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Stationary source emissions — Greenhouse gases —

Part 2:
Ongoing quality control of automated measuring systems

Émissions de sources fixes — Gaz à effet de serre —

Partie 2: Contrôle qualité continu des systèmes de mesurage automatiques

Reference number
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Foreword

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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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The committee responsible for this document is ISO/TC 146, *Air quality*, Subcommittee SC 1, *Stationary source emissions*.

ISO 14385 consists of the following parts, under the general title *Stationary source emissions — Greenhouse gases*:

— *Part 1: Calibration of automated measuring systems*

— *Part 2: Ongoing quality control of automated measuring systems*

Introduction

The measurement of greenhouse gas emissions (carbon dioxide, nitrous oxide, methane) in a framework of emission trading requires an equal and known quality of data.

This part of ISO 14385 describes the quality assurance procedures for calibration and ongoing quality control needed to ensure that automated measuring systems (AMS) installed to measure emissions of greenhouse gases to air are capable of meeting the uncertainty requirements on measured values specified by legislation, competent authorities, or in an emission trade scheme.

Stationary source emissions — Greenhouse gases —

Part 2:
Ongoing quality control of automated measuring systems

1 Scope

This part of ISO 14385 specifies procedures for establishing quality assurance for automated measuring systems (AMS) installed on industrial plants for the determination of the concentration of greenhouse gases in flue and waste gas and other flue gas parameters.

This part of ISO 14385 specifies the following:

— a procedure 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 using the relevant procedure in ISO 14956;

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

This part of ISO 14385 is designed to be used after the AMS has been accepted according to the procedures specified in ISO 14956.

This part of ISO 14385 is restricted to quality assurance (QA) of the AMS and does not include QA of the data collection and recording system of the plant.

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.

ISO 14385-1, *Stationary source emissions — Greenhouse gases — Part 1: Calibration of automated measuring systems*

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 terms and definitions given in ISO 14385-1 and the following apply.

3.1
control chart
graphical presentation of the regular recording of the difference of the reading of an instrument or measuring system, when measuring the pollutant concentration in a gas with known concentration, and the nominal value of the pollutant concentration in that gas

4 Symbols and abbreviations

4.1 Symbols

D_i difference between SRM value y_i and calibrated AMS measured value $\hat{y}_i$

$\bar{D}$ average of D_i

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

s_{AMS} standard deviation of the AMS used in ongoing quality control

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 can 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

y_i i^{th} measured value obtained with the SRM

$\bar{y}$ average of the SRM measured values y_i

$y_{i,s}$ SRM measured value y_i at standard conditions

$y_{s,min}$ lowest SRM measured value at standard conditions

$y_{s,max}$ highest SRM measured 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

$\hat{y}_{i,s}$ best estimate for the ”true value”, calculated from the AMS measured signal x_i at standard conditions

$\hat{y}_{s,max}$ best estimate for the ”true value”, calculated from the maximum value of the AMS measured signals x_i at standard conditions

ε_i deviation between y_i and the expected value

$\sigma 0$ standard deviation associated with the uncertainty derived from requirements of legislation

4.2 Abbreviations

AMS automated measuring system

AST annual surveillance test

EWMA chart	exponentially weighted moving average chart
QA	quality assurance
SRM	Standard Reference Method

5 Principle

5.1 General

An AMS to be used shall have been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the procedures, as specified by ISO 14956. Using this part of ISO 14385, it shall be proven that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in legislation or in requirements and specifications established in an international trading program. In ISO 14956, the total uncertainty required by the relevant regulations is calculated by summing all the relevant uncertainty components arising from the individual performance.

NOTE It is advisable that uncertainty figures are provided by independent testing bodies.

This part of ISO 14385 provides two procedures.

— 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 of the AMS, based on those used in the procedure for zero and span repeatability tests according to ISO 14956:2002, and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS can be necessary, depending on the results of this evaluation.

— A procedure which is used to evaluate whether the measured values obtained from the AMS still meet the maximum permissible uncertainty criteria, as demonstrated in the calibration procedure (ISO 14385-1). It also determines whether the calibration function obtained during the calibration procedure 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 part of ISO 14385.

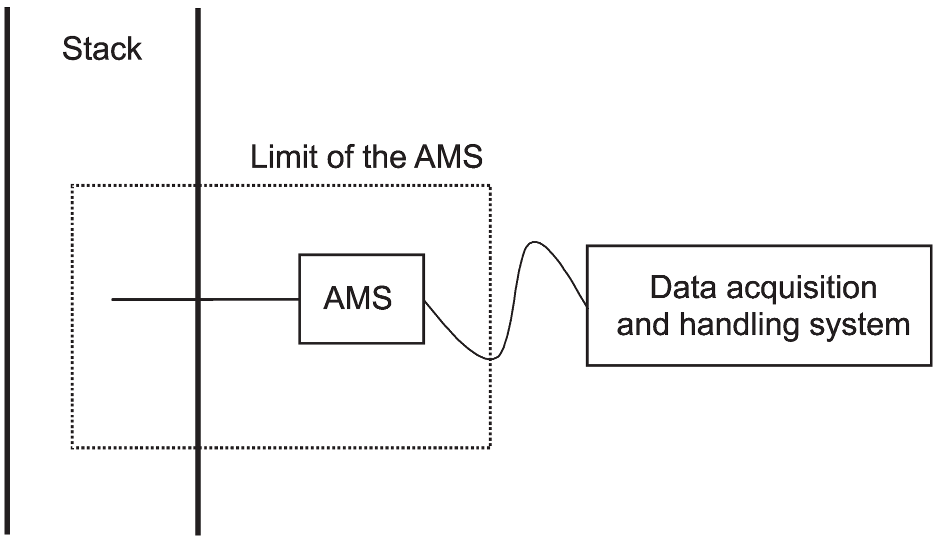

Figure 2 — Limits for the QA of the AMS excluding the data acquisition and handling system

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 excluded from this part of ISO 14385.

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 are taken directly from the AMS (e.g. expressed as analogue or digital signal) during the AST procedures specified in this part of ISO 14385, by using an independent data collection system provided by the organization(s) carrying out the AST tests. All data shall be recorded in their uncorrected form (without corrections for, e.g. temperature and oxygen). A plant data collection system with 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 national or international standards, as specified by legislation, competent authorities, or in emission trade scheme. Special attention shall be given to ensure that the AMS is readily accessible for regular maintenance and other necessary activities.

NOTE The AMS is intended to be positioned as far as practical in a position where it measures a sample, which 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-stream 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 minimize time taken to implement the quality assurance procedures of this part of ISO 14385. 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, which perform the measurements with the SRM, shall have an accredited quality assurance system according to 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 an international or national standard to ensure the provision of data of an equivalent scientific quality.

6 Ongoing quality assurance during operation

6.1 General

An AMS can drift or become less precise during routine operation. Drift or instability can be due to, for example, changes in the AMS, such as contamination of an optical surface, a gradual failure of a component, or a blockage in a filter. Such changes cause systematic errors in the data from the AMS. On the other hand, AMS are also subject to short-term variations in stability and precision due to the influences of factors such as changes in ambient temperature. These variations cause random errors. The magnitude of the random errors is assessed during the certification process of the AMS.

After the acceptance and calibration of the AMS, further quality assurance and quality control procedures shall be followed so as to ensure that the measured values obtained with the AMS meet the stated or maximum permissible uncertainty on a continuous basis (also described as *ongoing quality control*). The implementation and performance of the procedures given in this part of ISO 14385 are the responsibility of the plant owner (i.e. the owner of the AMS). It is also the responsibility of the plant owner to ensure that the AMS is operating inside the valid calibration range (see 6.5). The procedures shall be implemented and be in place at the same time that the collection of emission data by means of the AMS is mandatory for reporting to the authorities. It is recommended, however, that these procedures commence as soon as possible after the installation of the AMS in order to gain as much information on the performance of the AMS as possible. This can begin before the AMS has to be calibrated with the SRM in order to fulfil the procedure requirements according to ISO 14385-1.

The instrument reading shall reflect the actual drifts in both zero and span readings. Negative instrument readings at zero level shall be recorded.

For some monitors, it is difficult to achieve a zero and span readings. In those situations, the supplier shall give instructions on how to achieve readings that reflect the actual drift in zero and span readings, as demonstrated in the procedures according to ISO 14956, and conforming to the definition of the zero reading.

6.2 Procedures to maintain ongoing quality

The aim of the procedure is to maintain and demonstrate the quality of the AMS, so that the requirements for the stated zero and span repeatability and drift values are met during ongoing operation and the AMS is maintained in the same operational condition as when installed. This shall be achieved by confirming that the drift and precision determined during the procedures according to ISO 14956 remain under control. A suitable methodology shall determine the combined drift and precision of the AMS.

The methodology shall identify whether an extra-maintenance (e.g. by the manufacturer) is necessary in order to adjust the AMS. The procedure uses control charts which plot the drifts (zero and span) against the time. In this procedure, reference materials are needed. The value of the reference material shall be known. The drift and precision components obtained from the procedure described in ISO 14956 and the uncertainty shall be combined and compared against the combined drift and precision obtained in the field.

Control charts require regular and ideally frequent measurements. The needed frequency of the ongoing quality control is at least the period of the maintenance interval. In order to extend a maintenance interval, some AMS suppliers developed automatic checks and adjustments which guarantee very limited drifts over time. Regular measurements at zero and reference points are the foundations of the procedure. Using control charts to show trends in the zero and reference point measurements show each measurement in context and can help prevent the operator from making adjustments to the AMS only when required.

A frequency of the ongoing quality of at least once every 2 weeks is recommended. Depending on the results of the zero and span checks, this frequency can be changed.

Therefore, ongoing quality control requires plant operators to have a procedure which describes the requirements for

— measuring zero and span values,

— plotting these values on control charts, and

— using the control charts to determine whether there are systematic errors, whether the random errors exceed the acceptable limits established by the implementation requirements in an international trading scheme.

The following sub-sections describe the following:

— choosing control charts;

— setting parameters for control charts;

— zero and span measurements;

— documentation and interpretation of the control charts.

6.3 Choosing control charts

6.3.1 General

Any type of control chart, manual or automated, can be used. Different charts have different advantages and can be more or less complicated to use, depending on the type of chart chosen. This part of ISO 14385 describes two types of chart: the Shewhart chart and the EWMA chart.

6.3.2 Shewhart chart

Shewhart charts simply plot the readings and test them against multiples of s_{AMS}. Its advantage is its simplicity; its disadvantage is that the approach is not as sensitive as other approaches such as EWMA charts. Furthermore, Shewhart charts cannot distinguish between systematic errors and random errors. Shewhart charts only indicate if the AMS has drifted or whether the precision has worsened. However, the Shewhart chart method is simple to set up and understand, and it is well suited for manual procedures.

Annex D describes in detail the procedure for Shewhart chart.

6.3.3 EWMA chart

Compared with the Shewhart chart, the exponentially weighted moving average (EWMA) chart is more appropriate for early detection of small- or medium-sized maladjustments. It keeps the graphical format of the Shewhart chart. This approach also implements only one decision rule. The approach also reduces the risks of unnecessary intervention due to the natural variability of the process.

Annex E describes in detail the procedure for EWMA chart.

6.3.4 Built-in methods

An alternative to an external control chart is to use an instrument built-in method. Many instruments have a built-in check of zero and span points, and give alarm, if set limits are surpassed.

Some AMS equipped with automatic systems for zero and span checks do not ordinarily output the data for zero and span drift for plotting on control charts, even though the automatic systems are designed to achieve the same result as control charts, i.e. measuring drift and alerting the plant operator if the AMS has drifted out of control. Some systems also automatically adjust the zero and/or the span point in order. If a plant operator has such a system, it can be accepted as a method for ongoing quality control provided that an assessment of the total drifts and adjustments are possible during the AMS maintenance by the AMS supplier and that the information is also accessible to the operator and for third party auditing.

6.4 Setting parameters for control charts

6.4.1 Calculation of the standard deviation s_{AMS} using performance data

The standard deviation s_{AMS} shall be derived from the information obtained for the calculations according to ISO 14956. s_{AMS} shall be calculated considering actual plant conditions and not the test conditions during the procedures according to ISO 14956.

For example, during establishing performance characteristics of an instrument testing the influence of ambient temperature on the AMS could be defined in a range such as 5 °C to 40 °C. However, if the AMS is kept in a climate controlled enclosure where the temperature varies from 18 °C to 23 °C, then the operator uses a temperature variation of 5 °C in the calculation for S_{AMS}.

S_{AMS} shall be calculated by

$$S_{AMS} = \sqrt{u_{inst}^2 + u_{temp}^2 + u_{volt}^2 + u_{pres}^2 + u_{others}^2} \quad (1)$$

where

u_{inst}	is the uncertainty from instability;
u_{temp}	is the uncertainty relating from variations in ambient temperature;
u_{volt}	is the uncertainty relating from variations in voltage;
u_{pres}	is the uncertainty relating from variations in ambient pressure;
u_{others}	is any other uncertainty that can influence the reading on zero and span reference material (e.g. dilution).

NOTE 1 S_{AMS} is expressed as a standard deviation; therefore, all above uncertainties are expressed as standard deviations. E.g. if the uncertainties are given as values at 95 % confidence, it is divided by the coverage factor (k_s = 2) for the correct calculation of S_{AMS}.

NOTE 2 It is advisable that values of uncertainties are provided by independent testing bodies.

If any of the above uncertainties are time dependent, this shall be taken into account. For example, if the uncertainty for instability is given as an upper and lower boundary such as a percentage value ± p per q days, then q equals the time between two readings for the control charts.

Examples of calculation of the standard deviation of the AMS at zero and span level are given in Annex F.

6.4.2 Setting limits for control charts

The control charts required for ongoing quality control are a means of determining whether any zero and span readings are true outliers, rather than acceptable random variations. As the standard deviation S_{AMS} determines the positions of the warning and alarm limits, the value of S_{AMS} is a critical part of the control chart. In statistical terms, the purpose of S_{AMS} is to determine if there is a significant probability that a zero or span measurement is different from the target value. Therefore, S_{AMS} is usually chosen to represent one standard deviation of the acceptable variations in zero and span readings. Multiples of S_{AMS} can be chosen to represent statistical confidence intervals for the variations in zero and span readings.

6.4.3 Alternative approach for setting the control chart limits

Site data are necessary to calculate S_{AMS}. They are also needed to check whether the AMS is suitable for the monitoring purpose, i.e. to check that the uncertainty of the AMS after start-up at that particular site is lower than the maximum permissible uncertainty.

However, the collection of site data is sometimes complicated and several assumptions have to be made. Therefore, instead of using a S_{AMS} value including assumptions, some operators prefer a pragmatic and simpler approach consisting in using fixed limits for their control chats. The limits are then equal to the maximum permissible uncertainty.

Another pragmatic solution is to calculate S_{AMS} based on the specifications from performance testing. For example, an AMS can have easily met the requirements. If so, then the value of S_{AMS} based on data from test reports can result in relatively low warning and alarm limits. If the performance of the AMS falls slightly, then the control charts can direct the operator to perform more frequent maintenance than required, as some variations in performance could mean that the AMS still easily meets the uncertainty