation drier is used before the gas enters the analyser in order to separate water vapour from the flue gas. A dew-point temperature of 4 °C shall not be exceeded at the outlet of the permeation drier.