SLOVENSKI STANDARD
SIST EN 14181:2004

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Emisije nepremiļ nih virov - Zagotavljanje kakovosti avtomatskih merilnih sistemov

Stationary source emissions - Quality assurance of automated measuring systems

Emissionen aus stationären Quellen - Qualitätssicherung für automatische Messeinrichtungen

Émissions des sources fixes - Assurance qualité des systemes automatiques de mesure

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13.040.40	Emisije nepremiļ nih virov	Stationary source emissions

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Stationary source emissions - Quality assurance of automated measuring systems

Émission des sources fixes - Assurance qualité des systèms automatiques de mesure

Emissionen aus stationären Quellen - Qualitätssicherung für automatische Messeinrichtungen

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Contents

Foreword

This document (EN 14181:2004) 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of an identical text or by endorsement, at the latest by December 2004, and conflicting national standards shall be withdrawn at the latest by December 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. It supports requirements in the EU Directives 2000/76/EC [1] and 2001/80/EC [2] and may also be applicable for other purposes.

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.

Introduction

This standard describes the quality assurance procedures needed to assure that an Automated Measuring System (AMS) installed to measure emissions to air are capable of meeting the uncertainty requirements on measured values given by legislation, e.g. EU Directives [1], [2] or national legislation, and more generally by competent authorities.

Three different Quality Assurance Levels (QAL1, QAL2, and QAL3) are defined to achieve this objective. These Quality Assurance Levels cover the suitability of an AMS for its measuring task (e.g. before or during the purchase period of the AMS), the validation of the AMS following its installation, and the control of the AMS during its ongoing operation on an industrial plant. An Annual Surveillance Test (AST) is also defined.

The suitability evaluation of the AMS and its measuring procedure are described in EN ISO 14956 (QAL1) where a methodology is given for calculating the total uncertainty of AMS measured values. This total uncertainty is calculated from the evaluation of all the uncertainty components arising from its individual performance characteristics that contribute.

1 Scope

This European Standard specifies procedures for establishing quality assurance levels (QAL) for automated measuring systems (AMS) installed on industrial plants for the determination of the flue gas components and other flue gas parameters.

This standard specifies:

— a procedure (QAL2) to calibrate the AMS and determine the variability of the measured values obtained by it, so as to demonstrate the suitability of the AMS for its application, following its installation;

— a procedure (QAL3) to maintain and demonstrate the required quality of the measurement results during the normal operation of an AMS, by checking that the zero and span characteristics are consistent with those determined during QAL1;

— a procedure for the annual surveillance tests (AST) of the AMS in order to evaluate (i) that it functions correctly and its performance remains valid and (ii) that its calibration function and variability remain as previously determined.

This standard is designed to be used after the AMS has been accepted according to the procedures specified in EN ISO 14956 (QAL1).

This standard is restricted to quality assurance (QA) of the AMS, and does not include the QA of the data collection and recording system of the plant.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999)*.

3 Terms and definitions

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

3.1
air quality characteristic
one of the quantifiable properties relating to an air mass under investigation, for example, concentration of a constituent

[ISO 6879:1995]

3.2
automated measuring system AMS
measuring system permanently installed on site for continuous monitoring of emissions

NOTE 1 An AMS is a method which is traceable to a reference method.

NOTE 2 Apart from the analyser, an AMS includes facilities for taking samples (e.g. sample 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.

3.3
calibration function
linear relationship between the values of the SRM and the AMS with the assumption of a constant residual standard deviation

3.4
competent authority
organisation or organisations which implement the requirements of EU Directives and regulate installations which must comply with the requirements of this European Standard

3.5
confidence interval (two-sided)
when T_1 and T_2 are two functions of the observed values such that, θ being a population parameter to be estimated, the probability $P_r(T_1 \leq \theta \leq T_2)$ is at least equal to $(1 - \alpha)$ [where $(1 - \alpha)$ is a fixed number, positive and less than 1], the interval between T_1 and T_2 is a two-sided $(1 - \alpha)$ confidence interval for θ

[ISO 3534-1:1993]

NOTE The 95 % confidence interval is illustrated in Figure 1, where:

$T_1 = \Theta - 1{,}96\ \sigma_0$ is the lower 95 % confidence limit;

$T_2 = \Theta + 1{,}96\ \sigma_0$ is the upper 95 % confidence limit;

$I = T_2 - T_1 = 2 \times 1{,}96 \times \sigma_0$ is the length of the 95 % confidence interval;

$\sigma_0 = I / (2 \times 1{,}96)$ is the standard deviation associated with a 95 % confidence interval;

n is the number of observed values;

f is the frequency;

m is the measured value.

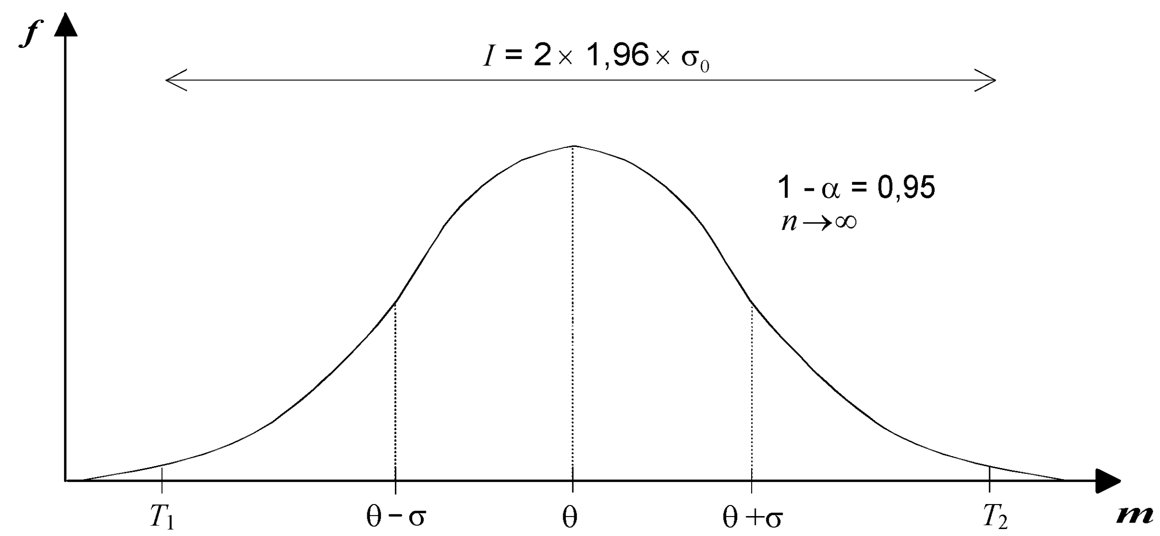

Figure 1 — Illustration of the 95 % confidence interval of a normal distribution

In this European Standard, the standard deviation σ_0 is estimated in QAL2 by parallel measurements with a SRM. It is assumed that the requirement for σ_0, presented in terms of an allowable uncertainty budget i.e. variability, is provided by the regulators (e.g. in some EU Directives). In the procedures of this standard, the premise is that the required variability is given as σ_0 itself, or as a quarter of the length of the full 95 % confidence interval.

3.6
CUSUM chart
calculation procedure in which the amount of drift and change in precision is compared to the corresponding uncertainty components which are obtained during QAL1

3.7
drift
monotonic change of the calibration function over stated period of unattended operation, which results in a change of the measured value

3.8
emission limit value
limit value related to the uncertainty requirement

NOTE For the EU directives [1] and [2] it is the daily emission limit value that relates to the uncertainty requirement.

3.9
extractive AMS
AMS having the detection unit physically separated from the gas stream by means of a sampling system

3.10
instability
change in the measured value comprised of drift and dispersion resulting from the change in the calibration function over a stated period of unattended operation, for a given value of the air quality characteristic. Drift and dispersion specify the monotonic and stochastic change with time of the output signal, respectively

[ISO 6879:1995]

3.11
instrument reading
indication of the measured value directly provided by the AMS without using the calibration function

3.12
legislation
directives, Acts, ordinances and regulations

3.13
measurand
particular quantity subject to measurement

[ENV 13005:1999]

3.14
measured value
estimated value of the air quality characteristic derived from an output signal; this usually involves calculations related to the calibration process and conversion to required quantities

[ISO 6879:1995]

3.15
non-extractive AMS
AMS having the detection unit in the gas stream or in a part of it

3.16
period of unattended operation
maximum admissible interval of time for which the performance characteristics will remain within a predefined range without external servicing, e.g. refill, calibration, adjustment

[ISO 6879:1995]

3.17
peripheral AMS or SRM
measuring system or SRM used to gather the data required to convert the measured values to standard reference conditions, i.e. AMS or SRM for moisture, temperature, pressure and oxygen

3.18
precision
closeness of agreement of results obtained from the AMS for successive zero readings and successive span readings at defined time intervals

3.19
reference material
material simulating a known concentration of the input parameter, by use of surrogates and traceable to national standards

NOTE Surrogates normally used are calibration gases, gas cells, gratings or filters.

3.20
response time
time taken for an AMS to respond to an abrupt change in value of the air quality characteristic

[ISO 6879:1995]

3.21
span reading
instrument reading of the AMS for a simulation of the input parameter at a fixed elevated concentration.

NOTE 1 This simulation should test as much as possible all the measuring elements of the system, which contribute significantly to its performance.

NOTE 2 The span reading is approximately 80 % of the measured range.

3.22
standard conditions
conditions as given in the EU-directives to which measured values have to be standardised to verify compliance with the emission limit values

3.23
standard deviation
positive square root of: the mean squared deviation from the arithmetic mean divided by the number of degrees of freedom

NOTE The number of degrees of freedom is the number of measurements minus 1.

3.24
Standard Reference Method SRM
method described and standardised to define an air quality characteristic, temporarily installed on site for verification purposes

NOTE Also known as a reference method.

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

[ENV 13005:1999]

3.26
variability
standard deviation of the differences of parallel measurements between the SRM and AMS

3.27
zero reading
instrument reading of the AMS on simulation of the input parameter at zero concentration

NOTE This simulation should test as much as possible all the measuring elements of the AMS, that contribute significantly to its performance

4 Symbols and abbreviations

4.1 Symbols

a	intercept of the calibration function
$\hat{a}$	best estimate of a
b	slope of the calibration function
$\hat{b}$	best estimate of b
D_i	difference between measured SRM value y_i and calibrated AMS value $\hat{y}_i$
$\overline{D}$	average of D_i
D_{adjust}	amount by which the AMS has to be adjusted, in the case that drift is detected
d_t	difference between actual instrument reading of the AMS and the reference value
d_{t-1}	difference between previous instrument reading of the AMS and the reference value
E	emission limit value
h_s	test value for detection of a decrease in precision
h_x	test value for detection of drift
k_s	constant in the calculation in the provisional sum for standard deviation
k_{v}	test value for variability (based on a χ^2-test, with a β-value of 50 %, for N numbers of paired measurements)
k_x	constant in the calculation in the provisional sum for positive and negative differences and in the calculation of the required adjustment of the AMS
N	number of paired samples in parallel measurements
$N(s)$	number of readings since the standard deviation was different from zero
N(pos)	number of readings since a positive difference was detected
N(neg)	number of readings since a negative difference was detected
P	percentage value
s_{p}	provisional normalised sum of the standard deviations of the AMS (QAL3)

s_t	provisional normalised sum of the standard deviations of the AMS at time t (QAL3)
s_{t-1}	provisional normalised sum of the standard deviations of the AMS at time t-1 (QAL3)
s_D	standard deviation of the differences D_i in parallel measurements
u_{inst}	uncertainty due to instability (expressed as a standard deviation)
u_{temp}	uncertainty due to influence of temperature (expressed as a standard deviation)
u_{pres}	uncertainty due to influence of pressure (expressed as a standard deviation)
u_{volt}	uncertainty due to influence of voltage (expressed as a standard deviation)
u_{others}	any other uncertainty that may influence the zero and span reading (expressed as a standard deviation)
x_i	i^{th} measured signal obtained with the AMS at AMS measuring conditions
$\bar{x}$	average of AMS measured signals x_i
x_t	reference value at time t (QAL3)
y_i	i^{th} result obtained with the SRM
$\bar{y}$	average of the SRM results y_i
$y_{i,\text{s}}$	SRM value y_i at standard conditions
$y_{\text{s,min}}$	lowest SRM value at standard conditions
$y_{\text{s,max}}$	highest SRM value at standard conditions
$\hat{y}_i$	best estimate for the "true value", calculated from the AMS measured signal x_i by means of the calibration function
$\hat{y}_{i,\text{s}}$	best estimate for the "true value", calculated from the AMS measured signal x_i at standard conditions
y_t	actual instrument reading of the AMS at time t (QAL3)
Z	offset (the difference between the AMS zero reading and the zero)
$\Sigma(\text{pos})_\text{p}$	provisional normalised sum of the positive drift of the AMS
$\Sigma(\text{pos})_t$	normalised sum of the positive drift of the AMS at time t
$\Sigma(\text{pos})_{t-1}$	previous normalised sum of the positive drift of the AMS (at time t–1)
$\Sigma(\text{neg})_\text{p}$	provisional normalised sum of the negative drift of the AMS
$\Sigma(\text{neg})_t$	normalised sum of the negative drift of the AMS at time t
$\Sigma(\text{neg})_{t-1}$	previous normalised sum of the negative drift of the AMS (at time t–1)
s_{AMS}	standard deviation of the AMS used in QAL3
α	significance level
ε_i	deviation between y_i and the expected value
σ_0	uncertainty derived from requirements of legislation

4.2 Abbreviations

AMS	Automated Measuring System
AST	Annual Surveillance Test
ELV	Emission Limit Value
QA	Quality Assurance

QAL	Quality Assurance Level
QAL1	First Quality Assurance Level
QAL2	Second Quality Assurance Level
QAL3	Third Quality Assurance Level
QC	Quality Control
SRM	Standard Reference Method

5 Principle

5.1 General

An AMS to be used at installations covered by EU Directives, e.g. [1] and [2], shall have been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure, as specified by EN ISO 14956. Using this standard, it shall be proven that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. In QAL1 the total uncertainty required by the applicable regulation is calculated by summing in an appropriate manner all the relevant uncertainty components arising from the individual performance characteristics.

The QAL2 and AST procedures involve testing laboratories, whereas the QAL3 procedures involve the plant operators.

QAL2 is a procedure for the determination of the calibration function and its variability, and a test of the variability of the measured values of the AMS compared with the uncertainty given by legislation. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned. A calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated against the required uncertainty.

The QAL2 procedures are repeated periodically, after a major change of plant operation, after a failure of the AMS or as required by legislation.

QAL3 is a procedure which is used to check drift and precision in order to demonstrate that the AMS is in control during its operation so that it continues to function within the required specifications for uncertainty. This is achieved by conducting periodic zero and span checks on the AMS – based on those used in the procedure for zero and span repeatability tests carried out in QAL1 – and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS, may be necessary depending on the results of this evaluation.

The AST is a procedure which is used to evaluate whether the measured values obtained from the AMS still meet the required uncertainty criteria – as demonstrated in the previous QAL2 test. It also determines whether the calibration function obtained during the previous QAL2 test is still valid. The validity of the measured values obtained with the AMS is checked by means of a series of functional tests as well as by the performance of a limited number of parallel measurements using an appropriate SRM.

5.2 Limitations

Figure 2 illustrates the components of the AMS covered by this standard.

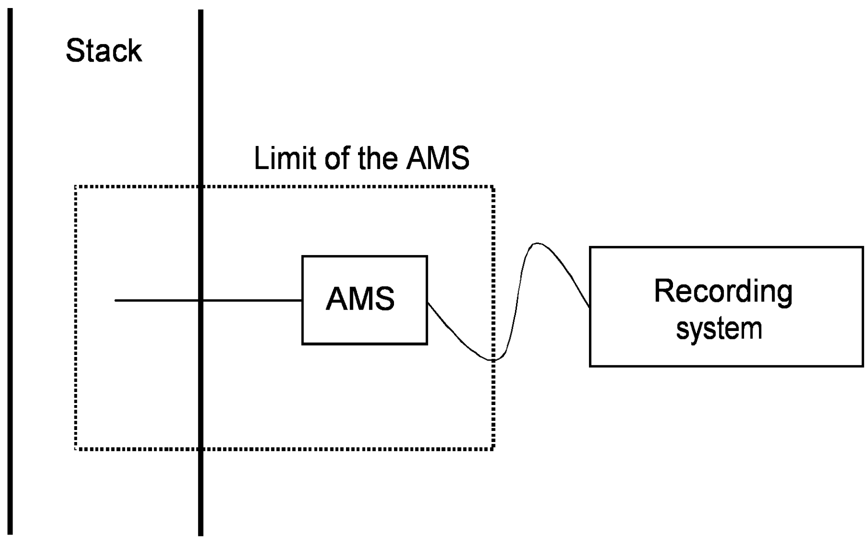

Figure 2 — Limits for the QA of the AMS excluding the data recording system

NOTE 1 The influence of the uncertainty of the measurement results, which arise from the data acquisition recording and handling system of the AMS or of the plant system, and its determination, are not covered from this standard.

NOTE 2 The performance of the data collection and recording system can be as influential as the AMS performance in determining the quality of the results obtained from the whole measuring system/process. There are different requirements for data collection recording and presentation in different countries.

When conducting parallel measurements, the measured signals from the AMS shall be taken directly from the AMS (e.g. expressed as analogue or digital signal) during the QAL2 and AST procedures specified in this standard, by using an independent data collection system provided by the organisation(s) carrying out the QAL2 and AST tests. All data shall be recorded in their uncorrected form (without corrections e.g. for temperature and oxygen). A plant data collection system with ongoing quality control can additionally be used to collect the measured signal from the AMS.

5.3 Measurement site and installation

The AMS shall be installed in accordance with the requirements of the relevant European and/or international standards. Special attention shall be given to ensure that the AMS is readily accessible for regular maintenance and other necessary activities.

NOTE The AMS should be positioned as far as practical in a position where it measures a sample that is representative of the stack gas composition.

All measurements shall be carried out on a suitable AMS and peripheral AMS installed within an appropriate working environment.

The working platform used to access the AMS shall readily allow parallel measurements to be performed using an SRM. The sampling ports for measurements with the SRM shall be placed as close as possible, but not more than three times the equivalent diameter up- or down-stream of the location of the AMS, in order to achieve comparable measurements between AMS and SRM.

It is necessary to have good access to the AMS to enable inspections to take place and also to minimise the time taken to implement the quality assurance procedures of this standard. A clean, well-ventilated and well-lit working space around the AMS is required to enable the staff to perform this work effectively. Suitable protection is required for the personnel and the equipment, if the working platform is exposed to the weather.

5.4 Testing laboratories performing SRM measurements

The testing laboratories performing the measurements with the SRM shall have an accredited quality assurance system according to EN ISO/IEC 17025, or shall be approved directly by the relevant competent authority. They shall also have sufficient experience in performing the measurements using the appropriate SRM. The SRM used shall be a European Standard, if available. If such a standard does not exist, international or national standards shall apply so as to ensure the provision of data of an equivalent scientific quality.

6 Calibration and validation of the AMS (QAL2)

6.1 General

Testing shall cover the following items:

— installation of the AMS;

— calibration of the AMS by means of parallel measurements with a SRM;

— determination of the variability of the AMS, and the check of compliance with the required uncertainty.

The sequence of the combined tests is shown in Figure 3.

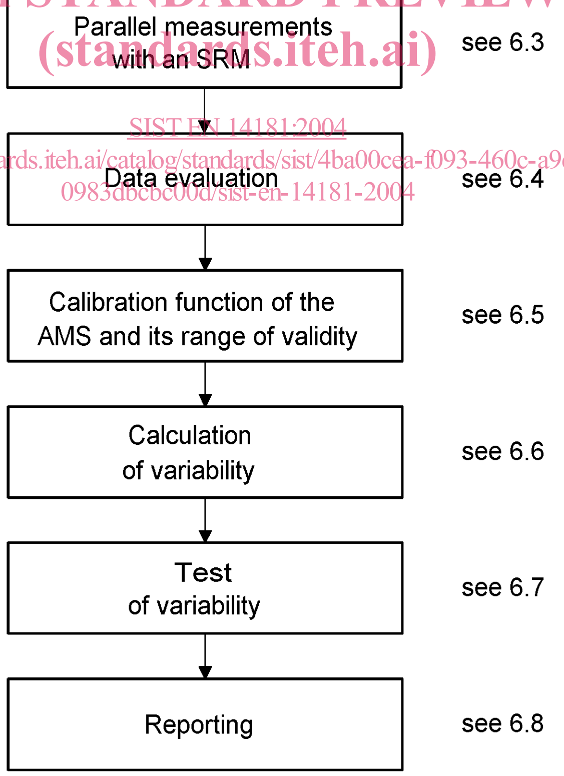

Figure 3 — Flow diagram for the calibration and variability tests

A QAL2 procedure shall be performed for all measurands:

— at least every 5 years for every AMS or more frequently if so required by legislation or by the competent authority (e.g. the EU Directive 2000/76/EC on the Incineration of Waste [1] specifies parallel measurements every 3 years);