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Stationary source emissions — Determination of the mass concentration of nitrogen oxides in flue gas — Performance characteristics of automated measuring systems

Émissions de sources fixes — Détermination de la concentration en masse des oxydes d'azote dans les effluents gazeux — Caractéristiques de performance des systèmes de mesurage automatiques

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 1, *Stationary source emissions*.

This second edition cancels and replaces the first edition (ISO 10849:1996), which has been technically revised.

The main changes are as follows:

— the structure and the components have been updated to be similar to the latest editions of e.g. ISO 12039 (measurement of CO, CO_2 and O_2), ISO 17179 (measurement of NH_3), ISO 13199 (measurement of total VOC), ISO 25140 (measurement of CH_4), ISO 21258 (measurement of N_2O);

— Clause 3 has been updated (addition or deletion and change in terms and definitions);

— a new analytical technique has been added (Fourier transform infrared spectroscopy) for measurement of NO and NO_2 or NO_x;

— the performance characteristics and criteria as well as QA/QC procedures have been changed to harmonize with latest ISO standards;

— examples of performance test results and the results of uncertainty calculation have been added for NO and NO_2 or NO_x measurement.

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

Nitrogen oxides are produced during most combustion processes. In fossil fuel combustion, nitrogen oxides are produced from nitrogen contained in the fuel and from the oxidation of nitrogen in the air used for combustion. The quantity of nitrogen oxides produced depends upon the nitrogen content of the fuel, the combustor design, and the combustor operating conditions.

In flue gases from conventional boiler combustion systems, the nitrogen oxides consist of approximately 95 % nitrogen monoxide (NO). The remaining oxide is predominantly nitrogen dioxide (NO_2) formed from the oxidation of NO when the flue gas temperature decreases. These two oxides (NO + NO_2) are generally designated as NO_x. It should be noted that in other processes the ratio of NO to NO_2, may be different and other nitrogen oxides may be present.

There are numerous ways of determining nitrogen oxides in the gases of combustion plants, both wet chemical/analytical methods and instrumental techniques.

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Stationary source emissions — Determination of the mass concentration of nitrogen oxides in flue gas — Performance characteristics of automated measuring systems

1 Scope

This document specifies a method for the determination of nitrogen oxides (NO_x) in flue gas of stationary sources and describes the fundamental structure and the key performance characteristics of automated measuring systems.

The method allows continuous monitoring with permanently installed measuring systems of NO_x emissions.

This document describes extractive systems and in situ (non-extractive) systems in connection with a range of analysers that operate using, for example, the following principles:

— chemiluminescence (CL);

— infrared absorption (NDIR);

— Fourier transform infrared (FTIR) spectroscopy;

— ultraviolet absorption (NDUV);

— differential optical absorption spectroscopy (DOAS);

Other equivalent instrumental methods such as laser spectroscopic techniques can be used provided they meet the minimum performance requirements specified in this document. The measuring system can be validated with reference materials, in accordance with this document, or comparable methods.

Automated measuring system (AMS) based on the principles listed above has been used successfully in this application for the measuring ranges as shown in Annex F.

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.

ISO 9169, *Air quality — Definition and determination of performance characteristics of an automatic measuring system*

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
analyser
analytical part in an extractive or in situ *automated measuring system* (3.2)

[SOURCE: ISO 12039:2019, 3.1]

3.2
automated measuring system
AMS
measuring system interacting with the flue gas under investigation, returning an output signal proportional to the physical unit of the *measurand* (3.9) in unattended operation

[SOURCE: ISO 9169:2006, 2.1.2, modified — Note is removed]

Note 1 to entry: For the purposes of this document, an AMS is a system that can be attached to a duct or stack to continuously or intermittently measure the mass concentration of NO, NO_2 or NO_x passing through the duct.

3.3
in situ AMS
non-extractive system that measures the concentration directly in the duct or stack

Note 1 to entry: In situ systems measure either across the stack or duct or at a point within the duct or stack.

3.4
parallel measurements
measurements taken on the same duct in the same sampling plane for the same period of time with the AMS under test and with the reference method at points a short distance from each other, providing pairs of measured values

Note 1 to entry: See 3.21.

3.5
independent reading
reading that is not influenced by a previous individual reading by separating two individual readings by at least four response times

3.6
interference
cross-sensitivity
negative or positive effect upon the response of the measuring system, due to a component of the sample that is not the measurand

3.7
interferent
interfering substance
substance present in the air mass under investigation, other than the *measurand* (3.9), that affects the response of *AMS* (3.2)

3.8
lack-of-fit
systematic deviation within the range of application, between the accepted value of a reference material applied to the measuring system and the corresponding result of measurement produced by the measuring system

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

Note 2 to entry: The expression “lack-of-fit” is often replaced in everyday language for linear relations by “linearity” or “deviation from linearity”.

[SOURCE: ISO 9169:2006, 2.2.9, modified —Note 2 is removed.]

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3.9
measurand
particular quantity subject to measurement

[SOURCE: ISO/IEC Guide 98-3:2008, B.2.9, modified— Example and Note is removed.]

3.10
NO_2/NO converter efficiency
ratio with which the converter device of a NO_x analyser reduces NO_2 to NO

3.11
performance characteristic
one of the quantities assigned to equipment in order to define its performance

Note 1 to entry: Performance characteristics can be described by values, tolerances, or ranges.

3.12
period of unattended operation
maximum interval of time for which the performance characteristics remain within a predefined range without external servicing, e.g. refill, adjustment

[SOURCE: ISO 9169:2006, 2.2.11]

Note 1 to entry: The period of unattended operation is often called maintenance interval.

3.13
reference material
substance or mixture of substances with a known concentration within specified limits, or a device of known characteristics

Note 1 to entry: Normally calibration gases, gas cells, gratings or filters are used.

[SOURCE: ISO 14385-1:2014, 3.20]

3.14
reference method
measurement method taken as a reference by convention, which gives the accepted reference value of the measurand

Note 1 to entry: See 3.4.

3.15
transport time in the measuring system
time period for transportation of the sampled gas from the inlet of the probe to the inlet of the measurement instrument

3.16
response time
time interval between the instant when a stimulus is subjected to bring about a specified abrupt change and the instant when the response reaches and remains within specified limits around its final stable value, determined as the sum of the lag time and the rise time in the rising mode, and the sum of the lag time and the fall time in the falling mode

[SOURCE: ISO 9169:2006, 2.2.4]

Note 1 to entry: Lag time, rise time and fall time are defined in ISO 9169:2006.

3.17
span gas
gas or gas mixture used to adjust and check the span point on the response line of the measuring system

Note 1 to entry: The concentration is often chosen around 70 % to 90 % of full scale.

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3.18
span point
value of the output quantity (measured signal) of the automated measuring system for the purpose of calibration, adjustment, etc. that represents a correct measured value generated by reference gas

3.19
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[SOURCE: ISO/IEC Guide 98-3:2008, 2.3.1]

3.20
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, 2.2.3 modified — Note 1, 2 and 3 removed.]

3.21
validation of an automated measuring system
procedure to check the statistical relationship between values of the measurand indicated by the automated measuring system and the corresponding values given by parallel measurements implemented simultaneously at the same measuring point

3.22
zero gas
gas or gas mixture used to establish the *zero point* (3.23) on a calibration curve within a given concentration range

[SOURCE: ISO 12039:2019, 3.20]

3.23
zero point
specified value of the output quantity (measured signal) of the AMS and which, in the absence of the measured component, represents the zero crossing of the calibration line

4 Symbols and abbreviated terms

e_i	Residual (lack-of-fit) at level i
K	Coverage factor
N	Number of measurements
s_r	Standard deviation of repeatability
$u(\gamma_X)$	Combined uncertainty of X (NO or NO_2) mass concentration
$U(\gamma_X)$	Expanded uncertainty of X (NO or NO_2) mass concentration
M_x	Molar mass of X (NO or NO_2, g/mol)
V_M	Molar volume (22,4 l/mol at standard conditions, 273,15 K; 101,325 kPa)
φ_X	Volume fraction of X (NO or NO_2)
γ_X	X (NO or NO_2) mass concentration at standard conditions in mg/m^3 (273,15 K; 101,325 kPa)
γ_R	NO or NO_2 mass concentration at reference conditions in mg/m^3 (273,15 K; 101,325 kPa; H_2O corrected)

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