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Stationary source emissions — Quality assurance of automated measuring systems

Émission des sources fixes — Assurance qualité des systèmes automatiques de mesurage

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by the European Committee for Standardization (CEN) (as EN 14181:2014) and was adopted, without modification by Technical Committee ISO/TC 146, *Air quality,* Subcommittee SC 1, *Stationary source emission*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document describes the quality assurance procedures needed to ensure that an automated measuring system (AMS) installed to measure emissions to air are capable of meeting the uncertainty requirements on measured values e.g. given by legislation[1],[2],[3] or 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 (QAL1) of the AMS and its measuring procedure are described in EN 15267-3 and ISO 14956 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.

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Stationary source emissions — Quality assurance of automated measuring systems

1 Scope

This document 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 document 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 document is designed to be used after the AMS has been certified in accordance with the series of documents EN 15267.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 15259:2007, *Air quality — Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 15267-1, *Air quality — Certification of automated measuring systems — Part 1: General principles*

EN 15267-2, *Air quality — Certification of automated measuring systems — Part 2: Initial assessment of the AMS manufacturer's quality management system and post certification surveillance for the manufacturing process*

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*

ISO 14956, *Air quality — Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

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— IEC Electropedia: available at https://www.electropedia.org/

3.1
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. sample probe, sample gas lines, flow meters, regulators, delivery pumps) and for sample conditioning (e.g. dust filter, water vapour removal devices, converters, diluters). This definition also includes testing and adjusting devices that are required for regular functional checks.

3.2
extractive AMS
AMS having the detection unit physically separated from the gas stream by means of a sampling system

3.3
in-situ AMS
AMS having the detection unit in the gas stream or in a part of it

3.4
peripheral AMS
AMS used to gather the data required to convert the AMS measured value to standard conditions

Note 1 to entry: A peripheral AMS is used to measure e.g. water vapour, temperature, pressure and oxygen.

3.5
reference method
RM
measurement method taken as a reference by convention, which gives the accepted reference value of the measurand

[SOURCE: EN 15259:2007]

3.6
standard reference method
SRM
reference method prescribed by European or national legislation

Note 1 to entry: Standard reference methods are used e.g. to calibrate and validate AMS and for periodic measurements to check compliance with limit values.

[SOURCE: EN 15259:2007]

3.7
peripheral SRM
SRM used to gather the data required to convert the SRM measured values to AMS or standard conditions

Note 1 to entry: A peripheral SRM is used to measure e.g. water vapour, temperature, pressure and oxygen.

3.8
standard conditions
conditions to which measured values have to be standardized to verify compliance with emission limit values

Note 1 to entry: Standard conditions are specified e.g. in EU Directives[1],[2] and[3].

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3.9
emission limit value
ELV
limit value related to the maximum permissible uncertainty

Note 1 to entry: For the EU Directives[1],[2] and[3] it is the daily emission limit value that relates to the uncertainty requirement.

3.10
maximum permissible uncertainty
uncertainty requirement on AMS measured values given by legislation or competent authorities

3.11
legislation
directives, acts, ordinances or regulations

3.12
competent authority
organization or organizations which implement the requirements of EU Directives and regulate installations which shall comply with the requirements of this document

3.13
calibration function
linear relationship between the values of the SRM and the AMS with the assumption of a constant residual standard deviation

Note 1 to entry: For dust measuring AMS, a quadratic calibration function can be used as described in EN 13284-2.

3.14
standard deviation
positive square root of the mean squared deviation from the arithmetic mean divided by the number of degrees of freedom

Note 1 to entry: The number of degrees of freedom is the number of measurements minus 1.

3.15
confidence interval
interval estimator (T_1, T_2) for the parameter θ with the statistics T_1 and T_2 as interval limits and for which it holds that $P[T_1 < \theta < T_2] \geq (1 - \alpha)$

[SOURCE: ISO 3534-1:2006]

Note 1 to entry: The two-sided 95 % confidence interval of a normal distribution 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.

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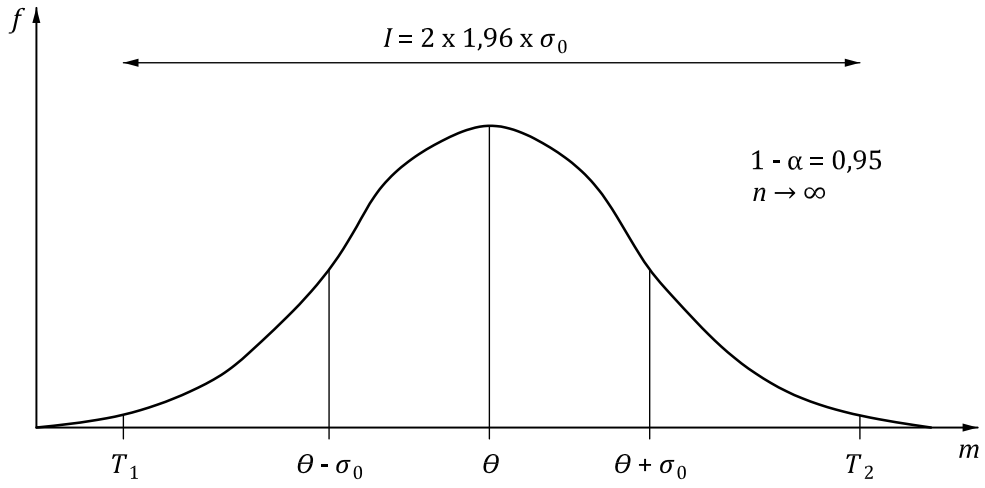

Figure 1 — Illustration of the 95 % confidence interval of a normal distribution

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

Note 2 to entry: In some EU Directives (see [1],[2],[3]) the uncertainty of the AMS measured values is expressed as half of the length of a 95 % confidence interval as a percentage *P* of the emission limit value *E*. Then, in order to convert this uncertainty to a standard deviation, the appropriate conversion factor is $\sigma_0 = P\ E\ /\ 1{,}96$.

3.16
variability
standard deviation of the differences of parallel measurements between the SRM and AMS

3.17
uncertainty
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]

3.18
measurand
particular quantity subject to measurement

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

Note 1 to entry: A measurand can be e.g. the mass concentration of a measured component or the waste gas velocity, pressure or temperature.

3.19
measured component
constituent of the waste gas for which a defined measurand is to be determined by measurement

[SOURCE: EN 15259:2007]

3.20
peripheral parameter
specified physical or chemical quantity which is needed for conversion of measured values to specified conditions

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3.21
measured value
estimated value of the measurand derived from a measured signal

Note 1 to entry: This usually involves calculations related to the calibration process and conversion to required quantities.

Note 2 to entry: A measured value is a short-term average. The averaging time can be e.g. 10 min, 30 min or 1 h.

3.22
instrument reading
measured signal directly provided by the AMS without using the calibration function

3.23
zero reading
instrument reading on simulation of the input parameter at zero concentration

3.24
span reading
instrument reading for a simulation of the input parameter at a fixed elevated concentration

3.25
instability
change in the measured signal comprised of drift and dispersion over a stated maintenance interval

Note 1 to entry: Drift and dispersion specify the monotonic and stochastic change with time of the measured signal, respectively.

3.26
drift
monotonic change of the calibration function over stated maintenance interval, which results in a change of the measured signal

3.27
precision
closeness of agreement of results obtained from the AMS for successive zero readings and successive span readings at defined time intervals

3.28
response time
t_{90}
time interval between the instant of a sudden change in the value of the input quantity to an AMS and the time as from which the value of the output quantity is reliably maintained above 90 % of the correct value of the input quantity

Note 1 to entry: The response time is also referred to as the 90 % time.

3.29
maintenance interval
maximum admissible interval of time for which the performance characteristics will remain within a predefined range without external servicing, e.g. refill, calibration, adjustment

3.30
reference material
substance or mixture of substances, with a known concentration within specified limits, or a device of known characteristics

3.31
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

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3.32
EWMA chart
calculation procedure in which the combined amount of drift and change in precision is compared to the corresponding uncertainty components which are obtained during QAL1

Note 1 to entry: The EWMA chart averages the data in a way that gives less and less weight to data as they are further removed in time.

4 Symbols and abbreviated terms

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 SRM measured value y_i and calibrated AMS measured value $\hat{y}_i$
$\overline{D}$	average of D_i
E	emission limit value
k_v	test value for variability (based on a χ^2-test, with a β-value of 50 %, for N numbers of paired measurements)
N	number of paired samples in parallel measurements
P	percentage value
s_{AMS}	standard deviation of the AMS used in QAL3
s_D	standard deviation of the differences D_i in parallel measurements
$t_{0,95;\ N-1}$	value of the t distribution for a significance level of 95 % and a number of degrees of freedom of $N - 1$
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
$\overline{x}$	average of AMS measured signals x_i
y_i	i^{th} measured value obtained with the SRM
$\overline{y}$	average of the SRM measured values y_i
$y_{i,s}$	SRM measured value y_i at standard conditions

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