
Emisije nepremičnih virov - Monitoring živega srebra z adsorpcijsko cevko

Stationary source emissions - Mercury monitoring using sorbent traps

Emissionen aus stationären Quellen - Quecksilbermonitoring mit Sorptionsfallen

Émissions de sources fixes - Surveillance du mercure à l'aide de pièges adsorbants

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**Stationary source emissions - Mercury monitoring using
sorbent traps**

Émissions de sources fixes - Surveillance du mercure à
l'aide de pièges adsorbants

Emissionen aus stationären Quellen -
Quecksilbermonitoring mit Sorptionsfallen

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The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

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European foreword

This document (CEN/TS 17286:2019) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

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1 Scope

The purpose of this document is to establish performance benchmarks for, and to evaluate the acceptability of, sorbent trap monitoring systems used to monitor total vapour- phase mercury (Hg) emissions in stationary source flue gas streams. These monitoring systems involve continuous repetitive in-flue sampling using paired sorbent traps with subsequent analysis of the time-integrated samples.

This document is suitable for both short-term (periodic) measurements and long-term (continuous) monitoring using sorbent traps.

NOTE When this Technical Specification has been validated, the sorbent trap method will be an Alternative Method subject to the restrictions on applicability defined below. Until that time, EN 13211 is the only accepted Reference Method for both short-term (periodic) measurements and for calibrating continuous monitoring systems, including those with long-term sampling systems. EN 13211 is a wet chemistry approach that relies on absorption of mercury into impinger solutions.

The substance measured according to this specification is the total vapour phase mercury in the flue gas, which represents the sum of the elemental mercury (Hg^0) and gaseous forms of oxidized mercury (Hg^{2+}), such as mercury (II) chloride, in mass concentration units of micrograms (μg) per dry meter cubed (m^3). The analytical range is typically 0,1 to greater than 50 $\mu\text{g}/\text{m}^3$.

The sorbent tube approach is intended for use under relatively low particulate conditions (typically less than 100 mg/m^3) when monitoring downstream of all pollution control devices, e.g. at coal fired power plants and cement plants. In this case, the contribution of mercury in the particulate fraction is considered to be negligible (typically less than 5 % of total mercury). However, it shall be noted that the sorbent trap does take account of the finest particle fraction that is sampled with the flue gas, in addition to capturing the vapour phase mercury.

This specification also contains routine procedures and specifications that are designed to evaluate the ongoing performance of an installed sorbent trap monitoring system. The operator of the industrial installation is responsible for the correct calibration, maintenance and operation of this long-term sampling system. Additional requirements for calibration and quality assurance of the long-term sampling system are then defined in EN 14884 and EN 14181.

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 14181, *Stationary source emissions — Quality assurance of automated measuring systems*

EN 14790 (series), *Stationary source emissions — Determination of the water vapour in ducts — Standard reference method*

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 (series), *Air quality — Certification of automated measuring systems*

EN 15853, *Ambient air quality — Standard method for the determination of mercury deposition*

EN ISO 16911-1:2013, *Stationary source emissions — Manual and automatic determination of velocity and volume flow rate in ducts — Part 1: Manual reference method (ISO 16911-1:2013)*

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>.

3.1

mercury

mercury and mercury compounds

3.2

total mercury

sum of the mercury in the exhaust gas independent from the state (gaseous, dissolved in droplets, solid, adsorbed or absorbed on and within particles)

3.3

sorbent trap

tube filled with a collection material on which gaseous mercury is collected

3.4

sorbent trap spiking

technique(s) used to spike mercury onto sorbent traps prior to sampling

3.5

sample probe

part of the apparatus that is placed in the flue for the purpose of sampling the gas and measuring the temperature

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3.6

moisture removal device

part of the apparatus that is placed before the sample flow measuring device for the purpose of removing water vapour from the sampled gas stream

3.7

gas flow meter

device of any type that allows the total dry sample gas volume to be determined, e.g., a volumetric flow meter or a mass flow meter

4 Symbols and abbreviations

AFR	ratio of dry combustion air to fuel (m^3/kg)
AFR _s	ratio of dry combustion air to fuel at stoichiometric conditions (m^3/kg)
B _w	flue gas moisture content by volume (m^3/m^3)
B _{wa}	concentration of water vapour in ambient air by volume (m^3/m^3)
B _{ws}	concentration of water vapour in stoichiometric flue gas by volume (m^3/m^3)
%B	percent breakthrough
C	concentration of mercury in the dry flue gas for the sample collection period ($\mu\text{g}/\text{m}^3$)
C _a	concentration of mercury in the dry flue gas for the sample collection period, for sorbent trap "a" ($\mu\text{g}/\text{m}^3$)
C _b	concentration of mercury in the dry flue gas for the sample collection period, for sorbent trap "b" ($\mu\text{g}/\text{m}^3$)
C _{est}	estimated mercury concentration in flue gas ($\mu\text{g}/\text{m}^3$)
C _{rec}	the concentration of spiked compound measured ($\mu\text{g}/\text{m}^3$)
CFR _s	ratio of dry flue gas to fuel at stoichiometric conditions (m^3/kg)
F _d	dry flue gas volume emitted during the sampling period (m^3)
F _w	wet flue gas volume emitted during the sampling period (m^3)
F _h	average sample flow rate for the hour, in appropriate units (e.g. L/min, mL/min, m^3/min)
F _{ref}	average sample flow rate for first hour of the collection period, in appropriate units (e.g. L/min, mL/min, m^3/min)
Hg ⁰	elemental mercury
Hg ²⁺	oxidized mercury
K	power of ten multiplier, to keep the value of R _{ref} between 1 and 100. The appropriate K value will depend on the selected units of measurement for the sample flow rate and the range of expected flue gas flow rates
m _s	the total mass of mercury measured on the spiked trap in the FRT (μg)
M _{exp}	expected sample mass (μg)
M _{spiked}	calculated mercury mass of the pre-sampling spike, from 8.2 of this Technical Specification, (μg)
m _{spiked}	the total mass of mercury spiked prior to the FRT (μg)
m _u	the total mass of mercury measured on the unspiked trap in the FRT (μg)
M*	total mass of mercury recovered from sections 1 and 2 of the sorbent trap, (μg)
M ₁	mass of mercury recovered from section 1 of the sorbent trap, (μg)
M ₂	mass of mercury recovered from section 2 of the sorbent trap, (μg)
M ₃	mass of mercury recovered from section 3 of the sorbent trap, (μg)
O _{2a}	concentration of oxygen in ambient air by volume (m^3/m^3)
O _{2,wet}	concentration of oxygen in flue gas by volume, on a wet basis (m^3/m^3)

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$O_{2,dry}$	concentration of oxygen in flue gas by volume, on a dry basis (m^3/m^3)
P_a	absolute pressure of ambient air (mbar)
P_T	absolute pressure of saturated flue gas (Pa)
P_v	vapour pressure of water (Pa)
Q_h	average flue gas volumetric flow rate for the hour (m^3/h)
Q_{ref}	average flue gas volumetric flow rate for first hour of collection period at reference conditions (m^3/h)
Q_s	the sample flow rate (L/min)
R	the percentage of spiked mass recovered from the FRT (%)
RD	relative deviation between the mercury concentrations from traps “a” and “b” (%)
R_h	ratio of hourly flue gas flow rate to hourly sample flow rate
RH	relative humidity (-)
R_{ref}	reference ratio of hourly flue gas flow rate to hourly sample flow rate
$\%R$	percentage recovery of the pre-sampling spike
t	temperature of ambient air ($^{\circ}C$)
t_s	expected monitoring period (min)
T	temperature of saturated flue gas (K)
v_s	the volume of gas sampled through the spiked trap in the FRT at standard conditions (m^3)
v_u	the volume of gas sampled through the un-spiked trap in the FRT at standard conditions (m^3)
V_t	total volume of volume measurement during the collection period (m^3). For the purposes of this Technical Specification, standard temperature and pressure are defined as $0^{\circ}C$ and 101.325 kPa, respectively.
W_{aFR}	ratio of ambient water vapour to fuel (m^3/kg)
W_{iFR}	ratio of injected water vapour to fuel (m^3/kg)
WFR_s	ratio of combustion water vapour to fuel at stoichiometric conditions (m^3/kg)
λ	excess air factor (-)
10^{-3}	conversion factor (m^3/L)
ABT	Analytical Bias Test
CRM	Certified Reference Material
CV AAS	Cold Vapour Atomic Absorption Spectrometry
CV AFS	Cold Vapour Atomic Fluorescence Spectrometry
FRT	Field Recovery Test
LOD	Limit of Detection
QA/QC	Quality Assurance/Quality Control
SRM	Standard Reference Method

5 Principle

Known volumes of flue gas are continuously extracted from a flue or duct through paired, in-flue, pre-spiked three-section sorbent traps at appropriate nominal flow rates. The sorbent traps in the sampling system are periodically exchanged with new ones, prepared for analysis as needed, and analysed by any technique that can meet the analytical performance criteria. Mercury is collected on section 1 of the trap. For quality assurance purposes, section 2 is also analysed to quantify mercury breakthrough from the first section. For quality assurance purposes, the third section of each sorbent trap is spiked with Hg^0 prior to sampling. Following sampling, the third section is analysed separately and a specified minimum percentage of the spike shall be recovered. The paired sampling train is required to determine method precision. An Analytical Bias Test (ABT) is required to demonstrate that the laboratory has the ability to recover and accurately quantify mercury from the chosen sorbent traps

A Field Recovery Test (FRT) is also required when the sorbent trap method is used for regulatory monitoring purposes, either for short-term, periodic, sampling (for each test campaign), or for long-term sampling (prior to initial operation and when the sorbent material is changed). For a limited number of FRTs, the spike is added to the first section of a two or three section trap, noting that only one of the paired traps is spiked on the first section. The average recovery of these spiked samples is then used to verify the performance of the measurement system under field conditions since section 1 is exposed to the full flue gas matrix.

Short-term sampling (for periodic monitoring) is typically from one hour to six hours sampling duration and long-term sampling (for semi-continuous monitoring) is typically from one day to two weeks sampling duration.

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6 Measuring equipment (standards.iteh.ai)

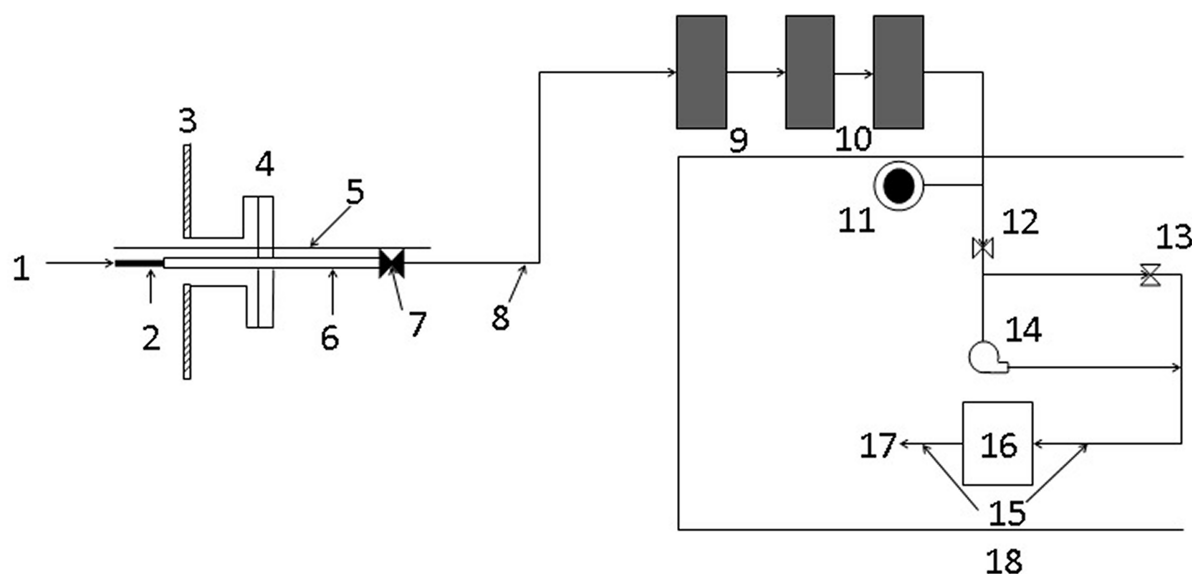
6.1 Sorbent trap monitoring system equipment specifications

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6.1.1 Monitoring system

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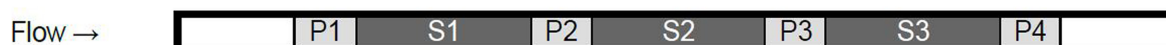
A typical sorbent trap monitoring system is shown in Figure 1.



Key

1 gas inlet	10 desiccant
2 sorbent trap	11 vacuum gauge
3 duct wall	12 isolation valve
4 port/probe flanges	13 flow control valve
5 temperature sensor	14 gas pump
6 probe	15 alternative locations for temperature and pressure sensors (for volumetric dry gas flow meter)
7 isolation valve	16 dry gas flow meter
8 sample line	17 discharge
9 water knockout	18 sampling console

Figure 1 — Sorbent trap monitoring system (only one trap and associated sampling system is shown)



Key

S1 MAIN: Standard collection section	P1 entry plug
S2 BACKUP: Break-through detection	P2 separation plug
S3 SPIKE: Pre-Injected mercury vapour (±50 % of expected mass to be collected)	P3 separation plug
	P4 exit plug

Figure 2— Three section sorbent trap

The sorbent used to collect mercury shall be configured in traps with three distinct segments or sections, connected in series, to be separately analysed, as shown schematically in Figure 2. Section 1 is designated for primary capture of gaseous mercury. Section 2 is a backup section for the determination of vapour-phase mercury breakthrough. Section 3 is specified for quality assurance/quality control (QA/QC) purposes. Section 3 shall be spiked with a known amount of gaseous Hg^0 prior to sampling and later analysed to determine the spike (and hence sample) recovery efficiency.

The spike is applied to the first section of the trap for the FRT and the ABT as described in Clause 11. These traps therefore consist of two, rather than three, sections.

Each sorbent trap shall be inscribed or otherwise permanently marked with a unique identification number, for tracking purposes. The sorbent media may be any collection material (e.g. activated carbon, a chemically-treated filter, etc.) capable of quantitatively capturing and recovering, for subsequent analysis, all gaseous forms of mercury in the emissions from the intended application. Selection of the sorbent media shall be based on the material's ability to achieve the performance criteria contained in this Technical Specification, especially the requirement to have a suitably high collection efficiency within the given flue gas matrix. The sorbent traps shall be obtained from a source that can demonstrate their quality assurance and quality control.

The paired sorbent traps are supported on a probe (or probes) and inserted directly into the flue gas stream, noting that the traps may be protected by a shield or baffle to prevent the ingress of droplets when present. Fine particles, associated with the gas sample, are drawn into the trap and are captured either within a pre-filter, or the plug of glass wool that separates each section, or within the sorbent itself. Mercury extracted from pre-filter(s) and plugs upstream of Section 1 is added to the Section 1 result. Mercury extracted from plugs immediately upstream and downstream of Section 2 are added to the Section 2 result. Mercury extracted from plugs downstream of Section 3 are added to the Section 3 result.

Further information on typical sorbent trap configurations is given in Annex D.

6.1.2 Moisture removal device

A moisture removal device or system shall be used to remove water vapour from the gas stream prior to entering the dry gas flow metering devices.

6.1.3 Vacuum pump

Use a leak-tight, vacuum pump capable of operating within the system's flow range. If the vacuum pump is the last element in the sampling train, located downstream of the sample to gas flow meter measurement device, it does not need to be leak-tight.

6.1.4 Total sample volume measurement

A dry gas flow meter (e.g. a volumetric flow meter, thermal mass flow meter, or other suitable measurement device) shall be used to determine the total sample volume on a dry basis, in units of standard cubic meters. The gas flow meter, with a maximum expanded uncertainty of 5,0 % at the anticipated flow rate, incorporating any associated uncertainties including the absolute pressure and absolute temperature measurement uncertainties (maximum expanded uncertainty of 2,0 % each), shall be calibrated at selected flow rates across the range of sample flow rates at which the sampling train will be operated, typically 0 to 2 L/min.

6.1.5 Sample flow rate meter and controller

Use an automated flow rate indicator and controller for maintaining the required sampling flow rate. Any additional standard uncertainty associated with a separate display device shall be less than 0,5 %.

NOTE Manual flow control and data recording can be employed for short-term sampling.

6.1.6 Temperature sensor

Temperature sensor with a standard uncertainty of less than 2,5 K (less than 1 % relative to the absolute temperature).