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Zunanji zrak - Avtomatski merilni sistemi za merjenje koncentracije delcev (PM10; PM2,5)

Ambient air - Automated measuring systems for the measurement of the concentration of particulate matter (PM10; PM2,5)

Außenluft - Automatische Messeinrichtungen zur Bestimmung der Staubkonzentration (PM10; PM2,5)

Air ambiant - Systèmes automatisés de mesurage de la concentration de matière particulaire (PM10; PM2,5)

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Ambient air - Automated measuring systems for the measurement of the concentration of particulate matter (PM10; PM2,5)

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European foreword

This document (EN 16450:2017) 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of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

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1 Scope

In order to be in compliance with EU Air Quality Directive requirements, the reference methods given in the Directive 2008/50/EC [1] for the measurement of mass concentrations of particulate matter are not commonly used for operation in routine monitoring networks. These networks usually apply automated continuous measurement systems (AMS), such as those based on the use of oscillating microbalances, ß-ray attenuation, or *in situ* optical methods. Such AMS are typically capable of producing 24-h average measurement values over a measurement range up to 1 000 µg/m³ and 1-h average measurement values up to 10 000 µg/m³, if applicable, where the volume of air is the volume at ambient conditions near the inlet.

The 1-h average values may be used for:

a) direct information of the public;

b) aggregation to produce daily or yearly average concentration values for regulatory reporting purposes.

NOTE National regulatory reporting purposes could require other time basis for averages (i.e. monthly).

Directive 2008/50/EC allows the use of such systems after demonstration of equivalence with the reference method, i.e. after demonstration that these systems meet the Data Quality Objectives for continuous measurements. Guidelines for the demonstration of equivalence are given in Reference [2].

This European Standard lays down the minimum performance requirements and test procedures for the type testing of appropriate AMS for particulate matter. The standard includes the evaluation of its equivalence with the reference method as laid down in Directive 2008/50/EC.

Further, this European Standard describes minimum requirements for ongoing quality assurance – quality control (QA/QC) of AMS deployed in the field. These requirements are necessary to ensure that uncertainties of measured concentrations are kept within the required limits during extended periods of continuous monitoring in the field, and include procedures for maintenance, calibration and control checks.

Additional procedures are described that determine whether an instrument's equivalence to the reference method is maintained through possible pollution climate changes, over periods longer than five years.

Lastly, this European Standard describes harmonized requirements and procedures for the treatment and validation of raw measurement data that are used for the assembly of daily or yearly average concentration values. Experience with existing methods for data treatment and validation – for similar AMS – has shown that the different ways of data treatment and validation applied may lead to significant differences in reported results for similar data sets [3].

When the European Standard is used for purposes other than measurements required by Directive 2008/50/EC, the range and uncertainty requirements may not apply.

This European Standard contains information for different groups of users.

Clauses 5 and 6 and Annex A contain general information about the principles of automated continuous measurement systems for particulate matter, and relevant equipment.

Clause 7 and Annexes B and C are specifically directed towards test houses and laboratories that perform type testing of automated continuous measurement systems for particulate matter. These clauses contain information about:

c) type testing conditions, test procedures and test requirements;

d) system performance requirements;

e) evaluation of the type testing results;

f) evaluation of the uncertainty of the measurement results of the automated continuous measurement systems for particulate matter based on the type testing results.

Clauses 8 to 11 are aimed at monitoring networks performing the practical measurements of particulate matter in ambient air. These clauses contain information about:

g) initial installation of the system in the monitoring network and acceptance testing;

h) ongoing quality assurance/quality control;

i) on-going verification of suitability;

j) treatment, validation and reporting of measurement results.

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 12341, *Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter*

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 workplaces as defined by Directive 89/654/EEC [4] where provisions concerning health and safety at work apply and to which members of the public do not have regular access

[SOURCE: Directive 2008/50/EC [1]]

3.2
automated measuring system
AMS
entirety of all measuring instruments and additional devices necessary for obtaining a measurement result

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

[SOURCE: EN 14211 [5]]

3.4
calibration
operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of a calibration.

[SOURCE: JCGM 200:2012 (VIM) [6]]

3.5
combined standard uncertainty
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[SOURCE: ISO/IEC Guide 98-3:2008 [7]]

3.6
competent authority
organization which implements the requirements of EU Directives and regulates installations, which shall comply with the requirements of applicable European Standards

Note 1 to entry: In ambient air quality monitoring this is an authority that performs one or more of the tasks listed in Article 3 of Directive 2008/50/EC.

3.7
competent body
organization which can demonstrate its competence for a specific task to the competent authority in the Member State

3.8
coverage factor
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

[SOURCE: ISO/IEC Guide 98-3:2008 [7]]

3.9
data capture
percentage of the time for which the AMS has produced valid data to the time for which the aggregated value is to be calculated, excluding periods of regular calibration or normal maintenance

[SOURCE: Directive 2008/50/EC [1]]

3.10
detection limit
smallest concentration of a measurand that can be reliably detected by a specific measurement process

3.11
equivalent method
method other than the reference method for the measurement of a specified air pollutant meeting the data quality objectives for fixed measurements specified in the relevant Air Quality Directive [1]

Note 1 to entry: Equivalence is granted for defined (regional) situations within a Member State, but may be granted for situations encompassing more than one region or Member State.

3.12
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 1 to entry: The fraction may be viewed as the coverage probability or level of confidence of the interval.

Note 2 to entry: To associate a specific level of confidence with the interval defined by the expanded uncertainty requires explicit or implicit assumptions regarding the probability distribution characterized by the measurement result and its combined standard uncertainty. The level of confidence that may be attributed to this interval can be known only to the extent to which such assumptions may be justified.

[SOURCE: ISO/IEC Guide 98-3:2008 [7]]

3.13
interferent
component of the air sample, excluding the measured constituent, that affects the output signal

3.14
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

[SOURCE: Directive 2008/50/EC [1]]

3.15
monitoring station
enclosure located in the field in which an AMS has been installed to measure particulate matter in such a way that its performance and operation comply with the prescribed requirements

3.16
parallel measurement
measurement from measuring systems, sampling from the same air over the same time period

3.17
performance characteristic
one of the parameters assigned to an AMS in order to define its performance

3.18
performance criterion
limiting quantitative numerical value assigned to a performance characteristic, to which conformance is tested

3.19
period of unattended operation
time period over which the drift is within the performance criterion for long term drift

3.20
PM_x
particulate matter suspended in air which passes through a size-selective inlet at a constant flow with a 50 % efficiency cut-off at x µm aerodynamic diameter

Note 1 to entry: By convention, the size-selective standard inlet designs prescribed in EN 12341 — used at the prescribed flow rates – possess the required characteristics to sample the relevant PM fraction suspended in ambient air.

Note 2 to entry: The efficiency of the size selectiveness of other inlets used could have a significant effect on the fraction of PM surrounding the cut-off, and, consequently on the mass concentration of PM_x determined.

3.21
reference method
RM
measurement method(ology) which, by convention, gives the accepted reference value of the measurand

3.22
sampled air
ambient air that has been sampled through the sampling inlet and sampling system

3.23
sampling inlet
entrance to the sampling system where ambient air is collected from the atmosphere

3.24
span
a means to produce an instrument response different from zero suitable to evaluate the sensitivity of the AMS

3.25
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[SOURCE: ISO/IEC Guide 98-3:2008 [7]]

3.26
surrounding temperature
temperature of the air directly surrounding the AMS (temperature inside the monitoring station or laboratory)

3.27
time coverage
percentage of the reference period of the relevant limit value for which valid data for aggregation have been collected

3.28
type approval
decision taken by a competent authority that the pattern of an AMS conforms to the requirements as laid down in this document

3.29
type testing
examination of two or more AMS of the same pattern which are submitted by a manufacturer to a competent body for testing of performance requirements

3.30
uncertainty (of measurement)
parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[SOURCE: ISO/IEC Guide 98-3:2008 [7]]

3.31
zero air
air containing particulate matter at a level ≤ 1,0 µg/m³

3.32
zero level
average of the results of a number of replicate measurements of zero air

4 Symbols and abbreviated terms

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

a, c	intercept of orthogonal regression of results of AMS vs. reference method results
A	availability of the AMS
b, d	slope of orthogonal regression of results of AMS vs. reference method results
k	coverage factor
L	limit value
ΔP	pressure difference determined for the time interval Δt (leak test)
P_0	pressure at t = 0 (leak test)
T_s	is the surrounding air temperature
$T_{s,lab}$	is the surrounding air temperature at the laboratory
Δt	time interval needed for the pressure rise (leak test)
t_{valid}	time during which valid data have been collected (field test)
$t_{cal,maint}$	time spent for scheduled calibrations and maintenance (field test)
t_{field}	total duration of the field test

V_L	volume leak rate (leak test)
V_{sys}	estimated total volume of the system (dead volume)
u	standard uncertainty
u_a	uncertainty of the intercept of the regression formula
u_b	uncertainty of the slope of the regression formula
$u_{bs,AMS}$	between-AMS uncertainty
$u_{bs,RM}$	between-RM uncertainty
u_{RM}	random uncertainty of reference method results
w	relative uncertainty
W	expanded relative uncertainty
x_i	individual measurement result of AMS
y_i	individual reference measurement result

AMS	Automated Measuring System
EU	European Union
GDE	Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods
GUM	Guide to the Expression of Uncertainty in Measurement
JCGM	Joint Committee for Guides in Metrology
PM	Particulate Matter
QA/QC	Quality Assurance / Quality Control
RM	Reference Method(ology)
RSS	Residual Sum of Squares

5 Principle

5.1 General

A number of measuring principles may be used to determine the mass concentration of particulate matter in ambient air. This European Standard is not limited to the application of a single system for the automated continuous measurement. In general (but not necessarily), the measuring system will consist of:

a) a size-selective inlet for PM_{10} or $PM_{2,5}$ (when using an optical system for size classification of particulate matter a size-selective inlet is not required);

b) a sample tube of a length needed to meet the specific sampling height requirements given in Reference [1];

c) a measuring section;

d) a vacuum pump;

e) flow meters and flow controllers;

f) temperature and pressure sensors;

g) hardware and software for data collection, storage and calculation of measurement results.

Auxiliary equipment may include:

h) sample tube heaters;

i) systems for (partial) drying of the sampled air;

j) humidity sensors;

k) hardware/software for performing compensation measurements, i.e. measurements to compensate for unwanted effects of interferents or random variations in the PM mass determination.

5.2 Measurement principles

Several measurement principles are currently applied in routine monitoring practice. Descriptions of the most common principles – which do not preclude other principles – are given in Annex A.

5.3 Type testing

The type testing of an AMS according to Clause 7 and subsequent QA/QC and verification procedures according to Clause 8 provide evidence that the defined requirements concerning data quality objectives laid out in relevant EU Directives can be satisfied. A competent body shall perform the type testing. The type testing shall be awarded by, or on behalf of, the competent authority of a Member State.

The type testing is based on the evaluation of performance characteristics determined under a prescribed series of tests. In this European Standard, test procedures are described for the determination of the actual values of the performance characteristics for at least two AMS in a laboratory and the same two AMS in the field. The evaluation for type testing of an AMS includes the calculation of the expanded uncertainty of the measuring result based on the numerical values of the tested performance characteristics and comparison with a prescribed maximum uncertainty.

Appropriate experimental evidence shall be provided by:

a) type testing performed under conditions of intended use of the specified method of measurement, and

b) calculation of expanded uncertainty of results of measurement.

5.4 Suitability testing

Before putting a type-approved AMS into operation, the body responsible for the field operation shall test its suitability for its specific field conditions. If the specific conditions have already been covered by the type testing, then the suitability test is not necessary. If these conditions have not been covered by the type testing field tests, suitability tests shall be performed at locations representative of these specific field conditions.

5.5 Field operation and quality control

After the initial installation of the AMS at the monitoring station its correct functioning shall be tested.

Requirements for quality assurance and quality control are given for the operation and maintenance of the AMS, to ensure that the uncertainty of subsequent measurement results obtained in the field is not compromised.

5.6 Data handling and validation

Practical experience with existing methods for data handling and validation – for similar AMS – has shown that the different ways of data treatment and validation applied may lead to significant differences in reported results for similar data sets [3].

Hence, requirements and recommendations are given for the treatment and validation of raw measurement data collected by the AMS (see Clause 9).

6 Sampling

6.1 General

Conditions and layout of the sampling equipment will contribute to the uncertainty of the measurement; to minimize this contribution to the measurement uncertainty, performance criteria for the sampling equipment are given in the following subclauses.

NOTE In Annex A, examples of equipment are schematically presented.

6.2 Sampling location

The location where the ambient air shall be sampled and analysed is not specified as this depends strongly on the category of a monitoring station (such as measurements in, e.g. a traffic or urban background area).

NOTE For guidance on sampling points on a micro scale, see reference [1].

6.3 Sample inlet and sampling line

Each AMS is equipped with its own sample inlet and sampling line. Sampling inlets may be – but are not restricted to – size-selective inlets for PM_{10} or $PM_{2,5}$.

NOTE Examples of designs of size-selective inlets for PM_{10} or $PM_{2,5}$ can be found in EN 12341.

The manufacturer should provide information on the design of the sample inlet and the sampling line.

The sample inlet and sampling line shall be made of an inert, non-corroding, electrically conducting material, preferably stainless steel, or anodized aluminium or aluminium alloy. The inlet shall be constructed in such a way that ingress of rainwater into the sampling line (or system) is prevented.

The construction of the sampling line shall be such that deposition losses of particulate matter by kinetic processes as well as losses due to thermal, chemical or electrostatic processes are minimized. Contact of the sampled air with cold surfaces may cause condensation and shall be avoided. If heating of surfaces is applied, the instrument shall be tested with this facility in operation as part of the type testing.

The air flow velocity in the sampling line shall be such that significant losses of particulate matter due to diffusion or turbulent inertial impaction are minimized.

6.4 Control and regulation of sample flow rate

Correct operation of the AMS requires calibration and control of sampling flow rate, and measurement of ambient temperature and pressure.

The sample flow rate into the AMS shall be maintained within the specifications as laid down in Table 1.

6.5 Expression of concentrations

Results shall be reported in units of mass per unit volume expressed at ambient conditions. The air temperature needed for the conversion to ambient conditions shall be measured close to the sampling inlet. The air pressure needed for the conversion shall be obtained from on-site measurements, or from measurements at a representative meteorological site nearby.

When using data from meteorological sites, care shall be taken to convert these to the correct altitude of the sampling site, if relevant.

It is essential that any conversion to ambient conditions is clearly and unambiguously identified by the manufacturer. The manufacturer shall inform the test laboratory or test house whether any built-in corrections are applied. Where no internal corrections are applied, the manufacturer shall provide the test laboratory or test house with any algorithms that are required for the conversion of the AMS readings to different temperatures and/or pressures.

7 Type testing

7.1 Performance requirements

This test programme describes a procedure for determining whether an AMS is suitable to be considered equivalent to the EU Reference Methods for the measurement of particulate matter in ambient air. Tested AMS will have to meet the Data Quality Objectives of Reference [1]. This test programme is suitable to evaluate AMS for monitoring different fractions – PM_{10} or $PM_{2,5}$ – of suspended particulate matter in ambient air.

This process of evaluation of the values of the performance characteristics comprises laboratory and field tests, and the calculation of the expanded uncertainty. Two AMS of the same pattern shall be included in the full test programme. Both of the AMS submitted for type testing are required to pass all of the tests listed under Clause 7.

A competent body shall perform the type testing. The type testing shall be awarded by or on behalf of the competent authority. The competent body performing the required tests shall be able to demonstrate that it works in conformity with the requirements of internationally accepted standards for test laboratories.

NOTE 1 EN ISO/IEC 17025 [9] is the harmonized internationally accepted standard that applies.

NOTE 2 A formal accreditation by a member body of the European Accreditation Organization to EN ISO/IEC 17025 is a demonstration of conformity.

7.2 Relevant performance characteristics and performance criteria

The performance characteristics which shall be determined during a laboratory and field test, and their related performance criteria, are given in Table 1.