Air quality — Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report

The European Standard EN 15259:2007 has the status of a British Standard

ICS 13.040.40

British Standards

National foreword

This British Standard is the UK implementation of EN 15259:2007.

The UK participation in its preparation was entrusted by Technical Committee EH/2, Air quality, to Subcommittee EH/2/1, Stationary source emission.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2007

ISBN 978 0 580 55616 6

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15259

October 2007

ICS 13.040.40

English Version

Air quality - Measurement of stationary source emissions - Requirements for measurement sections and sites and for the measurement objective, plan and report

Qualité de l'air - Mesurage des émissions de sources fixes - Exigences relatives aux sections et aux sites de mesurage et relatives à l'objectif, au plan et au rapport de mesurage

Luftbeschaffenheit - Messung von Emissionen aus stationären Quellen - Anforderungen an Messstrecken und Messplätze und an die Messaufgabe, den Messplan und den Messbericht

This European Standard was approved by CEN on 18 August 2007.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 15259:2007: E

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Foreword

This document (EN 15259:2007) 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 April 2008, and conflicting national standards shall be withdrawn at the latest by April 2008.

This document has been prepared by WG 19 “Emissions monitoring strategy” of CEN/TC 264 as one of three documents on measurements of stationary source emissions consisting of:

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

— CEN/TS 15674, *Air quality — Measurement of stationary source emissions — Guidelines for the elaboration of standardised methods*

— CEN/TS 15675, *Air quality — Measurement of stationary source emissions — Application of EN ISO/IEC 17025:2005 to periodic measurements*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This European Standard defines requirements for

a) measurement sections and sites at waste gas ducts of industrial plants and

b) measurement objective, plan and report.

This European Standard is intended to ensure reliable and comparable results when used in conjunction with reference methods such as those that have been developed by CEN/TC 264.

This European Standard is important to plant designers, constructors, plant operators, testing laboratories, accreditation bodies and regulators.

This European Standard requires the specification of a measurement objective. There can be various objectives for measuring emissions, e.g.

— for assessing whether industrial installations are operating in compliance with IPPC permits [1] (emission limit value compliance assessment),

— for emissions declaration and reporting for emission inventories (e.g. local, national and international e.g. for EPER [1], [2]),

— for acceptance tests (proof of guarantee),

— in case of complaints,

— for obtaining a permit (e.g. following changes to process operations or plant design),

— after expiration of a set time interval to establish the condition of the plant,

— in case of interruption or disturbance of operations,

— within the framework of safety precaution investigations,

— for the calibration of continuously operating emission measuring systems,

— for checking the function of continuously operating emission measuring systems,

— to establish the cause of particular emission behaviour (e.g. the determination of the cause of a failure of the waste gas treatment to maintain the guaranteed/required level of cleaning),

— to give a prognosis of likely emission levels in special operating conditions, e.g. after changes of procedure, in case of disturbance or interruption, or in case of expansion of capacity,

— for establishing emission trading schemes [3],

— for determining emission factors and

— for assessing available techniques for an industry sector (e.g. at company, sector and EU level) [3].

1 Scope

This European Standard specifies the following requirements:

a) requirements for measurement sections and sites with respect to performing emission measurements;

b) requirements for the measurement objective, plan and report of emission measurements of air pollutants and reference quantities to be carried out in waste gas ducts at industrial plants.

This European Standard applies to periodic measurements using manual or automated reference methods (RM).

This European Standard specifies generic principles which can be applied to perform emission measurements at different plant types and to meet different measurement objectives.

NOTE The measurement objective is specified by the customer. The testing institute identifies the measurement objective and related regulatory requirements at the beginning of the measurement planning. Where measurements are being made for regulatory purposes, the customer should seek approval from the competent authority.

This European Standard specifies procedures for taking representative samples in waste gas ducts.

This European Standard specifies a procedure for finding the best available sampling point for automated measuring systems used for continuous monitoring of emissions.

The planning and reporting aspects of this European Standard are applicable to emission measurements at diffusive and fugitive emission sources.

This European Standard does not address aspects of structural safety of chimneys and ducts, construction of working platforms and safety of personnel using them.

2 Normative references

The following referenced documents are indispensable for the application 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.

Not applicable.

3 Terms and definitions

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

NOTE These terms and definitions are in accordance with VIM and CEN/TS 15674.

3.1
measurement
set of operations having the object of determining a value of a quantity

[VIM:1993, 2.1]

NOTE The operations can be performed automatically.

3.2
individual measurement
measurement carried out over a defined period of time

NOTE Information on the start and end time of the measurement can be of importance, e.g. in case of parallel measurements of the reference method with an automated measuring system to be calibrated or validated.

3.3
periodic measurement
determination of a measurand at specified time intervals

NOTE The specified time intervals may be regular (e.g. once every month) or irregular. Measurands can include the amount or physical property of an emission. Measurements are usually made using portable equipment for typically less than 24 h.

3.4
grid measurement
determination of a measurand in a given grid of measurement points in the measurement plane

3.5
measurand
particular quantity subject to measurement

[VIM:1993, 2.6]

NOTE The measurand is a quantifiable property of the waste gas under test, for example mass concentration of a measured component, temperature, velocity, mass flow, oxygen content and water vapour content.

3.6
measured component
constituent of the waste gas for which a defined measurand is to be determined by measurement

3.7
reference quantity
specified physical or chemical quantity which is needed for conversion of the measurand to standard conditions

NOTE Reference quantities are e.g. temperature (T_{ref} = 273,15 K), pressure (p_{ref} = 101,325 kPa), water vapour volume fraction (h_{ref} = 0 %) and oxygen volume fraction o_{ref}.

3.8
reference method
RM
measurement method taken as a reference by convention, which gives the accepted reference value of the measurand

NOTE 1 A reference method is fully described.

NOTE 2 A reference method can be a manual or an automated method.

NOTE 3 Alternative methods can be used if equivalence to the reference method has been demonstrated.

3.9
standard reference method
SRM
reference method prescribed by European or national legislation

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

3.10
automated measuring system
AMS
measuring system permanently installed on site for continuous monitoring of emissions

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

[EN 14181:2004, 3.2]

3.11
measurement site
place on the waste gas duct in the area of the measurement plane(s) consisting of structures and technical equipment, for example working platforms, measurement ports, energy supply

NOTE Measurement site is also known as sampling site.

3.12
measurement section
region of the waste gas duct which includes the measurement plane(s) and the inlet and outlet sections

3.13
measurement plane
plane normal to the centreline of the duct at the sampling position

NOTE Measurement plane is also known as sampling plane.

3.14
hydraulic diameter
d_h
quotient of four times the area A and the perimeter P of the measurement plane

$$d_\mathrm{h} = \frac{4 \times A}{P} \tag{1}$$

3.15
measurement line
line in the sampling plane along which the sampling points are located, bounded by the inner duct wall

NOTE Measurement line is also known as sampling line.

3.16
measurement point
position in the measurement plane at which the sample stream is extracted or the measurement data are obtained directly

NOTE Measurement point is also known as sampling point.

3.17
representative measurement point
measurement point at which the local mass flow density of the substance to be determined is equal to the mass flow density averaged over the measurement plane

3.18
measurement port
opening in the waste gas duct along the measurement line, through which access to the waste gas is gained

NOTE Measurement port is also known as sampling port or access port.

3.19
clearance area
area of free space at the working platform outside the waste gas duct without obstacles in which the appropriate measuring probes are moved and handled

NOTE See Table 1 in 5.2.3.2.

3.20
measurement objective
scope of the measurement programme

3.21
measurement plan
structured procedure to fulfil a defined measurement objective

3.22
measurement report
report established by the testing laboratory according to the customer request and containing at least the information required in the standards applied in the measurements programme, in particular this European Standard

3.23
site review
visit conducted by the testing laboratory before undertaking emission measurements to ensure that the physical and logistical situation is fully understood before arriving on-site to conduct work

NOTE The site review provides information essential for determining the appropriate measurement method and development of the measurement plan.

3.24
timing
time at which samples or measurements are taken

NOTE Timing can be crucial to obtaining a result which is relevant to the measurement objective.

3.25
sampling duration
period of time over which the sample is taken

3.26
mass concentration
c
quotient of mass m of the measured component and gas volume V

$$c = \frac{m}{V} \tag{2}$$

3.27
mass flow rate
$\dot{m}$
quotient of the mass m flowing through the measurement plane and the time t

$$\dot{m} = \frac{m}{t} \tag{3}$$

3.28
mass flow density
$\dot{m}_\mathrm{d}$
quotient of mass flow rate $\dot{m}$ and corresponding cross-sectional area a

$$\dot{m}_\mathrm{d} = \frac{\dot{m}}{a} \tag{4}$$

3.29
sample volumetric flow
volumetric flow extracted from the main stream for determination of the measured component

3.30
volumetric flow rate
quotient of the volume flowing through a plane and the time

3.31
testing laboratory
laboratory that performs tests

NOTE 1 The term *testing laboratory* can be used in the sense of a legal entity, a technical entity or both.

NOTE 2 A testing laboratory undertakes work at the laboratory's permanent facilities, at sites away from their permanent facilities and in temporary or mobile laboratories.

NOTE 3 The sampling and analysis stages often occur at different locations as the analysis stage can be carried out at a permanent laboratory.

3.32
customer
organization or person that defines the measurement objective and receives the measurement report

NOTE Adapted from EN ISO 9000:2005, Definition 3.3.5.

4 Symbols and abbreviations

4.1 Symbols

a cross-sectional area

A area of the measurement plane

c mass concentration

d diameter of the duct

d_h hydraulic diameter

F statistical value of the F-test

h_m measured water vapour content as volume fraction

h_ref standard water vapour content as volume fraction

m mass

$\dot{m}$ mass flow rate

$\dot{m}_\mathrm{d}$ mass flow density

N number of measurements

o_m measured oxygen content as volume fraction

o_ref standard oxygen content as volume fraction

P perimeter of the measurement plane

p_m measured pressure

p_{ref}	standard pressure
r_i	ratio of actual value $y_{i,grid}$ of the measurand in the grid and the value $y_{i,ref}$ of the reference measurement
$\bar{r}$	average of the ratios r_i
s_{grid}	standard deviation of the grid measurements
s_{inh}	standard deviation due to the inhomogeneity of the waste gas
s_{pos}	standard deviation of combined grid and reference measurement
s_{ref}	standard deviation of the reference measurements
t	time
T_m	measured temperature (absolute)
T_{ref}	standard temperature (absolute)
U_{perm}	permissible expanded uncertainty
U_{pos}	expanded uncertainty of the combined grid and reference measurement
U_{ref}	expanded uncertainty related to the reference measurements at the fixed point
v	velocity of the gas in the measurement plane
V	volume
$\dot{V}$	volume flow rate
$y_{i,grid}$	measured value at the ith sampling point
$y_{i,ref}$	ith measured value at the reference point

4.2 Abbreviations

AMS	Automated Measuring System
RM	Reference Method
SRM	Standard Reference Method
SCR	Selective Catalytic Reduction
SNCR	Selective Non Catalytic Reduction

5 Principles

5.1 General

Reliable and comparable results representative of the emissions in the context of the measurement objective (see Annex G) can be achieved provided that

a) measurement section and site, preferably created at the plant design stage, are available to enable a representative sample to be taken,

b) measurement objective and the measurement plan are available before measurements are carried out,

c) sampling strategy is specified in the measurement plan to meet the measurement objective,

d) report of the results is produced which includes all relevant information and

e) competent testing laboratories are used.

NOTE Requirements on the competence of laboratories are specified in EN ISO/IEC 17025 and CEN/TS 15675.

Figure 1 illustrates key stages of periodic measurements of emissions from stationary sources.

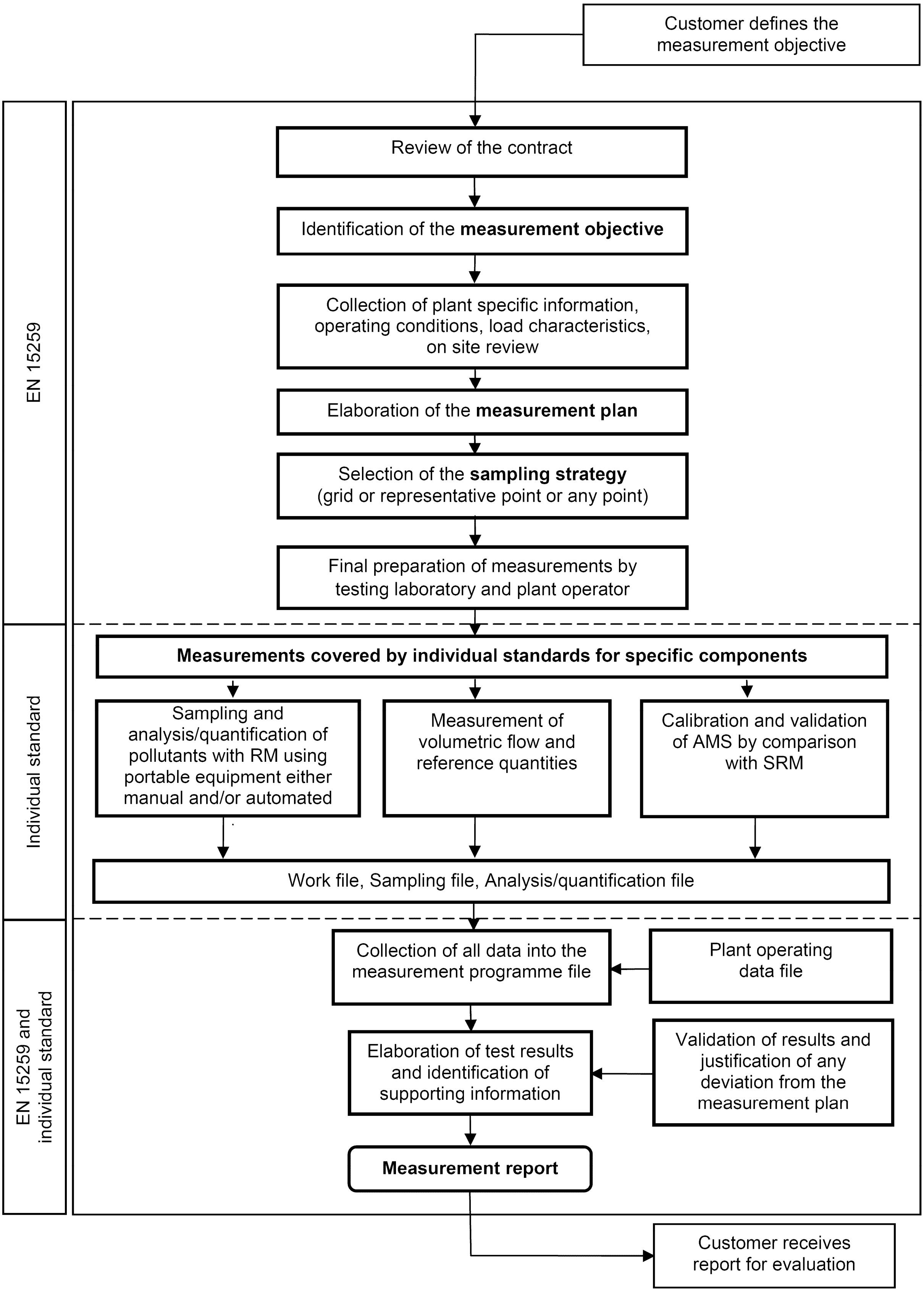


Figure 1 — Illustration of key stages of periodic measurements of emissions from stationary sources

5.2 Measurement section and measurement site

Plants designed or adapted to enable representative sampling have a section of the waste gas ducting engineered to ensure an ordered flow profile free from vortexing and backflow, where a measurement plane is located that provides a grid of sampling points sufficient to assess the distribution of measurands and reference quantities. The measurement site allows access to the sampling plane for typical sampling equipment via a platform that enables measurement personnel to work safely and efficiently.

5.3 Measurement objective and measurement plan

The measurement objective specifies the work to be carried out, the plant operating conditions under which measurements are to be taken, any plant or process related information to be collected, working procedures to be used and any associated requirements. The results of these considerations are outlined in the measurement plan. To ensure that the measurement plan meets the measurement objective it is important to ensure that the measurement section has been assessed and any deviations from standard geometry is taken into account. Measurements are performed by suitable qualified personnel, under adequate supervision. In view of the measurement objective, simplified procedures may be used in some circumstances provided that the plant conditions are well understood and provided it is acceptable within the measurement objective. Any deviations from the standard procedures described in European Standards are justified and reported.

5.4 Sampling strategy

The sampling strategy ensures that a representative sample is taken. The procedures specified in Clause 8 are chosen to suite the degree of homogeneity of the measurand distribution and any anticipated variability in time. Procedures are adopted to identify the number and placement of the sampling points and the sampling duration at each point.

5.5 Measurement report

The measurement report provides the results of measurement supported by a comprehensive account of the measurements, a description of the measurement objective, and the measurement plan. It also provides sufficient detail to enable the results to be traced back through the calculations to the collected basic data and process operating conditions.

6 Measurement section and measurement site

6.1 General

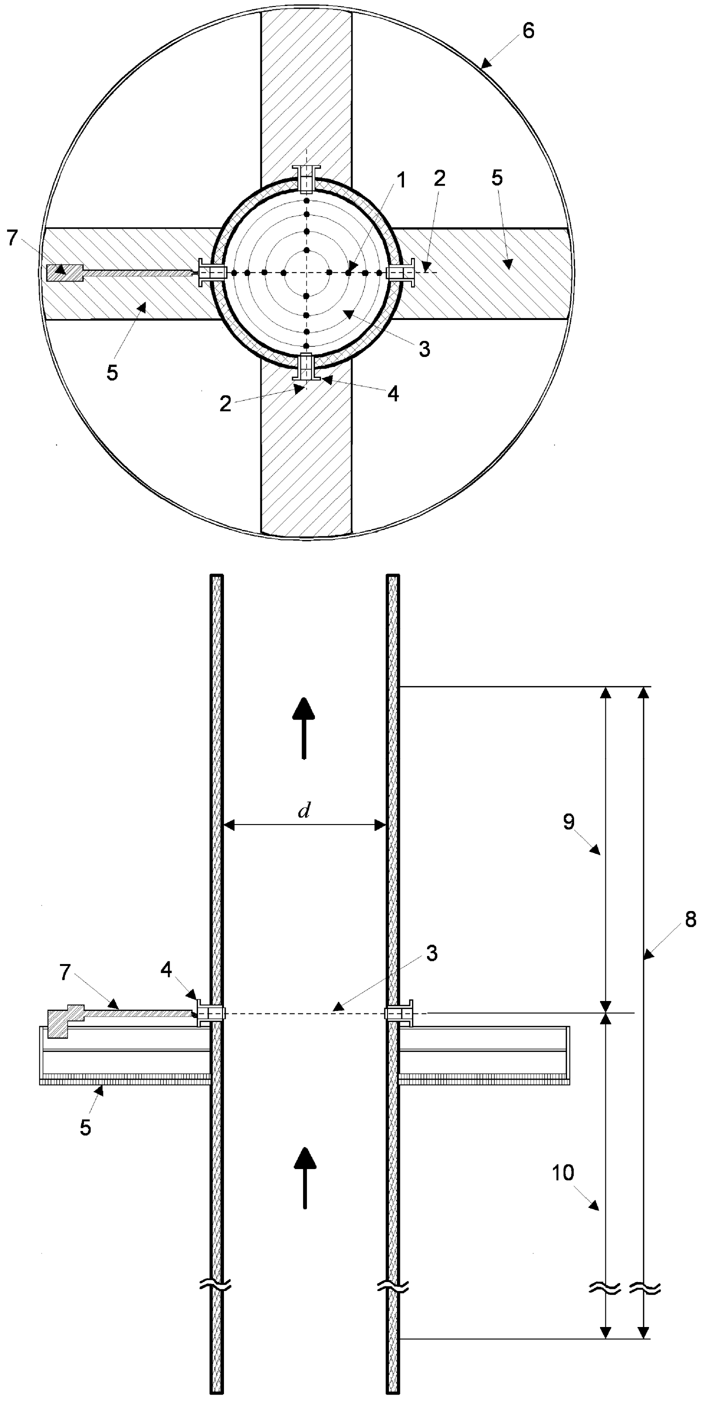
Suitable measurement sections and measurement sites are necessary to obtain reliable and comparable emission measurement results. Therefore, appropriate measurement sections and sites shall be planned when designing a plant (see [4]). Terms related to the measurement section and site are illustrated in Figure 2.

Emission measurements in flowing gases require defined flow conditions in the measurement plane, i.e. an ordered and stable flow profile without vortexing and backflow so that the velocity and the mass concentration of the measured component in the waste gas can be determined. These requirements result from the definition of the mean concentration (see Annex G). This is the only way in which results from different measurements, for example on different plants, can be compared.

Emission measurements require appropriate measurement ports and working platforms. Therefore, the installation of measurement ports and working platforms shall be taken into account in the planning phase of a measurement section.

Specifications of regulations and official requirements shall be taken into account in the selection and specification of measurement sections and sites. Expert advice should be sought.

NOTE Aspects of structural safety of chimneys and ducts as well as construction of working platforms and safety of personnel using them are not treated in this European Standard.



Key

1 measurement point

2 measurement line

3 measurement plane

4 measurement port

5 clearance area

6 measurement site

7 manual sampling train

8 measurement section

9 outlet section

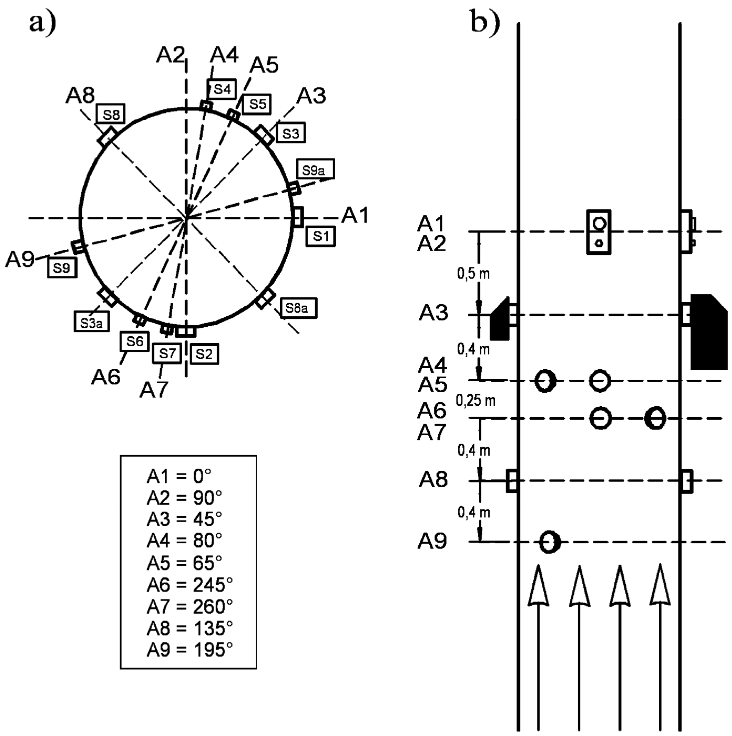
10 inlet section

Symbols

d internal duct diameter

Figure 2 — Illustration of terms related to the measurement site and measurement section

Figure 3 gives an example of mounting locations of measuring systems in a measurement section. For the different measurement activities six measurement planes are used in this example. The working platform is not represented for simplification.



Key

a)	top view	b)	front view
A	measurement line, measurement plane		
S	measurement port		
S1	reference method	S6	HCl, total carbon, water-vapour AMS
S2	reference method	S7	reference method
S3	dust AMS (optical head)	S8	volume flow AMS (transmitter)
S3a	dust AMS (reflector)	S8a	volume flow AMS (receiver)
S4	SO_2, NO, O_2 AMS	S9	temperature
S5	reference method	S9a	pressure

Figure 3 — Example of the mounting location of measuring systems within a measurement section at a waste gas duct (working platform not represented for simplification)

6.2 Measurement section

6.2.1 Measurement section and measurement plane

The measurement section shall allow the sampling and execution of measurements at a suitable measurement plane.

NOTE 1 The measurement section is the region of a conducted source (e.g. waste gas duct, stack) which includes the actual measurement plane and the inlet and outlet sections.

NOTE 2 For extensive emission measurement programmes more than one measurement section and/or more than one measurement plane within each measurement section can be necessary. The requirements on measurement sections and measurement planes apply to each section and plane.

In the planning and selection of a measurement section, the following aspects in accordance with the measurement objective shall be considered:

a) measurement section shall allow that representative samples of the emission can be taken in the measurement plane for the determination of volumetric flow and mass concentration of pollutants;

NOTE 3 The measured component can still change due to secondary reactions (degradation or synthesis) between the measurement plane and the point of escape to the open atmosphere.

b) measurement plane shall be situated in a section of the waste gas duct (stack etc.) where homogenous flow conditions and concentrations can be expected;

NOTE 4 The requirement for homogeneous flow conditions is generally fulfilled if the measurement plane is

– as far downstream and upstream from any disturbance, which could produce a change in direction of flow (e.g. disturbances can be caused by bends, fans or partially closed dampers),

– in a section of a duct with at least five hydraulic diameters of straight duct upstream of the sampling plane and two hydraulic diameters downstream (five hydraulic diameters from the top of a stack; see A.2) and

– in a section of a duct with constant shape and cross-sectional area.

NOTE 5 Effective aerodynamic arrangements (e.g. fans, vanes, ducting design) can be required to achieve mixing of the gases before entering the (straight) duct where the measurement section is located in order to get a homogeneous concentration profile at the measurement plane, especially when several gases of different characteristics in composition, coming from different installations are collected in the same duct.

NOTE 6 It can be advisable to perform an exploratory velocity traverse before committing to a comprehensive installation.

c) measurements at all the sampling points defined in 8.2 and Annex D shall prove that the gas stream at the measurement plane meets the following requirements:

1) angle of gas flow less than 15° with regard to duct axis;

NOTE 7 A method for the determination of the angle of gas flow is given in Annex B of EN 13284-1:2001.

2) no local negative flow;

3) minimum velocity depending on the flow rate measuring method used (for Pitot tubes a differential pressure larger than 5 Pa);

4) ratio of the highest to lowest local gas velocities less than 3:1;

NOTE 8 The above requirements are generally fulfilled in sections of duct with at least five hydraulic diameters of straight duct upstream of the measurement plane and two hydraulic diameters downstream (five hydraulic diameters from the top of a stack). Therefore, it is strongly recommended to design sampling locations accordingly.

d) installation of measurement sections in vertical ducts should be preferred to installation in horizontal ducts;

NOTE 9 At high dust concentrations, for some particle fractions, sedimentation can occur in horizontal ducts. This can lead to errors in the measurement of pollutants contained in the particle fraction, e.g. heavy metals, PCDD/PCDF.

e) measurement section shall be situated where it is possible to erect suitable working platforms with the provision of the necessary infrastructure;

f) measurement section shall be clearly identified and labelled.

NOTE 10 Labels are intended to identify the emission source unambiguously for regulatory and other purposes.

6.2.2 Measurement ports

Measurement ports shall be provided to allow sampling at specified measurement points (see 8.2).

Additional measurement ports in the same measurement plane or section shall be provided to allow measurements of other quantities (for example flow velocity, temperature, water vapour) when required by the measurement objective.

NOTE 1 In addition it can be necessary to install additional access ports for operational measurements or for instruments for continuous emission monitoring in the region of the measurement plane.

NOTE 2 Examples of suitable measurement ports are shown in A.1.

Measurement ports shall be planned at the design stage of new plants or during plant modification, as later changes of the waste gas duct can be difficult and costly (if, for example, protective linings are present).

NOTE 3 The examples of Annex A have been proven suitable. Tight-sealing covers avoid hazard.

NOTE 4 If the distance between a measurement port and the opposite interior wall of the waste gas duct is large (e.g. more than 2 m), depending on the measurement objective, two opposing measurement ports can be provided per measurement line, and the platform extended accordingly.

In the case of rectangular ducts, the measurement ports should be installed on the longer side (see Figure A.6).

6.2.3 Working area and working platform

6.2.3.1 Load bearing capacity

Permanent and temporary working platforms shall have a load bearing capacity sufficient to fulfil the measurement objective.

NOTE Sampling can comprise of two to six persons with equipment weighing between 50 kg and 300 kg.

Temporary working platforms shall be tied or supported to a permanent structure to prevent collapse or overturning. They shall be checked before use in accordance with national regulations on safety at work.

6.2.3.2 Position and working space

Working platforms shall provide sufficient working area and height (working space) for the measurement objective, i.e. to manipulate the probes and operate the measuring instruments. Clearance area at the working platform shall be dimensioned appropriately. Probe introduction should not be impeded e.g. by guard fences and other built-in elements.

NOTE 1 Grid measurements require a sufficiently large working area outside the waste gas duct along the measurement lines so that the measurement points can be sampled with the appropriate probes in the measurement plane. The minimum probe length depends on the internal diameter or depth of the waste gas duct and the wall thickness.

NOTE 2 A sufficient depth of the working area is given by the sum of the internal diameter or depth of the waste gas duct and the wall thickness plus 1,5 m for flanged-on instruments (see A.2). If two opposite measurement ports are installed for one measurement line, a correspondingly smaller operating area depth is sufficient.

NOTE 3 If the waste gas has a vertical direction of flow, both with round and rectangular waste gas ducts, a working height from the platform to the measurement lines can be established, which is approximately 1,2 m to 1,5 m.

EXAMPLE Table 1 shows examples of working platform areas required for the following two measurement objectives:

a) small measurement plane and simple measurement objective (open width of the waste gas duct: 0,2 m diameter, measurement: total carbon);

b) acceptance testing in a waste incineration plant (open width of the vertical waste gas duct: 2 m width (measurement ports) and 1,5 m depth, wall thickness: 0,3 m, measurement: total dust, total carbon, hydrogen chloride, hydrogen fluoride, sulphur dioxide, nitrogen oxides, carbon monoxide, PCDD/PCDF, heavy metals, oxygen, waste gas volumetric flow rate, waste gas pressure, waste gas temperature, carbon dioxide, water vapour).

Table 1 — Examples of working platform areas

Measurement objective	Clearance area m^2	Minimum area required for instruments, operations or movement m^2	Minimum total area m^2
a	not needed	4	4
b	6	12	18

6.3 Measurement site

6.3.1 Power supply and equipment

Power connections of an appropriate size and safeguarded in accordance with national requirement shall be installed at the measurement site. Compressed air, water connections and wastewater disposal may be necessary.

6.3.2 Safety and environmental conditions

The measurement sites shall be installed in such a way as to comply with national safety at work requirements.

At least the following aspects shall be considered:

— easy and safe access to the measurement site;

— transport means, for example hoists or lifts [18], to transport measuring instruments, in the case of measurement sites which are not at ground level;

— avoidance of area of sources which emit unexpectedly, for example rupture disks, overpressure valves or steam discharges;

— avoidance of any hazard by engineering or procedural measures;

— avoidance of areas of significant positive pressure;

— availability of measures to ensure personnel carrying out the emission measurements are informed of any operating faults which would endanger them;

— possibility to accommodate the working platform or measurement site within the plant building;

— protection of the working area from heat and dust;

— protective measures, for example weather protection and heating, to ensure the necessary environmental conditions for the personnel and the equipment used.

7 Measurement objective and measurement plan

7.1 Measurement objective

7.1.1 Specification of the measurement objective

The measurement objective shall be specified by the customer.

In view of the measurement objective, simplified procedures may be adopted for small and/or frequently visited plants provided these are documented in the emission measurement report.

The measurement objective shall specify at least:

- measurement objective;
- measurement site, for details see 7.2.7;
- process and operating conditions, which are relevant for the emission, for details see 7.2.2;
- measurands (e.g. pollutant mass concentration, reference quantities, mass flow, volumetric flow) and expected values;
- period of measurement campaign, for details see 7.2.9;
- competence of the testing laboratory.

The measurement objective can also specify the measurement methods to be applied (for details see 7.2.6) and requirements on the measurement uncertainty.

7.1.2 Identification and review of the measurement objective

The measurement objective shall be identified by the testing laboratory at the beginning of the measurement planning on the basis of the contract with the customer. This shall include any regulatory requirement.

All plant specific information which is relevant to the measurement objective shall be collected.

NOTE 1 Depending on the complexity of the measurement, plant specific information can be obtained at a site review of the plant during the basic planning, or in the case of smaller or frequently visited plants, e.g. by telephone.

NOTE 2 A site review can include a preparatory meeting with participation of e.g. a representative of the testing laboratory, the technically responsible plant personnel, a representative of the competent authority in the case of compliance monitoring, a representative of the delivery firm in the case of acceptance tests [5].

In particular the following items shall be considered:

a) relevant documents, e.g. contracts, permits, legal requirements;

b) technical data of the plant including waste gas conditions, operating conditions and periods (examples are given in B.2.3);

   NOTE 3 These data can be acquired from measurement reports, emissions declarations, or permit documents.

c) air pollution abatement techniques in operation (examples are given in B.2.4);

d) technical prerequisites for the measurement sites including measurement section, measurement ports, working area and platform, power supplies and other services;

e) technical prerequisites for continuous monitoring of emissions (examples are given in B.2.5).

If the measurement objective consists of calibration of an AMS according to EN 14181, then it is also to be checked whether the requirements for calibration on the part of the device including its installation have been met, and which possibilities exist to vary the mass concentration of waste gas components with operation of the facilities;

f) supplemental information.

Additional information collected within the framework of the measurement planning can in some cases significantly reduce the effort required for the measurement, or make further measurements unnecessary.

NOTE 4 This additional information can arise from

- previous measurements of emissions at the identical source of emissions under comparable conditions,
- measurements of emissions at comparable emission sources,
- calculated or estimated mass flow of emissions, e.g. using data from the plant or its operation with the aid of balance sheets for individual substances and
- data related to the process, e.g. knowledge of the relationship between the temperature curve of the process and emissions.

Based on the information collected, the measurement objective shall be reviewed and amended, if necessary.

7.2 Measurement plan

7.2.1 Specification of measurement plan

The measurement plan shall be specified on the basis of the measurement objective (see 7.1).

NOTE Where measurements are being made for regulatory purposes, the customer can need approval of the measurement plan from the competent authority.

In particular the following shall be specified:

a) operating conditions of the plant including fuel or feedstock, waste gas components and reference quantities to be measured;

b) timing and siting arrangements of the required individual measurements and measurement dates;

c) measurement methods to be applied;

d) measurement sections and measurement sites;

e) technical supervisor, necessary personnel and auxiliary help for carrying out of the measurements;

f) reporting arrangements.

7.2.2 Plant operating conditions and load characteristics

The operating conditions of the plant, waste gas composition and reference quantities to be measured shall be specified in accordance with the measurement objective.

The influence of the mode of plant operation, the feed materials, and the waste gas cleaning system in the plant on the emission shall be considered (examples are given in B.1).

NOTE 1 An essential feature of the specification is the maximum plant output. This determines, for example,

- in the case of combustion plants, the size and shape of the combustion space, the number of burners or number of transporters for combustible matter and the amount of combustible matter which can be fed and

- in the case of production plants, the amount of feed materials which can be used in combination with auxiliaries, additives and the maximum amount of energy required in the form of fuels or electrical energy.

If emission measurements are performed at the highest emission state, this state is established usually at the maximum plant output. However, this relationship does not apply to all measured components. The type and composition of the feed materials shall also be taken into account with respect to the expected emissions. Depending on the plant, the individual emission behaviours can also proceed in opposite directions, for example in the case of combustion plants, the components carbon monoxide and nitrogen monoxide are observed to behave in opposite ways depending on combustion conditions.

NOTE 2 The highest emission state is characterized by the highest emission mass flow. The maximum emission concentration does not inevitably occur at the highest emission mass flow. The measurement objective can refer either to concentration or to mass flow or both.

NOTE 3 To determine the highest emission state it is advisable to make use of the following:

- knowledge from the literature (e.g emission factors);
- specialist discussion with the plant operator and if necessary with the inspection authorities and a plant visit;
- knowledge of the plant type and the associated emission behaviour on the basis of measurements which have already been made on the plant in question or on comparable plants.

7.2.3 Number of individual measurements

The number of individual measurements shall be specified in accordance with the measurement objective.

NOTE When measuring a stable emission best practice is to make a minimum of three measurements. In the case of unstable emissions, the number of samples can be increased to meet the measurement objective. In the case of compliance monitoring for regulatory purposes, the number of individual measurements can be specified in the permit. Examples of regulatory requirements are given in the *Reference Document on the General Principles of Monitoring* [3].

7.2.4 Timing and duration of individual measurements

The timing and duration of the emission measurement shall be specified in the measurement plan in accordance with the measurement objective.

Where specified, the sampling duration for individual measurements prescribed by legislation (see e.g. [6], [7]), administrative provisions or other official regulations shall be used for emission measurements.

For manual methods, where low concentrations of the measured component are suspected, maximum permissible sampling duration as specified in method of measurement should be used in the first instance to meet the requirement for the field blank.

Sampling timing and duration shall be appropriate for the emission behaviour of the plant considered. A distinction should be made between the following cases:

- continuous processes (constant in time);
- continuous processes with influences varying over time;
- batch processes.

Typical examples of suitable timing and sampling duration for various process types are given in B.1.

7.2.5 Measurement points

Emission measurements of particulate pollutants shall be performed always as grid measurements (see 8.1).

Measurements of gaseous pollutants may be performed at one representative measurement point or at any measurement point, if the corresponding requirements on the distribution of the measurand specified in 8.3 are fulfilled. In all other cases the measurements shall be performed as grid measurements.

NOTE Supplementary information as described in 7.1.2 f) can provide information on the homogeneity.

7.2.6 Measurement methods

The measurement methods to be applied shall be selected according to the measurement objective. In the case of legally prescribed measurements, standard reference methods (SRM) shall be applied.

If alternative methods are used, CEN/TS 14793 shall be considered.

NOTE Guidance for selection of measurement methods is given in CEN/TS 15675.

If periodic measurements are carried out using automated reference methods, the measuring systems shall be checked in accordance with the requirements of the applicable standard before they are used in the field.

7.2.7 Measurement section and measurement site

Requirements for working platforms, positions of measurement ports, power supply, safety and environmental conditions are specified in 6.2.3.

The measurement section and measurement site shall be specified and described in detail in the measurement plan (see example form of an emission measurement plan in B.3).

In the case that the full requirements of this European Standard can not be met, the principles and procedures shall be followed as fully as possible and any deviation shall be described in the measurement plan.

In some cases, especially in existing plants, it is impossible to choose the position of measurement section and measurement site freely. In such cases the measurement section and measurement site shall be installed or modified in accordance with local plant conditions.

Measurement planning shall consider plant-specific conditions. A check shall be made as to whether in view of the measurement objective the necessary measuring conditions are satisfied (see [8]). Alternative arrangements shall be sought if, due to plant conditions, it is not possible to install an optimum measurement section which complies with the requirements of this European Standard. From the alternative arrangements, the best possible measurement section for the measurements under the given circumstances and the best possible measurement site shall be selected and installed.

NOTE In special cases it can be necessary

a) to measure the total volumetric flow rate (full stream measurement) for measuring the volumetric flow e.g. in small diameter ducts,

b) to measure the mass concentration and determine the volumetric flow rate by calculation, or

c) to calculate the mass concentration, for example from the vapour pressure, and to measure the volumetric flow rate.

7.2.8 Technical supervisor and necessary personnel

Appropriate personnel shall be used to carry out the measurement programme.

NOTE Detailed requirements for personnel carrying out emission measurements are given in CEN/TS 15675.

The following key personnel shall be nominated at the start of the measurement from a list of competent personnel in the measurement plan:

a) personnel responsible for carrying out the measurement;

b) person technically responsible (technical supervisor);

c) personnel nominated by the plant to be responsible for the plant operation during the measurement.

The sampling times selected for the measurement plan should be co-ordinated with the shift patterns of the plant personnel. The responsible plant personnel should be available when sampling takes place.

7.2.9 Planning of the measurement dates

Measurement dates shall be specified in the measurement plan. The dates shall be selected to ensure that

a) the measurement objective is met,

b) suitable process conditions are available (i.e. condition of the plant and waste gas cleaning facility),

c) the infrastructure for measurement is in place and operational,

d) the measuring and analytical systems are available and

e) the personnel and assistants are available.

7.2.10 Preparation of the measurement

7.2.10.1 Preparations by the plant operator

The measurement plan shall be communicated in accordance with the measurement objective and to relevant parties involved in the measurement process.

The following preparations for measurements shall be performed by the plant operator:

— specified operating conditions (combustion materials/raw materials/load) shall be realized during the time of measurement;

— if not already available, provision of the measuring sites complying with the requirements of 6.2;

— covers of the measurement ports shall be lubricated to facilitate easy removal by the testing laboratory; any extraneous matter that has accumulated in or around the measurement port shall be removed;

NOTE 1 Auxiliary staff can be needed for the period of the measurement campaign to assist the personnel performing the measurements.

NOTE 2 Changing room(s) and, if required, a work room can be provided.

NOTE 3 In certain countries legislation can require that measurement sites be inspected by a competent person to determine that the structural integrity of the measurement site is suitable for the work planned.

7.2.10.2 Preparations by the testing laboratory

The following preparations for measurements shall be performed by the testing laboratory:

— necessary personnel for the period of measurement campaign shall be provided;

— necessary measurement equipment for the period of measurement campaign shall be provided in accordance with the requirements of the individual measurement standards that are to be applied;

— measurement filters and sampling materials shall be prepared;

— measurement dates shall be confirmed;

— measuring systems used shall be checked, adjusted or calibrated on site.

7.2.10.3 Preparations after arrival at the plant

After arrival at the plant the responsible persons from the plant and the testing laboratory shall check that the requirements on following items specified in the measurement plan are met:

a) prepared measurement sites;

b) information on the operating conditions;

c) automated measuring systems, if applicable.

8 Sampling strategy

8.1 General

The requirements for the measurement section given in 6.2 do not, alone, ensure that the composition and physical parameters of the waste gas are homogeneous. Therefore, an appropriate sampling strategy has to be applied (see Figure 4).

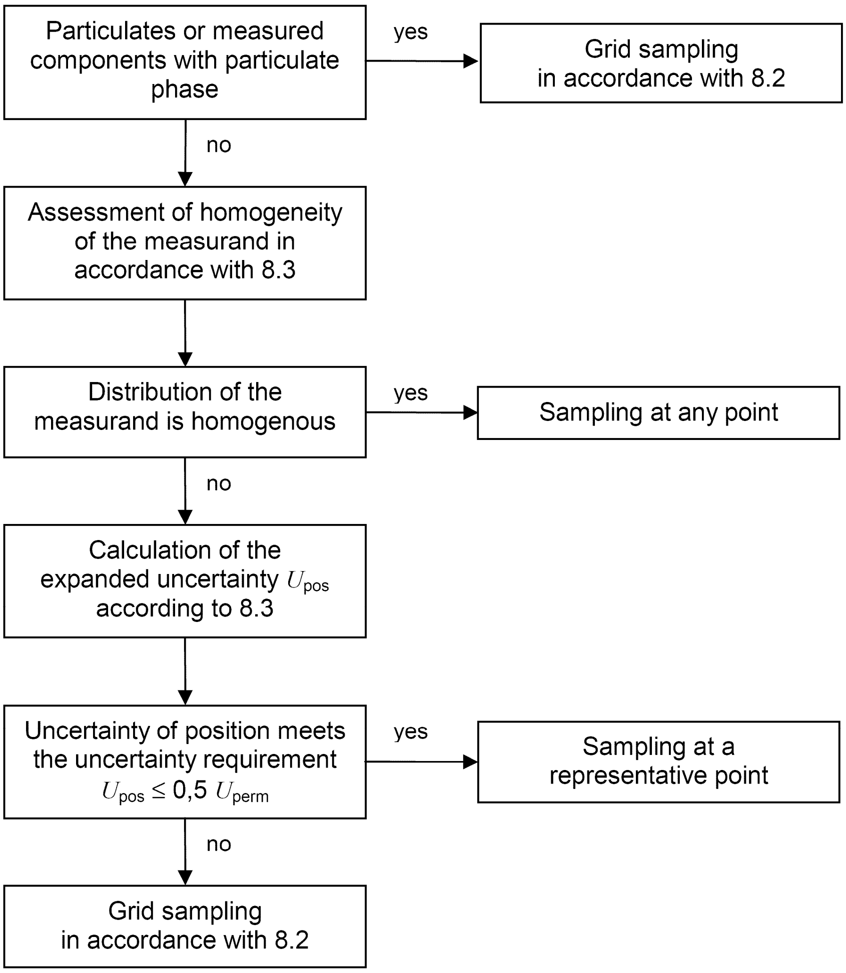


Figure 4 — Scheme of the sampling strategy

When measuring particulates or measured components that have a particulate phase as well as a vapour phase (e.g. dioxins or metals), it is always necessary to perform grid measurements as specified in 8.2.

When measuring gaseous mass concentrations of waste gas, the sampling strategy depends on the homogeneity of the waste gas which can be assessed according to 8.3 on the basis of the grid measurement approach outlined in 8.2. The sample may be taken at any single measurement point in the measurement plane provided that the homogeneity of the distribution of the measurand in the measurement plane has been demonstrated according to 8.3. The sample may be taken at a representative measurement point in the measurement plane, if the distribution of the measurand has been shown inhomogeneous according to the criteria in 8.3 but without exceeding the permissible expanded uncertainty U_{perm} as specified in 8.3. In all other cases, the measurements have to be performed as grid measurements.

NOTE If information on the distribution of the measurand in the measurement plane is available (e.g. from previous measurements or former measurement reports), it is not necessary to repeat the assessment of the homogeneity.

Grid measurements are not always feasible for automated methods. When the sampling of an automated method is restricted to one point, a representative sampling position shall be selected according to 8.4.

8.2 Measurement of particulates and other components by grid measurements

In case of dust or any particulate matter or water droplets, grid measurements shall be performed with isokinetic sampling.

If gaseous components are measured in parallel with particulate matter, where isokinetic sampling is required, the flow rate in the secondary lines need to be proportional to the total flow rate. Furthermore, the absorption or adsorption efficiency of the collecting media of the gaseous phase shall be maintained.

When gaseous components are being measured, the following two cases of grid measurements can be distinguished:

a) if the measurement uses a collecting phase, the following two procedures can be applied:

   1) the flow rate through the collecting media can be adapted to the local mass flow in the partial area (mass flow proportional sampling);

   2) the flow rate cannot be adapted without decreasing the collection efficiency of the system (manual methods with e.g. washing bottles) or cannot be changed (automated methods); in this case the sample is taken at each point during a time period proportional to the local velocity;

b) if the concentration is determined directly at the measurement points in the measurement plane, for example using automated reference methods, then the sample mass flow per partial area that is required for the calculation, i.e. the mass flow density, is calculated from the combination of local concentration and local velocity (see Equation (G.10) of Annex G).

The dimensions of the sampling plane dictate the minimum number of sampling points. This number increases as the duct dimensions increase.

Tables 2 and 3 specify the minimum number of sampling points to be used for circular and rectangular ducts respectively. The sampling points to be used shall be located at the centre of equal areas in the sampling plane (see Annex D).

Sampling points shall be located either more than 3 % of the sampling line length or more than 5 cm whichever is the greater value from the inner duct wall. This can arise when selecting more than the minimum numbers of sampling points presented in Tables 2 and 3, for example in cases of unusual duct shape.

Table 2 — Minimum number of sampling points for circular ducts

Range of sampling plane areas m^2	Range of ducts diameters m	Minimum number of sampling lines (diameters)	Minimum number of sampling points per plane
< 0,1	< 0,35	–	1 [a]
0,1 to 1,0	0,35 to 1,1	2	4
1,1 to 2,0	>1,1 to 1,6	2	8
> 2,0	> 1,6	2	at least 12 and 4 per m^2 [b]

a Using only one sampling point can give rise to errors greater than those specified in this European Standard.

b For large ducts, 20 sampling points are generally sufficient.

Table 3 — Minimum number of sampling points for rectangular ducts

Range of sampling plane areas m^2	Minimum number of side divisions [a]	Minimum number of sampling points
< 0,1	–	1 [b]
0,1 to 1,0	2	4
1,1 to 2,0	3	9
> 2,0	≥ 3	at least 12 and 4 per m^2 [c]

a Other side divisions can be necessary, for example if the longest duct side length is more than twice the length of the shortest side (see C.3).

b Using only one sampling point can give rise to errors greater than those specified in this European Standard.

c For large ducts, 20 sampling points are generally sufficient.

NOTE 1 When the requirements for the sampling plane cannot be met, it may be possible to improve representative sampling by increasing the number of sampling points above those specified in Tables 2 and 3.

NOTE 2 If a high level of confidence is required for certain questions, for example in guarantee, acceptance or design measurements, more measurement points may need to be incorporated in planning.

If a grid measurement cannot be performed due to the restricted number of sampling ports or restricted access to sampling ports, the available measurement lines shall be used. The deviation and the reason for the deviation shall be reported.

8.3 Determination of homogeneity

Waste gas is assumed to be homogeneous for an individual measurand, if the actual value varies only in time but not over the measurement plane. The test for homogeneity is shown in Figure 5.

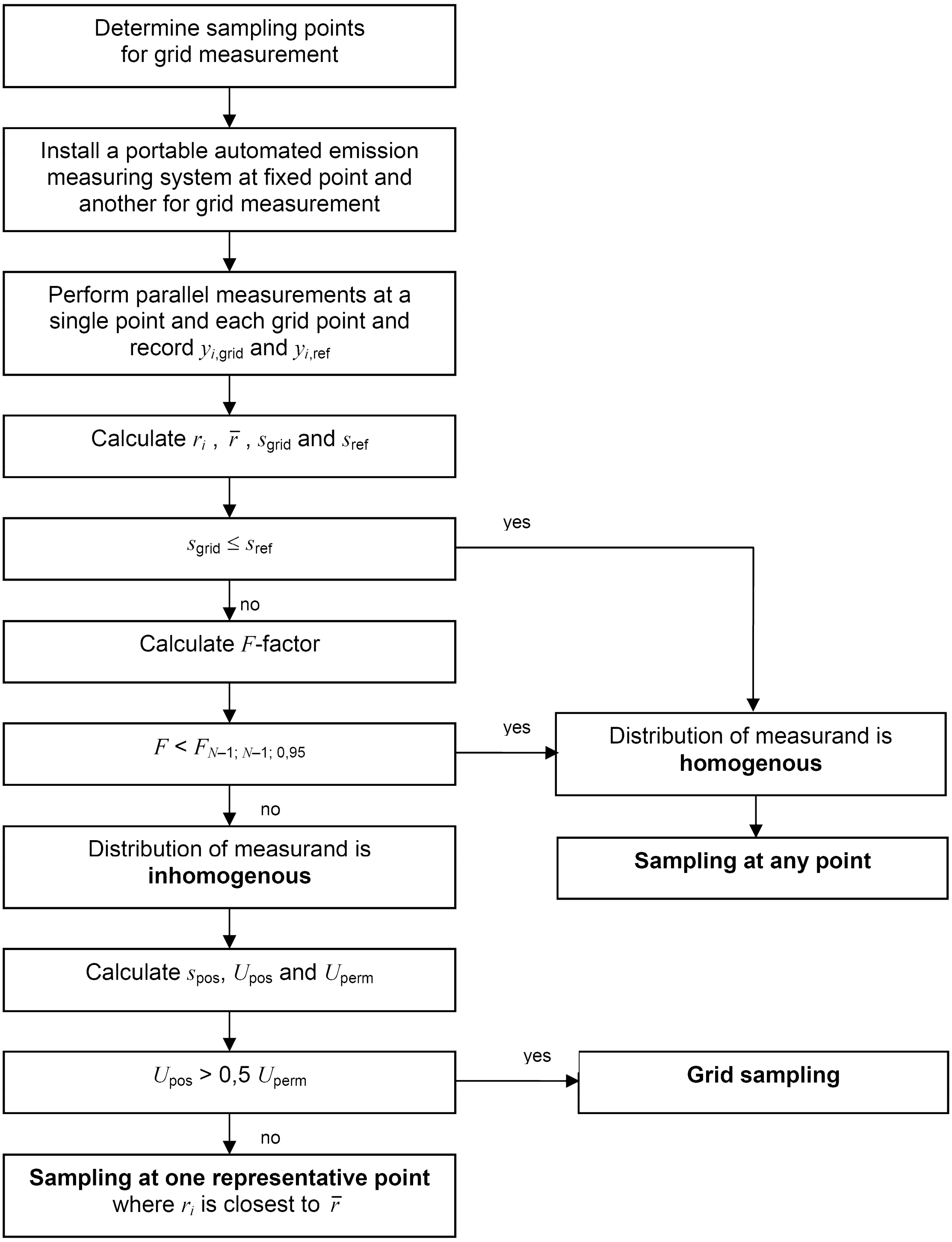


Figure 5 — Schematic diagram of homogeneity test

Homogeneity of the distribution of a measurand in the measurement plane shall be determined by a grid measurement and for the same operating conditions of the measurand specified in the measurement objective. Since the measurand also varies in time due to fluctuations in the process, additional parallel measurements with an independent measuring system at a fixed point in the measurement section shall be performed.

NOTE 1 The distribution of measurands in the waste gas can still be inhomogeneous even when a homogeneous waste gas velocity distribution has been observed.

NOTE 2 Homogeneity can be demonstrated for the measurand considered or for a surrogate parameter, e.g. continuously measured total organic carbon can be used as a surrogate parameter for the homogeneity of the toluene mass concentration.

NOTE 3 Homogeneity is usually determined once. The homogeneity is influenced by certain factors like load or fuel. A change in such factors can cause a repetition of the determination of the homogeneity.

NOTE 4 Homogeneity is usually determined using direct-reading instruments.

The following procedure covering spatial and temporal variations shall be applied to determine the homogeneity:

a) determine the sampling points for the grid measurement according to 8.2;

b) install the probe of the measuring system for the grid measurement;

c) install the probe of an independent measuring system (reference measurement) at a fixed point in the measurement section;

d) adjust the sample flow in both systems in order to obtain equal response times;

e) perform a grid measurement and in parallel measurements at a fixed point in the measurement section, with a sampling time of at least four times the response time of the measuring system but not less than three minutes for each sampling point;

NOTE 5 According to EN ISO 14956 the sampling time at each point is four times the response time for dynamic processes and ten times the response time for highly dynamic processes.

NOTE 6 If there are substantial variations in the actual reference value in time, the inhomogeneity can not be distinguished from the effects due to process variations. Therefore the process conditions should be as stable as possible during the grid measurements.

f) record for each sampling point i the actual value $y_{i,\text{grid}}$ of the measurand in the grid and the value $y_{i,\text{ref}}$ of the reference measurement;

g) calculate for each sampling point i the ratio r_i according to Equation (5):

$$r_i = \frac{y_{i,\text{grid}}}{y_{i,\text{ref}}} \tag{5}$$

h) calculate

— standard deviation s_{grid} of the grid measurements according to Equation (6):

$$s_{\text{grid}} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(y_{i,\text{grid}} - \bar{y}_{\text{grid}}\right)^2} \tag{6}$$

— standard deviation s_{ref} of the reference measurements according to Equation (7):

$$s_{\text{ref}} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(y_{i,\text{ref}} - \bar{y}_{\text{ref}}\right)^2} \tag{7}$$

— average $\bar{r}$ of the ratios r_i according to Equation (8):

$$\bar{r} = \frac{1}{N}\sum_{i=1}^{N} r_i \tag{8}$$

NOTE 7 The standard deviation s_{ref} represents the variations in time due to fluctuations in the process and analysis. The standard deviation s_{grid} represents these variations as well as the variations due to the position in the cross-section of the duct (see k)). If s_{grid} is significantly greater than s_{ref}, the waste gas is inhomogeneous. The significance can be tested using the statistical F-test.

i) if s_{grid} is greater than s_{ref}, calculate the F-factor according to Equation (9):

$$F = \frac{s_{grid}^2}{s_{ref}^2} \quad (9)$$

if the F-factor is less than $F_{N-1;N-1;0,95}$ for the number of sampling points as given in Table 4, or if s_{grid} is smaller or equal to s_{ref}, the waste gas is assumed to be homogeneous and future sampling of the waste gas may be performed at any point in the measurement plane instead of sampling at all the points of the grid;

NOTE 8 The standard deviation s_{grid} is generally greater than s_{ref}, since it always includes additional contributions caused by the spatial inhomogeneity. In the case of spatially homogenous distributions, where the standard deviations do not differ significantly, s_{ref} can be larger than s_{grid} for statistical reasons due to the limited number of samples.

if the F-factor is greater or equal to the $F_{N-1;N-1;0,95}$ for the number of measurements as given in Table 4, the distribution in the waste gas is inhomogeneous;

j) if the distribution is inhomogenous, calculate the standard deviation s_{pos} of the position in the cross section according to Equation (10) and the corresponding expanded uncertainty U_{pos} according to Equation (11):

$$s_{pos} = \sqrt{s_{grid}^2 - s_{ref}^2} \quad (10)$$

$$U_{pos} = t_{N-1;\,0,95} \times s_{pos} \quad (11)$$

where $t_{N-1;\,0,95}$ is the Student's t-factor for a number of degrees of freedom of N–1 and a confidence level of 95 %;

k) determine the permissible expanded uncertainty U_{perm} specified for the measurand considered or the corresponding surrogate parameter;

NOTE 9 In some EU Directives (see [6], [7]) the uncertainty is expressed as half of the length of a 95 % confidence interval and as a percentage P of the emission limit value E. Then, the permissible expanded uncertainty U_{perm} and the corresponding standard deviation σ_0 are given by $U_{perm} = P\ E$ and $\sigma_0 = P\ E/1{,}96$ (as described in EN 14181). These uncertainties are specified in the EU Directives for standard conditions. Based on the measurement objective, it can be necessary to convert these values to operating conditions.

NOTE 10 For O_2 and CO_2 an expanded uncertainty U_{perm} of 6 % of the measurement range and for H_2O an expanded uncertainty U_{perm} of 30 % of the measurement range can be used.

NOTE 11 An expanded uncertainty U establishes an interval [y – U; y + U] around the result of measurement y. within which the unknown true value is expected to be with 95 % confidence.

The consequences of the observed inhomogeneity depend on the permissible expanded uncertainty U_{perm}.

If U_{pos} is less or equal to 50 % of the permissible expanded uncertainty U_{perm}, future measurements may be performed at one representative point in the measurement plane, since the contribution of the uncertainty due to the inhomogeneity of the waste gas to the total uncertainty is negligible. The grid point with the ratio r_i nearest to the average value $\bar{r}$ of the ratios is assumed to be the representative point.

If U_{pos} is greater than 50 % of the permissible expanded uncertainty U_{perm}, future measurements shall be performed as grid measurements.

Homogeneity can be demonstrated using only one single measuring system to determine firstly the homogeneity of spatial distribution of the measurand in the measurement plane by grid measurement and secondly at a fixed point the variation of the measurand in time following all the steps of the procedure outlined in 8.3. This simplified procedure is adequate in the case of demonstrated homogeneity or inhomogeneity (U_{pos} > 0,5 U_{perm}). If the result is inhomogeneity and U_{pos} ≤ 0,5 U_{perm} then the procedure with two independent measuring systems has to be performed.

NOTE 12 The independent measuring system at a fixed point can be a permanently installed AMS, working according to EN 14181. In this case, item d) should be taken into account.

Measured results obtained by measurements at the representative point are only representative for the measurand itself (e.g. mass concentration, mass flow density).

NOTE 13 The average concentration in the waste gas duct can be determined by dividing the total average mass flow by the average volumetric flow in the measurement plane (see Equation (G.2) of Annex G).

Table 4 — F–factors and t–factors as function of the number of sampling points for a confidence level of 95 % [9]

Number of sampling points N	F-factor $F_{N-1;\,N-1;0,95}$	t-factor $t_{N-1;0,95}$	Number of sampling points N	F-factor $F_{N-1;\,N-1;0,95}$	t-factor $t_{N-1;0,95}$
4	9,28	3,182	19	2,22	2,101
5	6,39	2,776	20	2,17	2,093
6	5,05	2,571	21	2,12	2,086
7	4,28	2,447	22	2,08	2,080
8	3,79	2,365	23	2,05	2,074
9	3,44	2,306	24	2,01	2,069
10	3,18	2,262	25	1,98	2,064
11	2,98	2,228	26	1,96	2,060
12	2,82	2,201	27	1,93	2,056
13	2,69	2,179	28	1,90	2,052
14	2,58	2,160	29	1,88	2,048
15	2,48	2,145	30	1,86	2,045
16	2,40	2,131	31	1,84	2,042
17	2,33	2,120	32	1,82	2,039
18	2,27	2,110	33	1,80	2,036

Examples of the determination of the homogeneity of waste gas are presented in E.1.

8.4 Permanently installed AMS

Permanently installed AMS are usually restricted to sampling at a single point, or along a single line-of-sight. These sampling points or lines shall be located such that a representative sample of the measurand is obtained. They shall be positioned so as not to obstruct, or be affected by sampling probes used to perform grid measurements (see Figure 3).

For AMS used for continuous monitoring of emissions, it is necessary that the measurement point is representative for the mass flow density and often also the oxygen volume fraction. Therefore, the best available sampling point for AMS shall be determined according to the following procedure:

a) determine the sampling points for the grid measurement according to 8.2;

b) install the probe of the measuring system for the grid measurement;

c) install the probe of an independent measuring system (reference measurement) at a fixed point in the measurement section;

d) adjust the sample flow in both systems in order to obtain equal response times;

e) perform a grid measurement and in parallel measurements at a fixed point in the measurement section, with a sampling time of at least four times the response time of the measuring system but not less than three minutes at each sampling point;

f) record for each grid point the observed reference gas temperature T_{ref}, waste gas velocity v_{ref}, oxygen volume fraction o_{ref} and the mass concentration c_{ref} and the observed values T_{grid}, v_{grid}, o_{grid} and c_{grid} of the profile measurement;

g) calculate for each grid point i the factor $F_{\text{rep},i}$ according to Equation (12):

$$F_{\text{rep},i} = \frac{c_{\text{grid},i} \times v_{\text{grid},i}}{c_{\text{ref},i} \times v_{\text{ref},i}} \times \frac{T_{\text{ref},i}}{T_{\text{grid},i}} \times \frac{21\,\% - o_{\text{ref},i}}{21\,\% - o_{\text{grid},i}} \tag{12}$$

NOTE 1 The terms $(21\,\% - o_{\text{ref},i})/(21\,\% - o_{\text{grid},i})$ and $(T_{\text{ref},i} / T_{\text{grid},i})$ are only used if variations of temperature and/or oxygen content occur in the measurement plane (e.g. at waste incinerators, combustion plants).

The best available sampling point of the AMS for concentration measurements is the point where $F_{\text{rep},i}$ is nearest to the average value F_{rep} of all the grid points. The AMS probe should be placed as close as is practical to this point.

NOTE 2 The remaining deviation from representativeness is incorporated by the calibration of the AMS with standard reference methods according to EN 14181 and is therefore not subject for special attention in this framework.

E.2 gives an example of the determination of a suitable measurement point for AMS.

9 Measurement report

The measurement report shall provide a comprehensive account of the measurements, a description of the measurement objective and the measurement plan. It shall provide sufficient detail to enable the results to be traced back through the calculations to the collected basic data and process operating conditions.

NOTE 1 The measurement report for the customer does not contain every detail which is included in the measurement file or work file.

NOTE 2 If measurements are being undertaken for regulatory purposes, the competent authority can specify the use of a standard report format.

An emission measurement report shall include at least the following items:

a) executive summary providing a general overview of the measurement work and results including e.g.

- operator's name and the address of the process plant where the measurement was made,
- name and address of the testing laboratory,
- measurement objective,
- substance(s) measured in the waste gas,
- sampling date (day, month and year),

— measurement uncertainties,

— measurement methods applied,

— deviations from the measurement plan and

— result(s) of measurement expressed in SI units and at the specified conditions;

b) definition of the project by specification of the measurement objective(s);

c) description of the plant and materials handled (see example in B.2);

d) identification of measurement section and measurement site;

e) identification of the measurement methods and apparatus according individual standards;

f) operating conditions of the plant during measurement including waste gas cleaning units [3];

g) reference on how to access and use the original data for verification purposes;

h) measurement results and other relevant data necessary for the interpretation of results;

i) calculation procedures;

NOTE 3 Typical calculations in the case of emission measurement are conversion of data to specific standard conditions (see Annex C).

j) presentation of the results.

The reporting requirements of individual standards shall be observed.

Any deviation from this European Standard shall be justified and documented in the measurement report.

Any deviation from the measurement plan shall be justified and documented in the measurement report.

The reporting follows all the steps of the planning procedures as described in Clause 7. It is recommended to use the completed forms [3] (e.g. according to B.3) of the emission measurement planning as the first part of the emission measurement report.

A suitable example of an emission measurement report is given in Annex F in connection with B.3.

Annex A
(informative)

Design and construction of measurement sites

A.1 Examples of measurement ports

Large rectangular ports, which can be closed with tight-sealing covers, can be readily adapted to a respective measurement objective. In the case of a correspondingly large waste gas duct diameter, rectangular measurement ports which can be sealed with covers have proved useful, the long side being installed parallel to the direction of flow. A minimum surface area of 100 mm × 250 mm is recommended, except for small ducts (less than 0,7 m diameter) for which the port size needs to be smaller [12].

Figure A.1 shows an example of a rectangular measurement port [12].

Figure A.2 shows an example of a rectangular measurement port with cover having an open width of 150 mm by 300 mm. The bore holes for attaching the sealing cover should have a diameter of 15 mm [10].

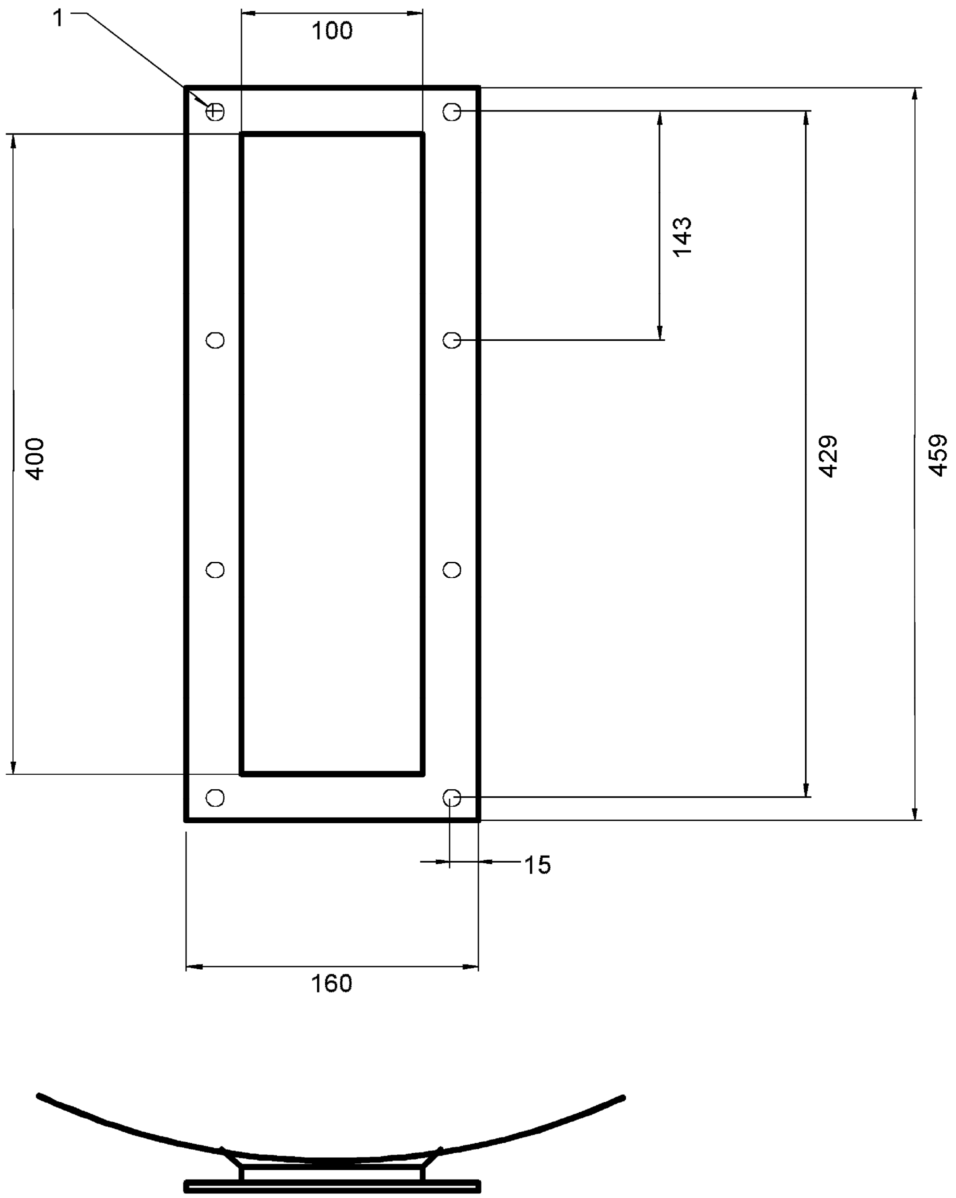
Round ports are widely used and for these a minimum diameter of 125 mm is recommended for ducts above 0,7 m.

Figure A.3 shows an example of a round measurement port with an internal diameter of 125 mm.

Figure A.4 shows an example of a round measurement port with a diameter of 75 mm for small ducts. The measurement port can be equipped with an internal or external thread [10].

The sealing covers of the measurement ports shown in Figure A.1 and Figure A.2 can be replaced during measurements by a plate which contains measurement ports adapted to the measured component (for example as in Figure A.3 or Figure A.4).

Dimensions in millimetres



Key

1 8 holes, ∅ 9 mm

Figure A.1 — Example of a rectangular measurement port

Dimensions in millimetres

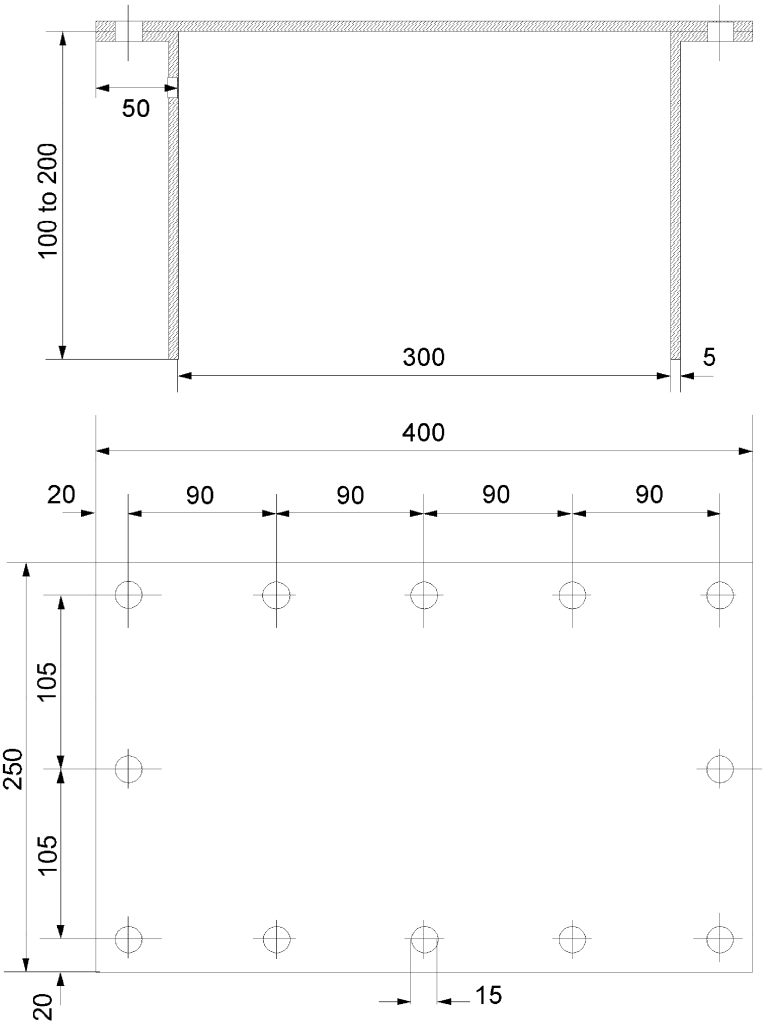
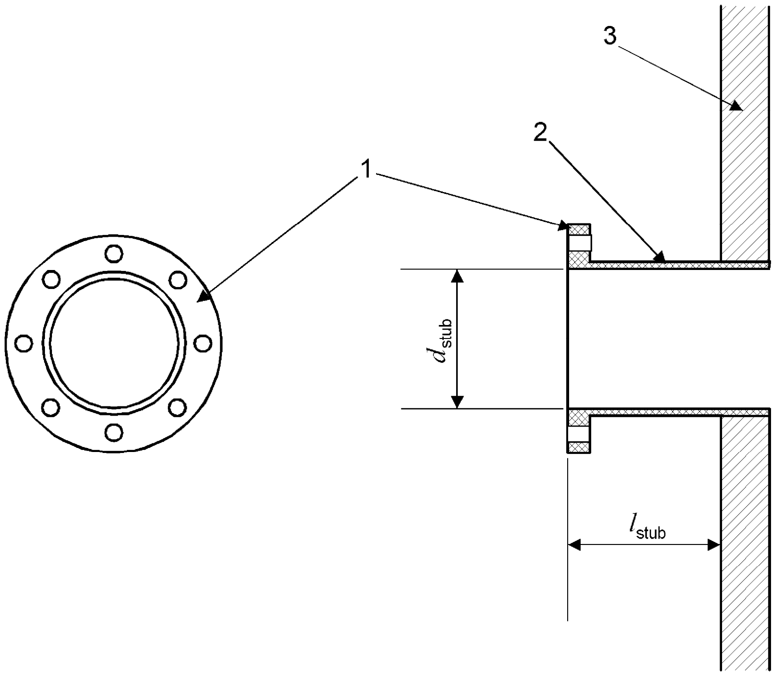


Figure A.2 — Example of a rectangular measurement port equipped with a cover



Key

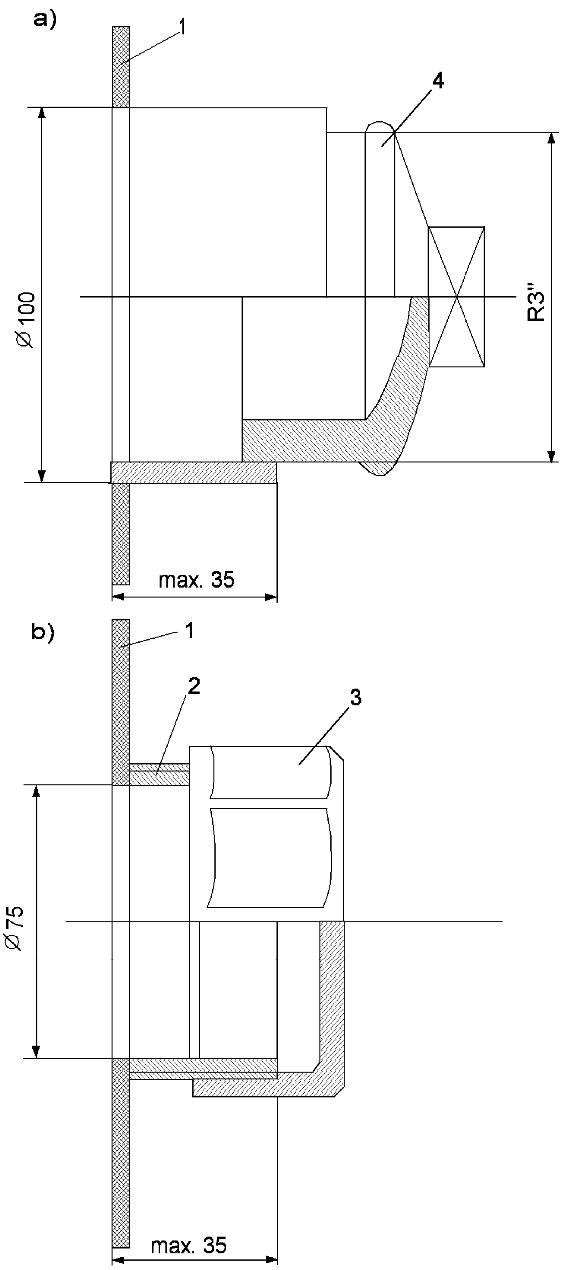
1 flange with internal diameter d_{stub} = 125 mm

2 pipe stub with internal diameter d_{stub} = 125 mm and minimum length l_{stub} = 75 mm from duct wall (recommended 100 mm)

3 duct wall

Figure A.3 — Example of a round measurement port with 125 mm internal diameter

Dimensions in millimetres



Key

1 duct wall

2 75 mm pipe nipple

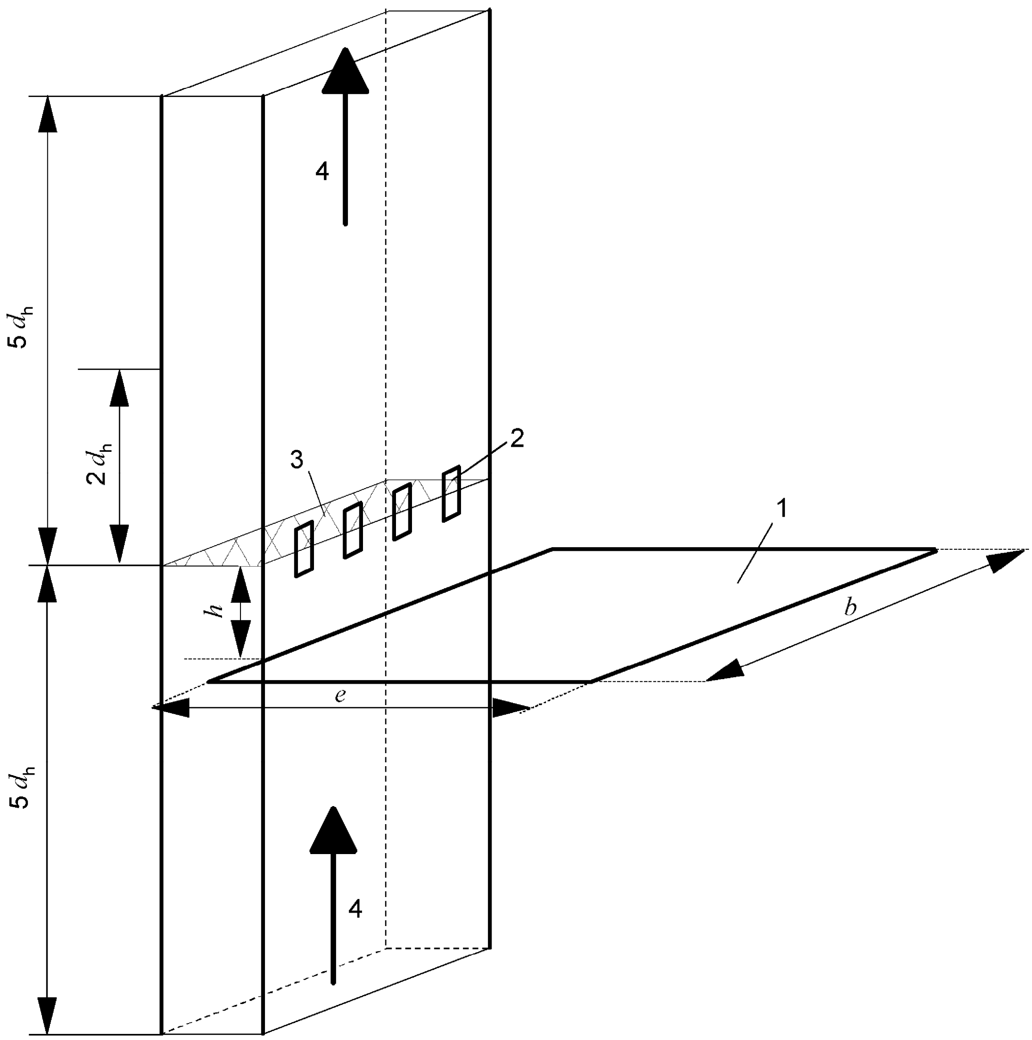
3 closure cap

4 closure stopper

Figure A.4 — Example of a round measurement port with 75 mm internal diameter and internal thread (a) and external thread (b)

A.2 Examples of measurement sections and working platforms

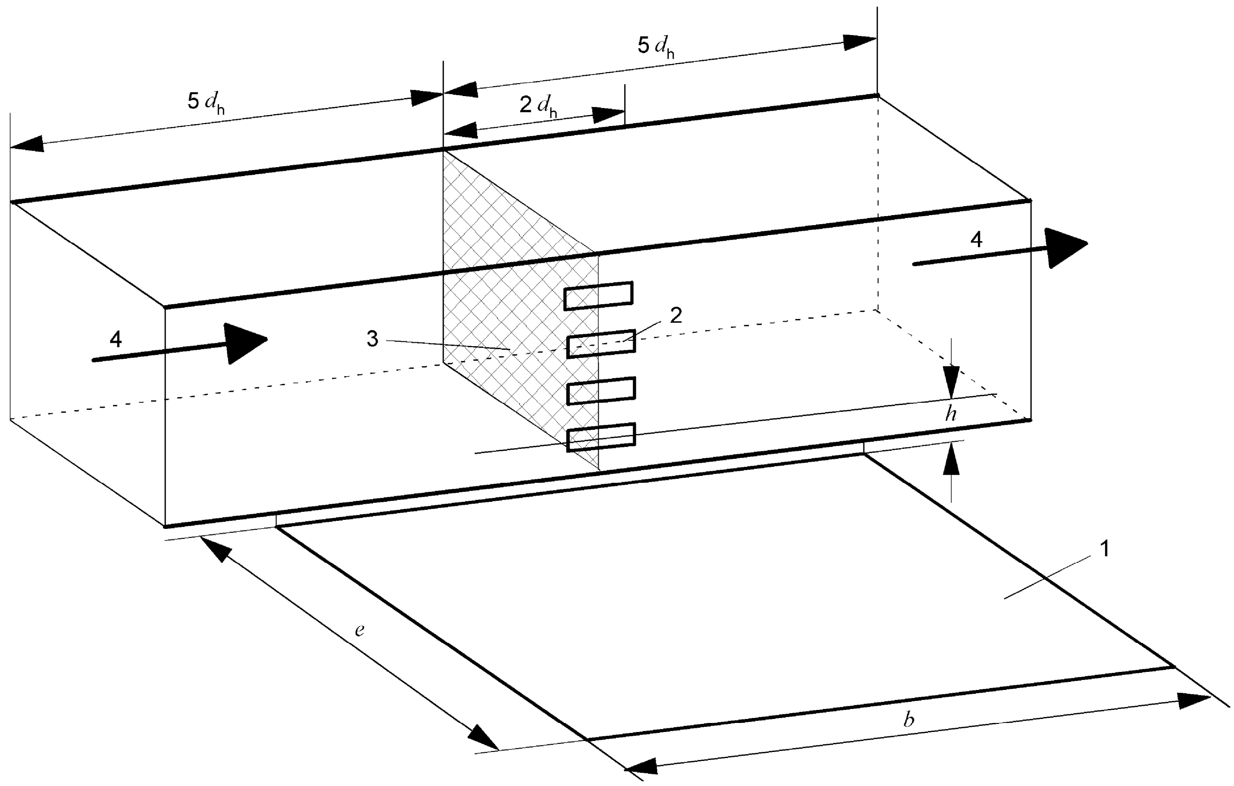
Figure A.5 to Figure A.8 show examples of working platforms and the position of the measurement ports in measurement sections of horizontal or vertical round and rectangular flow ducts.



Key

1	working platform	b	width of the working area
2	measurement port	d_h	hydraulic diameter of the waste gas duct
3	measurement plane	e	depth of the working area
4	flow direction	h	minimum working height

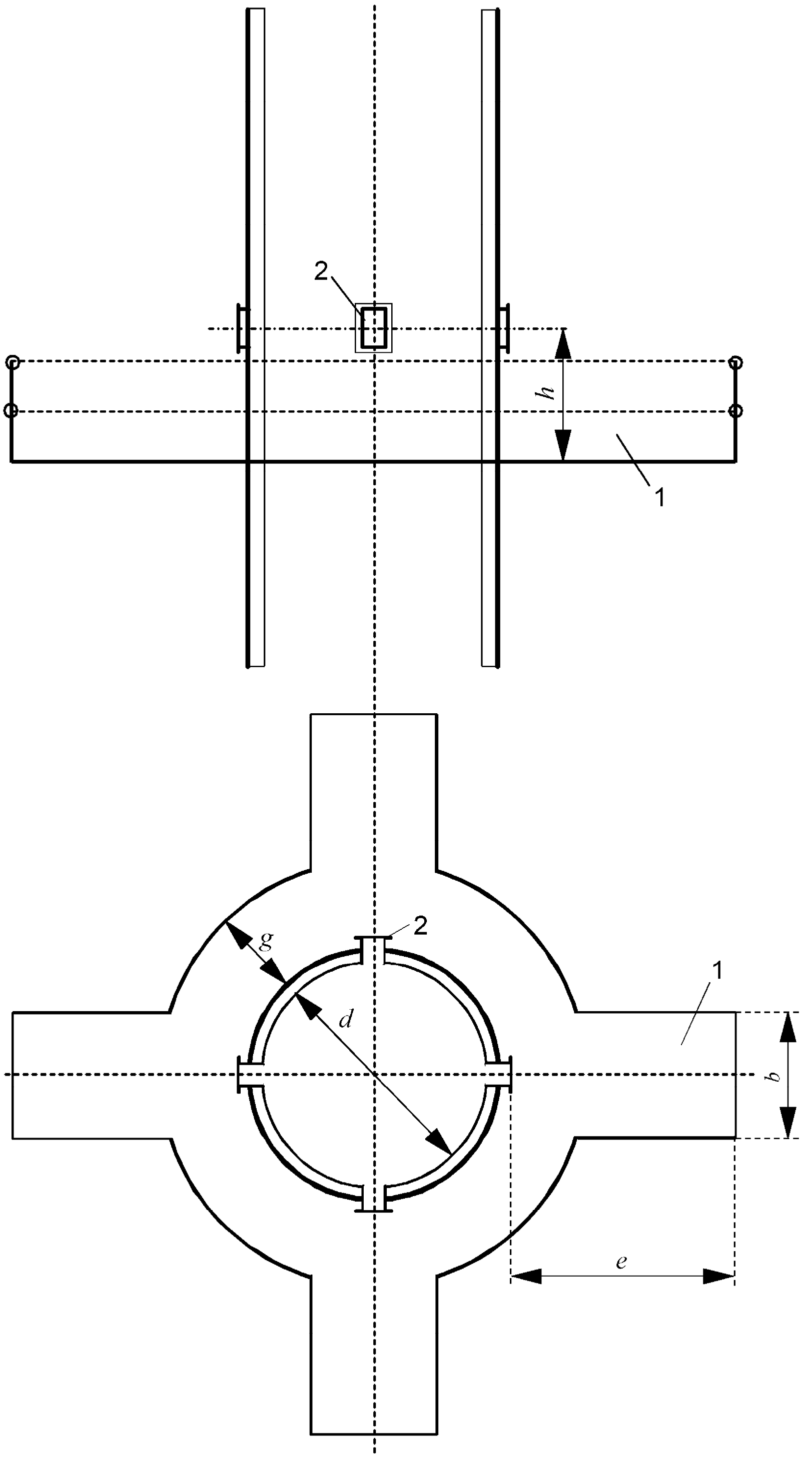
Figure A.5 — Example of a working platform and the position of measurement ports in a vertical rectangular waste gas duct



Key

1	working platform	b	width of the working area
2	measurement port	d_h	hydraulic diameter of the waste gas duct
3	measurement plane	e	depth of the working area
4	flow direction	h	minimum working height

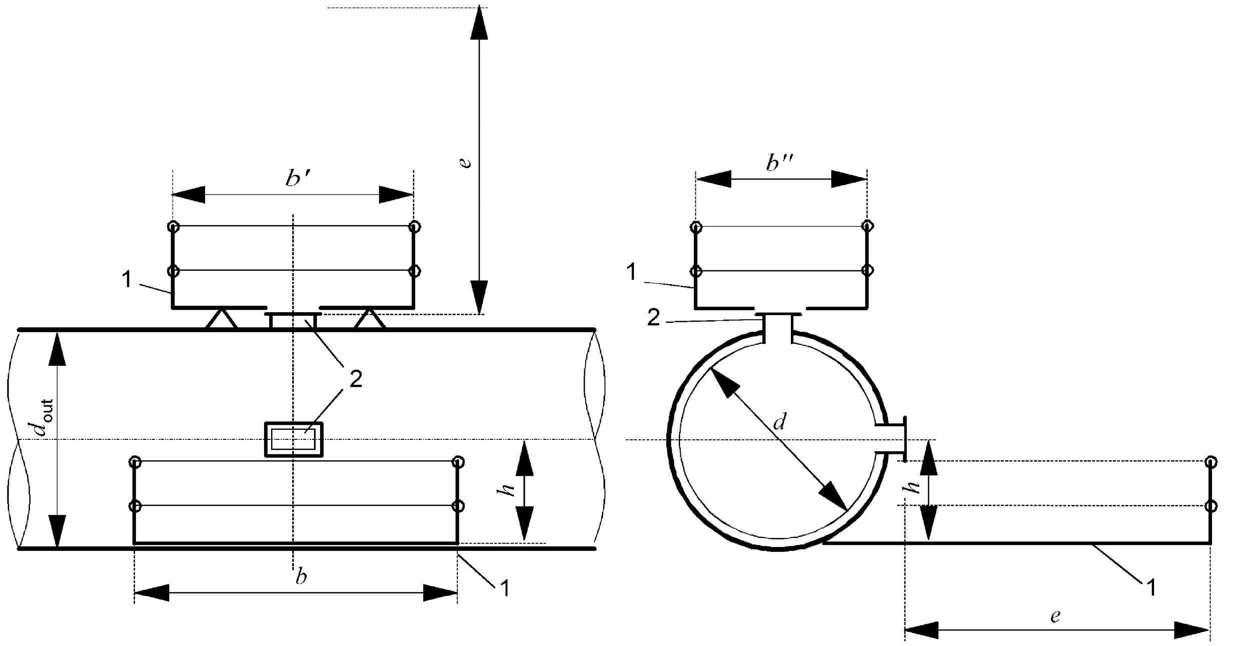
Figure A.6 — Example of a working platform and the position of the measurement ports in a horizontal rectangular waste gas duct



Key

1	working platform	*b*	width of the working area
2	measurement port	*d*	internal diameter of the waste gas duct
		e	depth of the working area
		g	passage width between the working areas
		h	working height

Figure A.7 — Example of a working platform and the position of measurement ports in a vertical round waste gas duct



Key

1	working platform	*b*, *b*′, *b*″	width of the working area
2	measurement port	*d*	internal diameter of the waste gas duct
		d_{out}	outer diameter of the waste gas duct
		e	depth of the working area
		h	working height

Figure A.8 — Example of a working platform and the position of the measurement ports in a horizontal round waste gas duct

Annex B
(informative)

Measurement planning

B.1 Examples of the timing of emission measurements

B.1.1 Continuous processes

Continuous processes are characterized by the fact that the material properties of the fuels used and the materials handled in the process as well as the mode of operation of the plant are approximately constant over a relatively long period of time. The emission behaviour of such processes can thus likewise be considered as essentially unchanged with time. The emission measurement can therefore be made at any point in time. For certain types of plant, for example hot water plants, because of low seasonal demand it is not always possible to operate the plant under full load for 30 min. In these cases a shorter sampling time can also be used if the half-hourly mean value can be calculated with sufficient certainty.

EXAMPLE Typical continuous processes are

— combustion plants,

— drying plants,

— coating plants,

— rotary kiln plants and

— crushing and classification plants.

B.1.2 Continuous processes subject to time-dependent effects

Continuous processes with influences varying over time can be characterized by the fact that with substantially constant material feed, time-dependent process steps can affect the emission behaviour. The timing of the emission measurements shall give adequate consideration to these conditions and take the changes in emission behaviour with time into account sufficiently.

EXAMPLE Typical continuous processes having influences varying over time are

— firing processes in brick manufacture (e.g. trolley charging in tunnel kilns) and

— glass manufacture in tank furnaces.

B.1.3 Batch processes

Batch processes are predominantly characterized by the fact that the emission behaviour is controlled, or can be controlled, by operating effects which vary as a function of material and/or with time. The timing of the emission measurements shall then take these circumstances into account sufficiently. Especially in the case of very short-term emission events, a check shall be made as to whether several similar emission events can be combined in one sampling in order to enable evaluation of the operating state.

EXAMPLE Typical batch processes are

— batch processes in the chemical industry,

— nonferrous metal melting plants,

— steel production and

— pot furnaces in glass production.

B.2 Example for collection of data and available knowledge

B.2.1 Introduction

As a rule it is not necessary to incorporate each and every detail of the following lists (see B.2.2 to B.2.8) into the report. It is much more important to note possible peculiarities of the plant to be investigated. The following list serves as an aid, but makes no claim to be complete.

B.2.2 General information

General information can include the following:

a) customer (operator's name);

b) contact person;

c) telephone, fax, e-mail;

d) date of commencement of contract;

e) measurement objective;

f) components to be measured in fulfilment of the objective.

B.2.3 Data particular to the plant

Data particular to the plant can include the following:

a) type of plant to be investigated;

b) plant identification/location of the plant;

c) operating capacity/throughput;

d) manufacturer/factory number;

e) year of construction;

f) feed materials/combustible materials;

g) operating periods and load performance;

h) periods with unfavourable emission conditions;

i) response of the plant during start-up and shut-down;

j) batch process;

k) sources of emission;

l) source numbers (from emissions declaration);

m) characteristic data regarding exhaust fans;

n) type and elevation of the waste gas duct;

o) diameter and cross-section of the waste gas duct;

p) necessity of consideration of diffuse emission sources.

B.2.4 Facilities for the reduction of emissions

Other cleaning units are to be described in a corresponding way. As a rule, only one of the waste gas cleaning units described under a) to j) needs to be indicated for the particular plant in question. However, it is quite possible to describe combinations.

a) Electrostatic precipitator

   Manufacturer of the electrostatic precipitator, year of manufacture, number of collection zones (fields), effective precipitation area, residence time in the electric field, de-dusting (wet/mechanical), upstream cooling (yes/no), water injection upstream of precipitator (yes/no), flow through precipitator, nominal rating of the suction fan, intervals between servicing, last service.

b) Thermal combustion units with/without heat exchanger

   Manufacturer of the thermal afterburner unit, year of manufacture, type of burner, type of fuel added, fuel throughput, temperature of the reaction chamber, residence time in the reaction chamber, nominal rating of the suction fan, intervals between servicing, last service.

c) Catalytic combustion unit

   Manufacturer of the catalytic combustion unit, year of manufacture, type of burner, type of fuel, fuel throughput, catalyst type, operating time of the catalyst, reaction chamber temperature, mean residence time, nominal rating of the suction fan, intervals between servicing, last service.

d) Activated carbon filter with/without recovery

   Manufacturer of the activated carbon filter, year of manufacture, activated carbon content, supplier/particle size/type of activated carbon, height of the activated carbon bed in the adsorber, plane of the activated carbon bed in the adsorber, frequency of desorption, type of desorption, nominal rating of the suction fan, pressure difference between raw gas/cleaned gas, intervals between servicing, last service.

e) Cyclone unit

   Manufacturer of the cyclone unit, model, year of manufacture, number of individual cyclones, arrangement (parallel/in series), cyclone diameter, nominal rating of the suction fan, pressure difference between raw gas/cleaned gas, volume flow of gas, intervals between servicing, last service.

f) Wet precipitator

   Manufacturer of the wet precipitator, model, year of manufacture, working principle of the wet precipitator (e.g. scrubbing tower, venturi scrubber, vortex scrubber, rotary scrubber, pressure-change precipitator):

   1) in the case of a scrubbing tower

      — the flow of the scrubbing liquid: cocurrent, countercurrent, cross-current),

      — construction: without internals, with plates, packed,

      — number of plates: sieve plates, bubble cap plates etc.,

      — height of the packed column,

      — type of packing: Raschig rings, saddles, disks and

— type of scrubbing liquid;

2) in the case of vortex scrubbers

— water level and

— sludge discharge;

3) in the case of pressure-change precipitators

— number of precipitation elements,

— scrubbing liquid,

— additives,

— amount of scrubbing liquid and

— scrubbing liquid flow;

4) for all wet precipitators

— amount of fresh scrubbing liquid added,

— frequency of scrubbing liquid replacement,

— pH value,

— stage 1,

— stage 2,

— temperature of the scrubbing liquid in the reservoir,

— last replacement of the scrubbing liquid in the settling tank,

— type of downstream droplet precipitator,

— nominal rating of the suction fan,

— intervals between servicing and

— last service.

g) Woven fabric filter

Manufacturer of the woven fabric filter, type, year of manufacture, number of filter chambers, number of tubes/bags, filter area, throughput per unit area of filter (gross/net), filter material, de-dusting (mechanical/pneumatic), de-dusting frequency, last filter cloth change, pressure difference between raw gas and cleaned gas sides, nominal rating of the suction fan, intervals between servicing, last service.

h) Nitrogen oxide abatement measures

Primary measures:

— flue gas recirculation, progressive combustion;

secondary measures:

— SNCR, SCR

reducing agent.

i) Bio-filter

Manufacturer of the bio-filter, year of manufacture, bed depth, throughput per unit area, material, raw gas temperature, water vapour content of the raw gas, pressure difference between raw gas/cleaned gas, intervals between changing the filter bed, last filter bed change, intervals between servicing, last service.

j) Condensation and sedimentation precipitation

Manufacturer, year of manufacture, construction type, flow (counter-current, co-current, cross-current), cooling liquid, condensate removal, baffles, cycling for melting off, ribbed tubes, injection condensers, pressure drop, intervals between servicing, last service.

B.2.5 Calibration and annual surveillance test of AMS

AMS is available/is not available (if necessary, fill out for each pollutant/constituent):

a) measured component/Reference quantity;

b) device manufacturer;

c) device model:

   1) adjusted measuring range;

   2) relationship of the adjusted measuring range to the emission limit;

   3) device model suitability tested;

   4) adjusted measuring range suitability tested;

   5) model suited to anticipated application;

d) placement of the sampling point:

   location: in advance of or subsequent to suction draught ventilator;

e) type of sampling (point/line/grid):

   proper installation of the devices already certified;

f) last annual surveillance test (AST);

g) last calibration;

h) possibilities of influencing the measured substance concentrations during the comparison tests for the calibration of the measuring instruments;

i) automatic analysis of the measurement results:

   1) computer manufacturer;

   2) computer type, software version;

   3) computer type suitability tested;

4) application covered by suitability test;

5) proper parameterization and functional operation certified;

6) last annual surveillance test.

B.2.6 Measurement site

Data particular to the measurement site can include the following:

a) location of the measurement site and measurement plane;

b) number and size of the measurement ports;

c) size of the working platform;

d) secured accessibility/device transport;

e) supplies;

f) working table;

g) weather protection;

h) auxiliary staff for measurements.

B.2.7 Measuring devices for waste gas constituents and reference quantities

Description of measuring devices for waste gas constituents and reference quantities, if necessary, separate list according to pollutants.

B.2.8 Required supplies

Data particular to the required supplies can include the following:

a) AC current/fused;

b) three phase current/fused;

c) water;

d) compressed air.

B.3 Example form of an emission measurement plan

This example is informative and lists elements which can be used when a measurement plan is prepared. Text presented in italics in the example form is for information only and should not be presented in the elaborated emission measurement plan.

Emission measurement plan

Name of the accredited testing laboratory: ....

Reference No./Report No.: .... Date:..

Plant operator: ....

Location: ....

Type of measurement: ....

Order number: ....

Order date: ....

Contents: .... Pages

.... Appendices

Objectives: ....

....

....

1 Identification of the measurement objective

1.1 Customer

1.2 Plant operator

1.3 Location

The information as to the location shall clearly indicate the position of the emission source in the case of a larger site, e.g. site C ..., Building 5.

1.4 Plant

Information with reference to Council Directive 96/61/EC, Annex 1.

1.5 Planned time of measurement (date)

1.5.1 Date of the last measurement

1.5.2 Date of the next measurement

1.6 Reason for the measurement

See 7.1.2 of this European Standard.

1.7 Objectives

This paragraph should give a detailed description of the measurement objective. In the case of measurements for the purposes of a permit or orders, the relevant numbers of the notice/order and the specified emission limit values are to be given. In the case of measurements for the purposes of European or/and national legislation, the numbers or limit values given there are to be stated. Reference is to be made to particular circumstances relating to measurement planning e.g. batch operation, material transfer processes. Reference should also be made to prior knowledge about the plant (e.g. preliminary experiments, adjustment work, if applicable according to the operator).

1.8 Measured components

1.9 Indication of whether and with whom the measurement plan has been agreed

1.10 Names of all persons participating in sampling on-site and number of assistants

1.11 Participation of further testing laboratories

1.12 Technically responsible person (technical supervisor)

Name: ....

Telephone/fax no.: ....

E-mail: ....

2 Description of the plant, materials handled

2.1 Type of plant

Any designation deviation from the Council Directive 96/61/EC, Annex 1 for more precise description.

2.2 Description of the plant

Brief description of the plant and the process with particular emphasis on the plant components, which are of particular importance in connection with the emission of air pollutants. In complex cases, a simplified flow diagram of the plant is to be attached. The requirement for a plant description is formulated in 7.1.2 of this European Standard. The plant description shall include not only the absolute but also a specific capacity figure in terms of, for example, the raw materials and/or the products. Parameters customary for the branch of industry shall be used. The figures shall be able to be assigned, as appropriate, to the operating unit or the respective emission source. Thus, fuels or heating media used for specific plant components or operating units are to be indicated, since in connection with No. 2.4 it can here be possible to draw conclusions as to the emission characteristics, e.g. fuel ratios in the case of mixed firing.

2.3 Location of the plant and description of the emission source

2.3.1 Location

2.3.2 Emission source

2.3.2.1 Height above ground

2.3.2.2 Cross-sectional area of outlet

2.3.2.3 Easting/northing value

2.3.2.4 Building design

2.3.2.5 Assignment specific to national or local code

Operating Company No.: ....

Plant No.: ....

For any further dealings, a precise description of the location is necessary. In this context, a statement regarding the way to draw off the waste gas and the figures for the easting and northing values for each source are likewise required.

2.4 Statement of raw materials possible according to the permit

To ensure that the requirement for an operating state with maximum emissions or other relevant state to be measured is met in respect of emission-relevant raw materials during the measurement, appropriate information has to be given.

2.5 Operating times

Statement of the daily and weekly total operating times and also times of possible pollutant emissions are necessary for the determination of the total emission over greater periods of time.

2.5.1 Total operating time

2.5.2 Emission time according to information of the plant operator

2.6 Device for collection and abating the emissions

A description of these devices should make possible an assessment of the waste gas cleaning equipment and give an indication as to whether appreciable diffuse emissions of air pollutants can occur from the plant in question. See B.2.4 of this European Standard.

2.6.1 Device for collection the emissions

2.6.1.1 Apparatus for emission collection

2.6.1.2 Collection element

2.6.1.3 Fan data

2.6.1.4 Suction area

2.6.2 Device for abating the emissions

Description in accordance with B.2.4 of this European Standard.

3 Description of the measurement site

3.1 Position of the measurement plane

The exact position of the measurement plane in the waste gas pipe system is to be indicated. The position of the measurement plane shall be indicated in such a way that it can be unambiguously seen from the description whether the installation of the measurement site has been carried out in accordance with 6.2.1 of this European Standard. If the measurement site does not correspond to the requirements of this European Standard, appropriate modifications shall be given and the measures which have been taken in order to obtain acceptable measurement results shall be described.

3.2 Diameter of the waste gas duct at the measurement plane or indication of the dimensions of the measurement plane

3.3 Number of measurement lines and position of the measurement points in the measurement plane

For emission sampling, the number and position of measurement points shall be specified in accordance with Clause 7 of this European Standard.

3.4 Measurement ports

The exact position of the measurement ports, also the additional ports e.g. temperature, water vapour on the waste gas duct shall be indicated and described. It can be necessary to provide a sketch. See also 6.2.2 of this European Standard.

3.5 Working platforms

The position of the working platform, the space requirement, the supply and also safety and environmental conditions shall be indicated and described. See also 6.2.3 of this European Standard.

4 Measurement and analytic methods, devices

The measurement devices and methods used shall be indicated and described. If devices and methods other than those examples listed here are used, a procedure analogous to that prescribed is to be followed.

4.1 Determination of the waste gas boundary conditions

4.1.1 Flow velocity

Pitot tube in combination with

– micromanometer, model/type: ....

– electronic micromanometer, model/type: ....

Other fine differential pressure gauge, model/type: ....

Vane anemometer, model/type: ....

Thermal anemometer, model/type:...

Determination by calculation *(e.g. from amount of fuel, air ratio, displacement volumes)*: ....

Determination by operating data *(e.g. fan rating)*: ....

4.1.2 Static pressure in waste gas duct

U-tube manometer: ....

Manometer as specified in No. 4.1.1 with provision for the appropriate connections: ....

4.1.3 Air pressure at the measurement site

Barometer, model/type: ....

Last check/calibration: ....

4.1.4 Waste gas temperature

Resistance thermometer, model/type: ....

Ni-Cr-Ni thermocouple, model/type: ....

Hg thermometer: ....

Other temperature measuring instruments, model/type: ....

It should be indicated whether the temperature measurement was determined continuously at a measurement point recognised as representative in the measurement plane during the entire sampling of the plant and recorded by a recording device, logged by means of a data logging unit and converted into half-hour means.

4.1.5 Proportion of water vapour in the waste gas

Adsorption on silica gel/calcium chloride/other and subsequent gravimetric determination: ....

Water vapour meter for gases, model/type: ....

Psychrometer, model/type: ....

Detector tubes: ....

4.1.6 Waste gas density

Calculated waste gas density taking into account the proportions of

- *oxygen (O_2),*
- *carbon dioxide (CO_2),*
- *atmospheric nitrogen (containing 0,933% of Ar),*
- *carbon monoxide (CO),*
- *other waste gas components such as ...,*
- *waste gas water vapour content and*
- *waste gas temperature and pressure in the duct.*

4.1.7 Waste gas dilution

E.g. for cooling purposes.

4.2 Gaseous and vapour emissions

4.2.1 Automated measurement methods

4.2.1.1 Measured component

4.2.1.2 Measurement method

EN, ISO or national standard: ....

Principle of the method: ....

4.2.1.3 Analyser (model/type)

4.2.1.4 Measuring range set

4.2.1.5 Performance characteristics in case of instruments without suitability-test

If instruments whose suitability for the measurement objective has been tested are available, these shall be used. In the case of measuring devices whose suitability has not been tested, the following performance characteristics are to be indicated. How these data are determined is also to be indicated.

Influence of accompanying substances (cross-sensitivity): ....

Response time (90 % time): ....

Detection limit: ....

Zero drift: ....

Standard deviation, if applicable: ....

Linearity: ....

4.2.1.6 Sampling equipment

Sampling probe:	heated: .... °C	unheated:
Dust filter:	heated: .... °C	unheated:
Sampling line before gas treatment:	heated: .... °C	unheated:
	Length: .... m	
Sampling line after gas treatment:		
	Length: .... m	

Materials of construction of gas-carrying parts: ....

Sample gas treatment: ....

Sample gas cooler, model/type: ....

Temperature, regulated to: .... °C

Desiccant (e.g. silica gel): ....

4.2.1.7 Checking of the instrument characteristic using test gases

Zero gas: ....

Test gas: .... mg/m^3

Manufacturer: ....

Date of manufacture: ....

Stability guarantee: .... months

Certified: yes/no

Checking of the certificate by................ on ....

4.2.1.8 90 % response time of the complete measuring system

How this value was determined is also to be described.

4.2.1.9 Recording of the measured values

Continuous by means of a pen recorder:

Line thickness:....................................

Quality class: ....Model/type: ....

By means of a data logging unit:

(Computer), model/type: ....

Logging software: ....

4.2.2 Manual measurement methods

4.2.2.1 Measured component

4.2.2.2 Measurement method

EN, ISO or national standard: ....

Principle of the method: ....

4.2.2.3 Sampling equipment

Sampling probe:

Material: ....

heated/unheated/cooled

Particle filter:

Type: ....

Material: ....

heated: ....°C unheated:

Absorption/Adsorption devices: ....

Standard impinger, wash bottles with frits, silica gel tubes, activated carbon tubes etc.

Sorbent: ....

Amount of sorbent: ....

If appropriate, sketch of the sampling train: ....

Distance between intake orifice of the sampling probe and the sorbent or collection element: ....

Sample transfer: ....

Time between sampling and analysis: ....

Participation of another testing laboratory: ....

Name, reasons, further details.

4.2.2.4 Analytical determination

Comprehensible description of the analytical method: ....

Sample preparation: ....

Analytical instruments:.. Model/type: ....

Specific information: ....

GC columns, temperature/time programs

Standards (recovery rates): ....

Combustion temperature: ....

Combustion time/temperature-time program: ....

Percentage distribution of loading:

in tube 1: ....

in tube 2: ....

4.2.2.5 Performance characteristics in case of deviations from the standard

Influence of accompanying substances (cross-sensitivity): ....

Detection limit: ....

Measurement uncertainty: ....

4.2.2.6 Measures for quality assurance

All quality assurance measures taken shall be described, e.g.

- *leak check of the sampling train,*
- *blank values,*
- *sampling conditions,*
- *uncertainty of the gas volume sampled, and*
- *uncertainty of pressure and temperature.*

4.3 Particulate emissions

4.3.1 Measurement method

EN, ISO or national standard: ....

Principle of the method: ....

4.3.2 Sampling apparatus

Flat filter: ....

Filter head with quartz wool sheath: ....

Combination of flat filter/filter head: ....

Other adsorption devices: ....

Design/material: ....

heated/unheated; internal in duct; external on duct

Sampling probe:

Material: ....

heated/unheated

If appropriate, sketch of the structure of the sampling device: ....

Information on the collection medium:

Material: ....

Sheet diameter and pore diameter: ....

Manufacturer/type: ....

4.3.3 Work-up and evaluation of the collection medium

Drying temperature of the collection medium before and after exposure: .... °C

Drying time of the collection medium before and after exposure:.............................. h

Air-conditioned weighing room: yes/no

Balance:

Manufacturer: ....

Type: ....

4.3.4 Performance characteristics in case of deviations from the standard

Detection limit: ....

Measurement uncertainty: ....

4.3.5 Measures for quality assurance

All quality assurance measures taken shall be described. See No. 4.2.2.6 of this standard form.

4.4 Odour emissions

4.4.1 Measurement method

EN, ISO or national standard: ....

Principle of the method: ....

4.4.2 Sampling device

Structure, materials, boundary conditions of sampling in accordance with the standard.

4.4.3 Olfactometer

4.4.4 Description of the test team

4.4.5 Evaluation of the samples

On site/in the laboratory after ...... h

4.4.6 Number of measurement series

4.4.7 Working times

4.4.8 Rest times for the test team

4.5 Toxic dust constituents

Particulate materials and materials which pass through a filter.

4.5.1 Measured component

Metals, metalloids and their compounds: ....

4.5.2 Measurement method

EN, ISO or national standard: ....

Principle of the method: ....

4.5.3 Sampling equipment

4.5.3.1 Retention system for particulate materials

Information according to No. 4.3.2 of this standard report.

4.5.3.2 Absorption system for materials which pass through a filter

Information according to No. 4.2.2.3 of this standard report.

Sketch of the overall structure of the sampling device: ....

4.5.4 Work-up and evaluation of the measuring filter and the absorption material

4.5.4.1 Measuring filter

Determination of the mass of dust *(see No. 4.3.3 of this standard report)*: ....

Description of the digestion method and analytical methods/standard: ....

Analytical instruments:...

Manufacturer/type: ....

4.5.4.2 Absorption solutions

Digestion process and analytical methods/standard: ....

Analytical instruments:...

Manufacturer/type: ....

4.5.4.3 Calibration methods

Addition methods: ....

Standard calibration methods: ....

Details of the standard solutions used: ....

4.5.5 Performance characteristics in case of deviations from the standard

Cross-sensitivities: ....

Standard deviation: ....

Detection limit: ....

Reproducibility: ....

Performance characteristics for the dust content determination: ....

Performance characteristics for the determination of the sum of particulate matter and matter which pass through a filter: ....

How these data were determined is also to be stated.

4.5.6 Measures for quality assurance:

All quality assurance measures taken shall be described. See No. 4.2.2.6 of this standard report.

4.6 Emission of high toxic organic compounds

4.6.1 Measured component

PCDD/F, PCB

4.6.2 Measurement methods

EN, ISO or national standard: ....

Principle of the method: ....

If appropriate, sketch of the structure of the sampling device: ....

4.6.3 Sampling equipment

Sampling probe: ....

Material: ....

heated/unheated/cooled

Length: .... m

Material (nozzle and elbow joint): ....

Insert: ....

Cooled condensation vessel: ....

Adsorption devices (adsorbent-filter module/standard impinger): ....

Material: ....

Sorbent: ....

Amount of sorbent: ....

Particle filter: ....

Manufacturer/type/material: ....

Standards of sampling: ....

Distance between intake orifice of the sampling probe and the sorbent or collection element: ....

Sample transfer: ....

Time between sampling and analysis: ....

Participation of another testing laboratory: ....

Name, reasons, further details.

4.6.4 Analytical determination

Comprehensible description of the analytical method: ....

Sample preparation: ....

Analytical instruments (GC): ....

Model/type: ....

Specific information: ....

GC columns, length of column, temperature/time programs

Analytical instruments (MS): ....

Model/type: ....

Standards (recovery rates): ....

4.6.5 Performance characteristics in case of deviations from the standard

Detection limit: ....

Measurement uncertainty: ....

4.6.6 Measures for quality assurance:

All quality assurance measures taken shall be described. See No. 4.2.2.6 of this standard report.

5 Planned operating condition of the plant during the measurements

Information on how the individual data have been obtained shall be given; e.g. operator information or own investigations.

....

Signature Technical supervisor Date

Appendix 1

Catalog of operating data of the waste gas cleaning units:

– Filters

  Dedusting cycle, pressure drop, last filter change

– Electrostatic precipitators

  Power drawn by the fields/units, knocking cycle, last service

– Mechanical precipitators

  Last cleaning, last service

– Thermal combustion

  Fuel usage, combustion temperature, last service

– Catalytic combustion

  Energy usage, operating temperature, catalyst operating time, last service

– Adsorbers

  Adsorbent, operating time, operating temperature, last service

– Absorbers (chemisorption)

  Sorbent, type/model, circulated amount, freshly added amount, pressure drop, last service, last sorbent change

– Wet precipitators

  Absorbent, additives, pH, pressure drop, operating temperature, scrubbing liquid circulation/feed, last replacement of *the absorbate (depending on the number of scrubbing stages, several data possible)*

– Biofilters

Last change of the filter bed, bed thickness, pressure drop, raw gas water vapour content, raw gas temperature

Annex C
(informative)

Conversion to reference quantities

C.1 Conversion of volume fraction to mass concentration

A volume fraction f (e. g. in 10^{-6}) is converted to a mass concentration c (e.g. in mg/m^3) by Equation (C.1):

$$c = f\ \frac{M_{mol}}{V_{mol}} \tag{C.1}$$

where

M_{mol} is the molar mass (e.g. in kg/mol);

V_{mol} is the molar volume (e.g. in m^3/mol).

Mass concentrations are usually reported at standard conditions for temperature and pressure (273,15 K and 101,325 kPa). Under these conditions the molar volume is equal to 22,41 m^3/kmol = 22,41 l/mol for all gases.

Abbreviated terms such as "ppm" and "ppb" shall not be used in European Standards. They are language dependent, ambiguous and not needed since they only stand for numbers, e.g. a volume fraction of 4,2 cm^3/m^3 or 4,2 x 10^{-6}.

C.2 Conversion of volume to standard conditions

The conversion factor F_T for the conversion of volume measured at temperature T_m to standard conditions of temperature is given by Equation (C.2):

$$F_T = \frac{T_{ref}}{T_m} \tag{C.2}$$

where

T_{ref} is the (absolute) standard temperature;

T_m is the (absolute) measured temperature of the gas sampled.

The conversion factor F_p for the conversion of volume measured at pressure p_m to standard conditions of pressure is given by Equation (C.3):

$$F_p = \frac{p_m}{p_{ref}} \tag{C.3}$$

where

p_{ref} is the standard pressure;

p_m is the measured pressure of the gas sampled.

The conversion factor F_h for the conversion of volume measured at water vapour content h_m to standard conditions of water vapour content is given by Equation (C.4):

$$F_h = \frac{100\,\% - h_m}{100\,\% - h_{ref}} \tag{C.4}$$

where

h_{ref} is the standard water vapour content (volume fraction, h_{ref} = 0 % at dry conditions);

h_m is the measured sample water vapour content (volume fraction) of the gas sampled.

The conversion factor F_o for the conversion of volume measured at oxygen content o_m to standard conditions of oxygen content is given by Equation (C.5):

$$F_o = \frac{21\% - o_m}{21\% - o_{ref}} \tag{C.5}$$

where

o_{ref} is the standard oxygen content (volume fraction);

o_m is the measured oxygen content (volume fraction) of the gas sampled.

C.3 Conversion of mass concentration with reference quantities

A mass concentration c measured at a temperature T_m is converted to the concentration $c(T_{ref})$ at standard temperature T_{ref} by Equation (C.6):

$$c(T_{ref}) = c\,\frac{1}{F_T} = c\,\frac{T_m}{T_{ref}} \tag{C.6}$$

A mass concentration c measured at a pressure p_m is converted to the concentration $c(p_{ref})$ at the reference pressure p_{ref} by Equation (C.7):

$$c(p_{ref}) = c\,\frac{1}{F_p} = c\,\frac{p_{ref}}{p_m} \tag{C.7}$$

For mass concentration measurements, the temperature T_m and the pressure p_m is determined at the point where the sample volume is measured.

A mass concentration c measured at a water vapour content h_m is converted to the concentration $c(h_{ref})$ at dry conditions by Equation (C.8):

$$c(h_{ref} = 0) = c\,\frac{1}{F_h} = c\,\frac{100\,\%}{100\,\% - h_m} \tag{C.8}$$

A mass concentration c measured at a oxygen volume fraction o_m is converted to the concentration $c(o_{ref})$ at the standard oxygen volume fraction o_{ref} by Equation (C.9):

$$c(o_{ref}) = c\,\frac{1}{F_o} = c\,\frac{21\% - o_{ref}}{21\% - o_m} \tag{C.9}$$

These equations can be combined to obtain the mass concentration c_{ref} under standard conditions according to Equation (C.10):

$$\begin{aligned} c_{\mathrm{ref}} &= c\,\frac{1}{F_T \times F_p \times F_h \times F_o} \\ &= c\,\frac{T_{\mathrm{m}}}{T_{\mathrm{ref}}} \times \frac{p_{\mathrm{ref}}}{p_{\mathrm{m}}} \times \frac{100\,\% - h_{\mathrm{ref}}}{100\,\% - h_{\mathrm{m}}} \times \frac{21\% - o_{\mathrm{ref}}}{21\% - o_{\mathrm{m}}} \end{aligned} \qquad \text{(C.10)}$$

NOTE 1 To convert to a dry basis, the standard water vapour content h_{ref} is set to zero.

NOTE 2 Only mass concentrations c (e.g. in mg/m^3) are affected by temperature and pressure. Volume fractions (e.g. in cm^3/m^3) are unaffected by temperature and pressure. Mass emissions results are also unaffected by temperature, pressure, oxygen or moisture levels and should not be corrected

C.4 Conversion of waste gas volume to standard conditions

The waste gas volume V_{ref} under standard conditions is calculated from the waste gas volume V_{m} under measuring conditions by Equation (C.11):

$$\begin{aligned} V_{\mathrm{ref}} &= V_{\mathrm{m}} \times F_T \times F_p \times F_h \times F_o \\ &= V_{\mathrm{m}} \times \frac{T_{\mathrm{ref}}}{T_{\mathrm{m}}} \times \frac{p_{\mathrm{m}}}{p_{\mathrm{ref}}} \times \frac{100\,\% - h_{\mathrm{m}}}{100\,\% - h_{\mathrm{ref}}} \times \frac{21\% - o_{\mathrm{m}}}{21\% - o_{\mathrm{ref}}} \end{aligned} \qquad \text{(C.11)}$$

Annex D
(normative)

Sampling strategy

D.1 Methods for determining the positions of sampling points in circular and rectangular ducts

D.1.1 Method for circular ducts

D.1.1.1 General

There are two methods for determining the position of sampling points in circular ducts as described in D.1.2 and D.1.3. Both methods are considered equivalent.

D.1.1.2 General method for circular ducts

In the *general method* applicable to circular ducts, the sampling plane is divided into equal areas. The sampling points, one at the centre of each area, are located on two or more diameters (sampling lines), and one point at the centre of the duct (see Figure D.1).

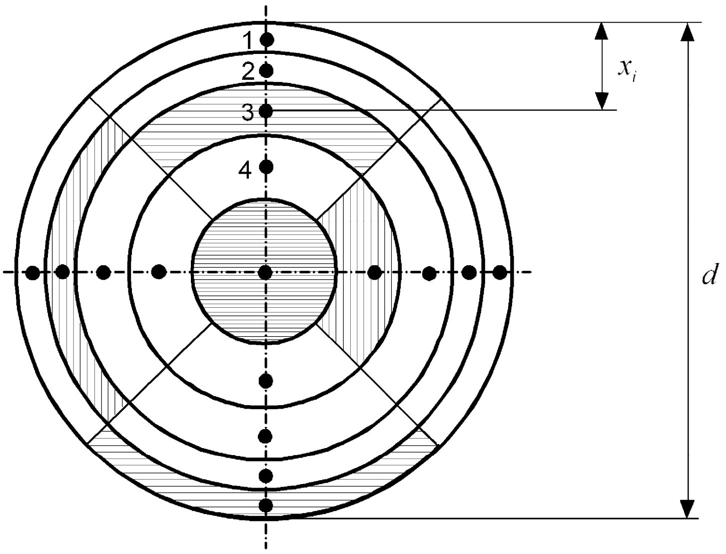


Figure D.1 — Sampling point positions in circular ducts - General method (showing positions for ducts over 2 m in diameter – The shaded positions are of equal area)

The locations of the sampling points are dependant on the number of sample points chosen.

For circular ducts two sampling lines (diameters) are sufficient, the distance x_i of each sampling point from the duct wall can be expressed as:

$$x_i = K_i d \quad \text{(D.1)}$$

where

K_i is the value, as a percentage, in accordance with Table D.1;

d is the diameter of the duct.

Table D.1 gives values of K_i as a percentage, where n_d is the number of sampling points per sampling line (diameter) and i is the number of individual sampling points along the diameter.

Table D.1 — Values of K_i as a percentage - General method for circular ducts

i	K_i			
	n_d = 3	n_d = 5	n_d = 7	n_d = 9
1	11,3	5,9	4,0	3,0
2	50,0	21,1	13,3	9,8
3	88,7	50,0	26,0	17,8
4		78,9	50,0	29,0
5		94,1	74,0	50,0
6			86,7	71,0
7			96,0	82,2
8				90,2
9				97,0

For circular ducts where it is necessary to increase the number of sampling lines (diameters) or the number of sampling points (because of adverse flow conditions for instance), the general Equations (D.2) to (D.4) for calculating the distance, from the duct wall along the diameter, are:

$$x_i = \frac{d}{2}\left[1 - \sqrt{\frac{n(n_d - 2i) + 1}{n(n_d - 1) + 1}}\right] \quad \text{for } i < \frac{n_d + 1}{2} \quad \text{(D.2)}$$

$$x_i = \frac{d}{2} \quad \text{for } i = \frac{n_d + 1}{2} \quad \text{(D.3)}$$

$$x_i = \frac{d}{2}\left[1 + \sqrt{\frac{n(2i - 2 - n_d) + 1}{n(n_d - 1) + 1}}\right] \quad \text{for } i > \frac{n_d + 1}{2} \quad \text{(D.4)}$$

where

i is the index of sampling point along the diameter;

n_d is the number of sampling points along each sampling line (including the centre);

n is either number of lines or diameters of sampling;

x_i is the distance of point i from the duct wall;

d is the diameter of the duct.

D.1.1.3 Tangential method for circular ducts

In the *tangential method* applicable to circular ducts, the sampling plane is divided into equal areas. The sampling points, one at the centre of each area, are located on two or more diameters (sampling lines), there being no sampling point at the centre of the duct (see Figure D.2).

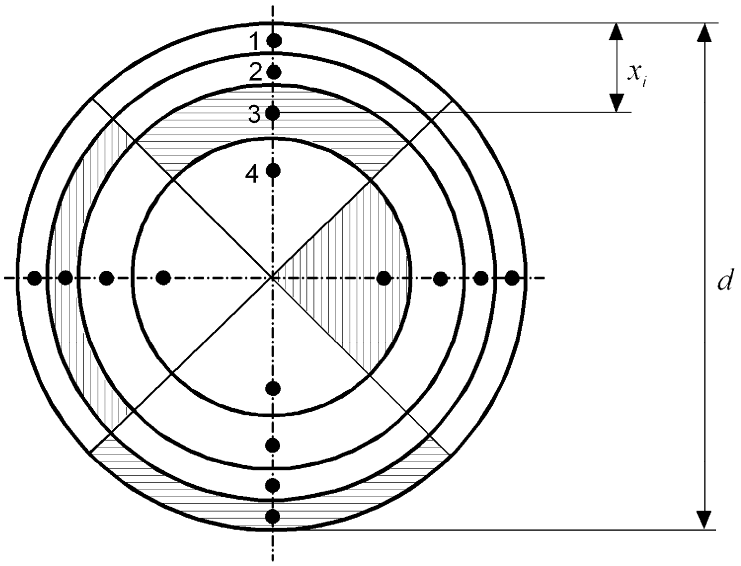


Figure D.2 — Sampling point positions in circular ducts – Tangential method (showing positions for ducts over 2 m diameter)

The locations of the sampling points on each diameter are dependent on the number of sampling points on each diameter but are independent of the number of sampling diameters.

For circular ducts where two sampling lines (diameters) are sufficient, the distance x_i of each sampling point from the duct wall can conveniently be expressed according to Equation (D.5) as:

$$x_i = K_i d \qquad \text{(D.5)}$$

where

K_i is the value, as a percentage, accordingly to Table D.2;

d is the diameter of the duct.

Table D.2 gives values of K_i as a percentage, where n_d is the number of sampling points per sampling line (diameter), and i is the number of individual sampling points along the diameter.

Table D.2 — Values of K_i as a percentage - Tangential method for circular ducts

i	K_i			
	n_d = 2	n_d = 4	n_d = 6	n_d = 8
1	14,6	6,7	4,4	3,3
2	85,4	25,0	14,6	10,5
3		75,0	29,6	19,4
4		93,3	70,4	32,3
5			85,4	67,7
6			95,6	80,6
7				89,5
8				96,7

For circular ducts where it is necessary to increase the number of sampling lines (diameters) or the number of sampling points, the tangential Equations (D.6) and (D.7) for calculating the distance, from the duct wall along the diameter, are:

$$x_i = \frac{d}{2}\left[1 - \sqrt{1 - \frac{2i-1}{n}}\right] \quad \text{for } i \le \frac{n_d}{2} \qquad \text{(D.6)}$$

$$x_i = \frac{d}{2}\left[1 + \sqrt{\frac{2i-1}{n} - 1}\right] \quad \text{for } i > \frac{n_d}{2} \qquad \text{(D.7)}$$

where the symbols have the same meaning as in Equations D.2 to D.4, but n_d does not include the centre.

This method is particularly useful for large ducts where it would be difficult to reach the centre of the duct.

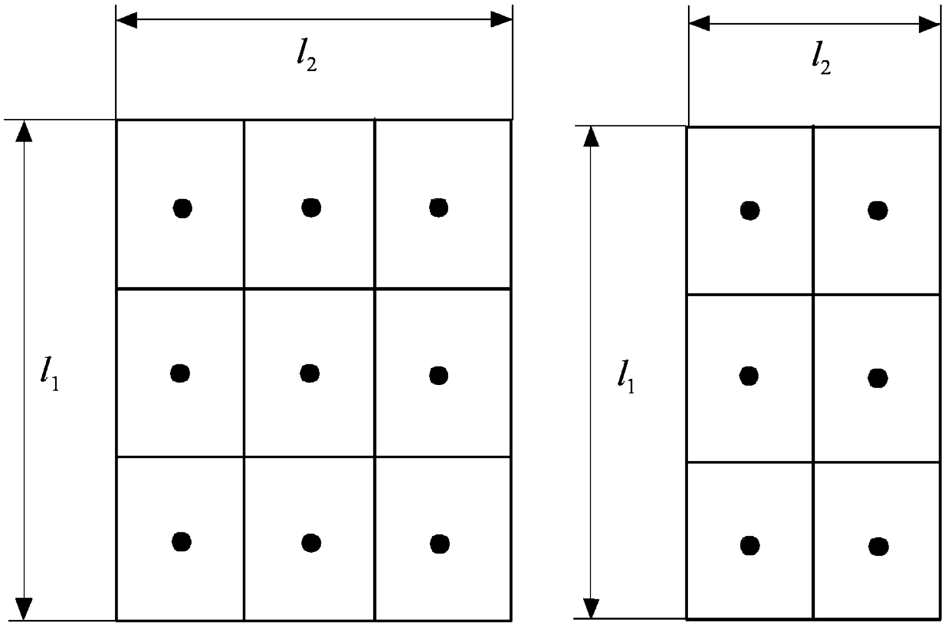
D.1.2 Method for rectangular ducts

In the method applicable to rectangular ducts, the sampling plane is divided into equal areas by lines parallel to the sides of the duct, and a sampling point is located at the centre of each area (see Figure D.3).

In general, both sides of the rectangular duct are divided into an equal number of parts, giving areas which have the same shape as the duct. The number of partial areas is thus the square of 1, 2, 3 etc. (see Figure D.3 a).

L_1 and L_2 being the dimensions of a section, where L_1/L_2 is greater than 2, side L_1 shall be divided by a higher number than L_2 so that for each of the partial sections, the ratio l_1/l_2 (partial section) is less than 2.

If the lengths of the sides of the duct l_1 and l_2 are divided into n_1 and n_2 parts respectively, the number of sampling points is n_1 times n_2 and the smallest distance from a wall of the duct is $l_1/2n_1$ and $l_2/2n_2$.



a) $\frac{l_1}{l_2} \leq 2$ b) $\frac{l_1}{l_2} > 2$

Figure D.3 — Illustrations of sampling point positions in rectangular ducts

Annex E
(informative)

Examples for determining homogeneity of waste gas profiles

E.1 Determination of the homogeneity

Table E.1 — Example 1 (NO_x)

Axis - depth	c_{grid} mg/m³	c_{ref} mg/m³	c_{grid} / c_{ref} %
Axis 1 - 0,16 m	523	492	106,3
0,47 m	554	501	110,6
0,78 m	567	499	113,6
1,09 m	539	504	106,9
Axis 2 - 0,16 m	496	493	100,6
0,47 m	497	489	101,6
0,78 m	505	486	103,9
1,09 m	480	463	103,7
Axis 3 - 0,16 m	510	468	109,0
0,47 m	523	474	110,3
0,78 m	553	472	117,2
1,09 m	544	474	114,8
Axis 4 - 0,16 m	460	467	98,5
0,47 m	445	447	99,6
0,78 m	466	455	102,4
1,09 m	447	445	100,4
Mean value	506,8	476,8	106,2
Standard deviation	s_{grid}	s_{ref}	
	39,3	18,8	
Number of measurements	16		
Degrees of freedom	15		
Homogeneity test:			
Test value $(s_{grid}/s_{ref})^2$	4,35		
$F_{95\%}$	2,40		
Waste gas	inhomogeneous		
Standard deviation of time s_{ref}	18,8 mg/m³		
Standard deviation of position s_{pos}	34,5 mg/m³		
Permissible expanded uncertainty U_{perm}	100 mg/m³		
$t_{N-1; 0,95}$	2,131		
U_{pos}	73,5 mg/m³		
$U_{pos} \leq 0,5\ U_{perm}$	no		
Required measurement type	grid		
Representative measurement point	–		
c_{grid} / c_{ref} at representative measurement point	–		

Table E.2 — Example 2 (NO_x)

Axis - depth	c_{grid} mg/m³	c_{ef} mg/m³	c_{grid} / c_{ref} %
Axis 1 - 0,16 m	412	393	104,8
0,47 m	418	390	107,2
0,78 m	417	389	107,2
1,09 m	423	393	107,6
Axis 2 - 0,16 m	363	394	92,1
0,47 m	397	391	101,5
0,78 m	404	388	104,1
1,09 m	384	370	103,8
Axis 3 - 0,16 m	357	374	95,5
0,47 m	373	379	98,4
0,78 m	393	377	104,2
1,09 m	396	379	104,5
Axis 4 - 0,16 m	368	373	98,7
0,47 m	366	367	99,7
0,78 m	377	364	103,6
1,09 m	377	363	103,9
Mean value	389,1	380,3	102,3
Standard deviation	s_{grid}	s_{ref}	
	21,5	11,0	
Number of measurements	16		
Degrees of freedom	15		
Homogeneity test:			
Test value $(s_{grid}/s_{ref})^2$	3,82		
$F_{95\%}$	2,40		
Waste gas	inhomogeneous		
Standard deviation of time s_{ref}	11,0 mg/m³		
Standard deviation of position s_{pos}	18,4 mg/m³		
Permissible expanded uncertainty U_{perm}	100 mg/m³		
$t_{N-1;\,0,95}$	2,131		
U_{pos}	39,2 mg/m³		
$U_{pos} \leq 0,5\ U_{perm}$	yes		
Required measurement type	point		
Representative measurement point	Axis 2 - 0,47 m		
c_{grid} / c_{ref} at representative measurement point	101,5 %		

Table E.3 — Example 3 (NO_x)

Axis - depth	c_{grid} mg/m³	c_{ef} mg/m³	c_{grid} / c_{ref} %
Axis 1 - 0,16 m	292	295	99,0
0,47 m	299	301	99,5
0,78 m	297	299	99,2
1,09 m	303	302	100,3
Axis 2 - 0,16 m	291	296	98,4
0,47 m	298	293	101,6
0,78 m	303	292	103,9
1,09 m	288	278	103,7
Axis 3 - 0,16 m	287	281	102,2
0,47 m	285	284	100,2
0,78 m	288	283	101,7
1,09 m	291	284	102,3
Axis 4 - 0,16 m	277	280	98,9
0,47 m	272	268	101,4
0,78 m	280	273	102,4
1,09 m	268	267	100,4
Mean value	288,7	286,1	100,9
Standard deviation	s_{grid}	s_{ref}	
	10,5	11,3	
Number of measurements	16		
Degrees of freedom	15		
Homogeneity test:			
Test value $(s_{grid}/s_{ref})^2$	0,86		
$F_{95\%}$	–		
Waste gas	homogeneous		
Standard deviation of time s_{ref}	–		
Standard deviation of position s_{pos}	–		
Permissible expanded uncertainty U_{perm}	100 mg/m³		
$t_{N-1;\,0,95}$	–		
U_{pos}	–		
$U_{pos} \leq 0,5\ U_{perm}$	–		
Required measurement type	any point		
Representative measurement point	–		
c_{grid} / c_{ref} at representative measurement point	–		

The permissible expanded uncertainty U_{perm} used in Tables E.1 to E.3 is calculated on the basis of a limit value for NO_x of E = 500 mg/m^3 set for the process investigated in this example. Directive 2001/80/EC [7] specifies a permissible relative expanded uncertainty for continuous NO_x measurements of P = 20 % at the daily emission limit value and for standard conditions. Therefore, the permissible expanded uncertainty is given by $U_{perm} = P \times E$ = 0,20 × 500 mg/m^3 = 100 mg/m^3 at standard conditions. The measured NO_x concentrations shown in Tables E.1 to E.3 have been determined at standard conditions.

E.2 Permanently installed AMS

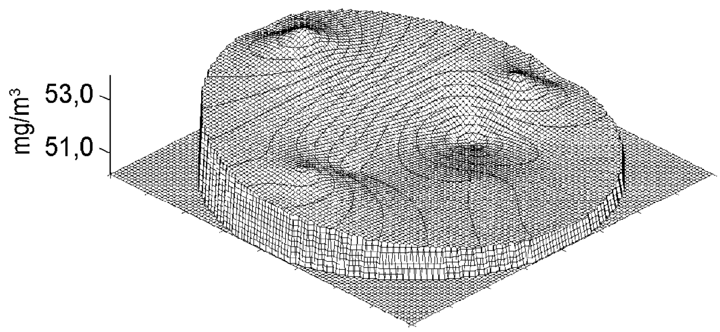
Table E.4 — Example of finding the best available sampling point for permanently installed AMS

	NO_x		Oxygen content		Temperature		Velocity			Info profile 1
Axis - depth	c_{grid} mg/m³	c_{ref} mg/m³	o_{grid} %	o_{ref} %	T_{grid} °C	T_{ref} °C	v_{grid} m/s	v_{ref} m/s	F_{rep} %	abs(deviation)
Axis 1 - 0,16 m	516	492	7,8	8,6	362	346	27,2	20,3	126,2	0,12
0,47 m	542	501	7,6	8,7	373	346	28,9	20,5	129,9	0,16
0,78 m	540	499	7,9	8,8	380	346	29,3	19,9	135,1	0,21
1,09 m	554	504	7,9	8,8	376	346	30,3	23,1	123,6	0,10
Axis 2 - 0,16 m	429	493	10,5	8,9	343	346	16,9	19,6	87,2	0,26
0,47 m	497	489	8,6	8,8	355	344	29,0	19,5	144,1	0,30
0,78 m	505	486	8,3	8,8	373	344	30,3	20,5	136,1	0,22
1,09 m	480	463	8,3	8,7	364	344	27,1	20,5	125,4	0,12
Axis 3 - 0,16 m	440	468	9,4	8,7	332	342	5,7	20,3	28,8	0,85
0,47 m	467	474	9,2	8,9	339	343	21,5	23,0	95,6	0,18
0,78 m	492	472	8,6	8,8	364	342	31,2	21,0	143,2	0,29
1,09 m	496	474	8,7	8,9	361	342	29,7	21,2	136,6	0,23
Axis 4 - 0,16 m	460	467	9,4	8,9	333	341	7,1	21,7	34,4	0,79
0,47 m	445	447	9,1	8,8	335	341	20,0	21,0	98,9	0,15
0,78 m	466	455	9,0	8,8	347	341	28,3	20,6	140,6	0,27
1,09 m	447	445	9,0	8,8	341	341	27,2	20,8	133,5	0,20
Mean value	486,0	476,8	8,7	8,8	354,9	343,4	24,4	20,8	113,7	0,10

Best available sampling point	Axis 1 - 1,09 m
F_{rep} at best available sampling point	123,6 %
Ratio of measured value at best available sampling point to mean value of all grid measurements for:	
NO_x	$c_{grid} / \overline{c_{grid}}$ = 114,0 %
oxygen	$o_{grid} / \overline{o_{grid}}$ = 90,7 %
temperature	$T_{grid} / \overline{T_{grid}}$ = 106,0 %
velocity	$v_{grid} / \overline{v_{grid}}$ = 124,4 %

E.3 Examples of waste gas profiles

Figure E.1 shows examples of homogeneous waste gas profiles.



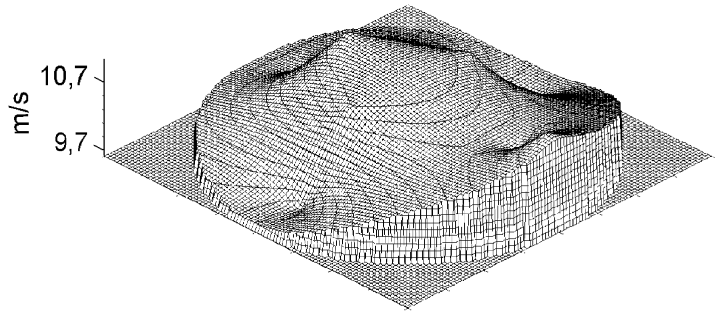
1) Mass concentration

s_{grid} = 1,01 mg/m³

s_{ref} = 0,62 mg/m³

Test value: 2,69

F-factor: 2,82



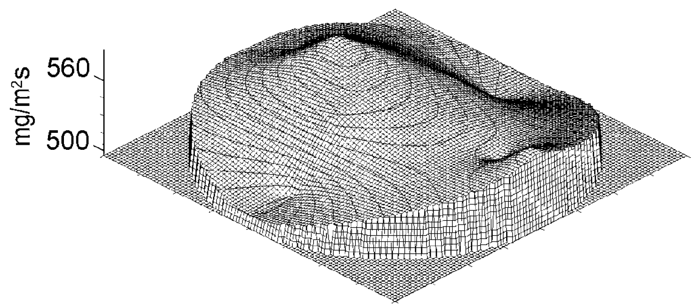
2) Velocity

s_{grid} = 10,3 m/s

s_{ref} = 11,3 m/s

Test value: 1,39

F-factor: 2,82



3) Mass flow density

s_{grid} = 532 mg/m²s

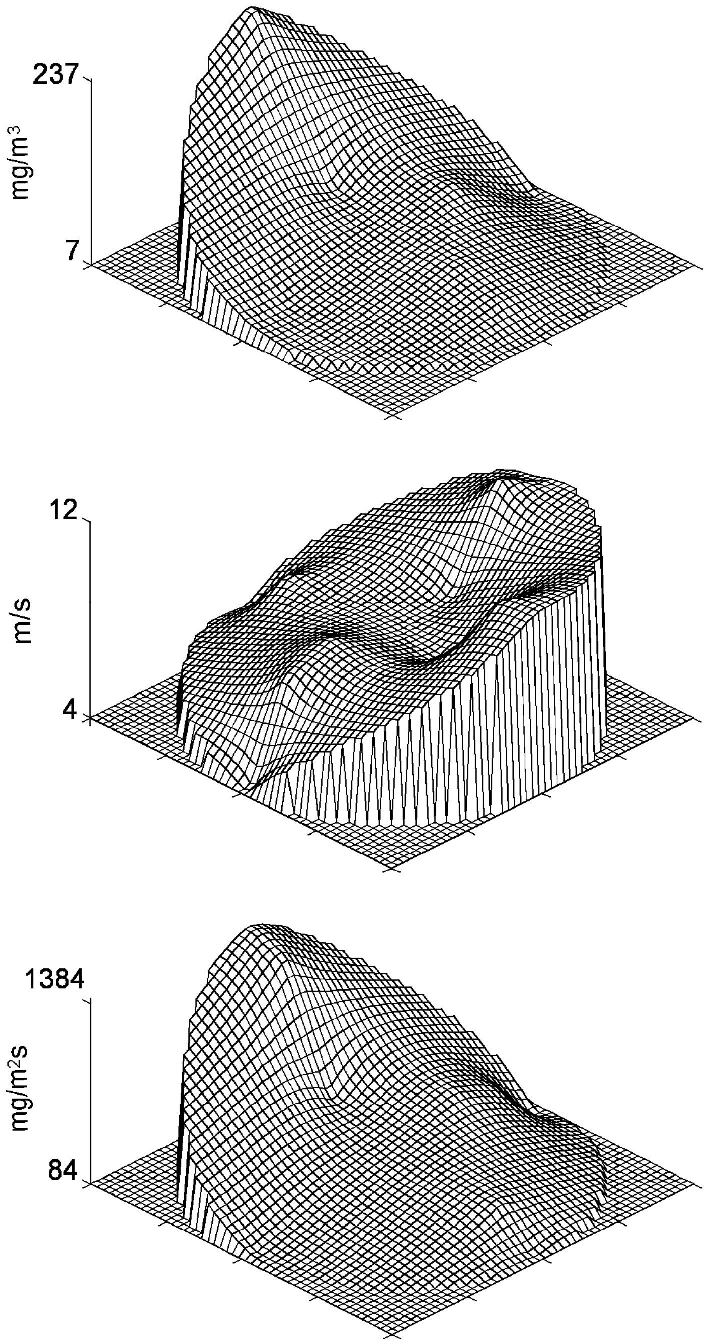
s_{ref} = 549 mg/m²s

Test value: 1,26

F-factor: 2,82

Figure E.1 — Example of a homogeneous distribution of an organic gaseous substance (propane reported as total C) in a round measurement plane

Figure E.2 shows examples of inhomogeneous waste gas profiles.



1) Mass concentration

s_{grid} = 70 mg/m³

s_{ref} = 0,87 mg/m³

Test value: 6 505

F-factor: 2,82

2) Velocity

s_{grid} = 2,3 m/s

s_{ref} = 0,27 m/s

Test value: 71,2

F-factor: 2,82

3) Mass flow density

s_{grid} = 446 mg/m²s

s_{ref} = 18,0 mg/m²s

Test value: 609,6

F-factor: 2,82

Figure E.2 — Example of an inhomogeneous distribution of an organic gaseous substance (propane reported as total C) in a round measurement plane

Annex F
(informative)

Example form of emission measurement report

This example is informative and lists elements which can be used when an emission measurement report is prepared. Text presented in italics in the example form is for information only and should not be presented in the elaborated emission measurement report.

Report on emission measurements

Name of the accredited testing laboratory: ....

Reference No./Report No.: .... Date: ....

Operating company: ....

Location: ....

Type of measurement: ....

Order number: ....

Order date: ....

Day of measurement: ....

Report contents: .... Pages

.... Appendices

Objectives: ....

....

....

Excecutive summary

Plant: ....

Operating times: ....

Emission source: ....

Measured components: ....

Measurement results: ....

Emission source No.: ....

Measured component	n	Mean value (concentration; mass flow) [mg/m^3; kg/h]	Maximum (concentration; mass flow) [mg/m^3; kg/h]	Limit value (concentration; mass flow) [mg/m^3; kg/h]	State which leads to the maximum emissions [yes/ no]

1 Description of the measurement objective

2 Description of the plant, materials handled

3 Description of the measurement site

4 Measurement and analytic methods, apparatus

It is recommended to use the completed planning forms for Clause 1 to 4 (see B.3 of this European Standard) including any deviation to the state of planning.

5 Operating condition of the plant during the measurements

Information on how the individual data have been obtained shall be given; e.g. operator information or own investigations.

5.1 Production plant

See B.2.3 of this European Standard.

Operating state *(e.g. normal operation, charging, running up, representative operating state, abnormal operating state relevant to emissions)*: ....

Throughput/output *(e.g. process data, steam)*: ....

Raw materials/fuels: ....

Products: ....

Characteristic operating parameters *(e.g. pressures, temperatures)*: ....

Deviations from approved mode of operation *(e.g. output, other raw materials, evaluation)*: ....

5.2 Waste gas cleaning units

See B.2.4 of this European Standard.

Operating data *(e.g. power drawn, p, pH, cleaning efficiency)*: ....

Operating temperatures *(e.g. thermal combustion unit, scrubber, catalyst)*: ....

Emission-influencing parameters *(e.g. cleaning cycles, pH, temperature, thermal afterburner, operating time of the catalyst)*: ....

Particular features of waste gas cleaning *(e.g. in-house construction, additional water injection)*: ....

Deviation from standard operating conditions: ....

6 Presentation of the measurement results and discussion

6.1 Evaluation of the operating conditions during the measurements

Indication of unusual occurrences.

This information serves to establish deviations from normal operation and, if applicable, to document consequent effects on the emission characteristics of the plant. In such an event, the technical expert should make a statement as to whether the state of the plant at the time of the measurement was the state which on the basis of experience leads to the maximum emissions.

6.2 Measurement results

All individual results (e.g. half-hourly mean values) of the components measured and the auxiliary parameters necessary for the determination are to be presented in tabular form. The pollutants are to be reported as mass concentrations and as mass flows. In addition, the maximum and the mean value of the measurements are to be documented. Measurement uncertainties are to be given for all measured values. If recording instruments have been employed, attachment of the recorder chart can be useful. Provisions of the guideline on which the measurement is based in respect of complete presentation of the measurement results shall be complied with.

All measurement reports shall be kept by the testing laboratory carrying out the measurements for at least 5 years.

6.3 Plausibility check

A plausibility check is to be made on the measurement results in respect of the utilization of plant capacity during the period of the measurement.

....

Signature Technical supervisor Date

Appendix

Measurement plan

Measured and calculated values (documentation of all original values)

Annex G
(informative)

Theoretical basis for the determination of the mean concentration in the measurement plane

Since mass concentration of emissions depend on the current state of plant and waste gas emission control technology, the emission limit is often formulated as a concentration value. This achievable mass concentration of emissions is, within defined limits, independent on the output or volumetric flow rate of waste gas of the plant. The mass concentration of emissions in this case is the concentration of the measured component averaged over the plane of the waste gas duct of the emission source over a defined duration. This duration is often a period of half an hour or an hour, that is to say the mass concentration of emissions is reported as a half-hourly or hourly mean value. Daily means are generally calculated on the basis of these mean values. The specifications regarding the encompassing of spatial and temporal changes in concentration in the plane of the waste gas duct shall be taken into account in emission measurements.

Concentration distributions which differ spatially can occur in the measurement plane of waste gas ducts. In addition, the concentrations can change with time. In particular, waste gas streams which are combined from different plants or sources and have different waste gas composition, temperature or density can mix inadequately and lead to the formation of non-uniform flow. If concentration and/or velocity profiles which are variable in space and time occur in waste gas ducts, the emissions, in an exact mathematical treatment, can only be determined as the integral for time and space over the measurement plane [10].

The instantaneous value c of concentration is equivalent to the ratio of mass flow rate $\dot{m}$ to volumetric flow rate $\dot{V}$ (see Equation (G.1)):

$$c = \frac{\dot{m}}{\dot{V}} \tag{G.1}$$

or, for the same time basis, the ratio of mass to volume. For the mean concentration $\bar{c}$ over time (for example half an hour) Equation (G.2) applies:

$$\bar{c} = \frac{\overline{\dot{m}}}{\overline{\dot{V}}} \tag{G.2}$$

The emission mass flow rate averaged over time $\overline{\dot{m}}$ is given by Equation (G.3):

$$\overline{\dot{m}} = \frac{\iiint \dot{m}_{\mathrm{d}}(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t}{\int \mathrm{d}t} \tag{G.3}$$

and $\dot{m}_{\mathrm{d}}(x,y,t)$ is the time-dependent mass flow density at each point or each partial area. Together with the velocity $v(x, y, t)$, which is a function of time and space, for the volumetric flow rate $\overline{\dot{V}}$ averaged over time, Equation (G.4) applies:

$$\overline{\dot{V}} = \frac{\iiint v(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t}{\int \mathrm{d}t} \tag{G.4}$$

Thus for the mean concentration $\bar{c}$ over time Equation (G.5) applies:

$$\bar{c} = \frac{\iiint \dot{m}_\mathrm{d}(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t}{\iiint v(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t} \tag{G.5}$$

The time- and space-dependent mass flow density $\dot{m}_\mathrm{d}(x,y,t)$ can also be represented as a product of the mass concentration c and the velocity v (see Equation (G.6)):

$$\dot{m}_\mathrm{d}(x,y,t) = c(x,y,t)\ v(x,y,t) \tag{G.6}$$

Thus for the mean concentration $\bar{c}$ over time Equation (G.7) applies:

$$\bar{c} = \frac{\iiint c(x,y,t)\,v(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t}{\iiint v(x,y,t)\,\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}t} \tag{G.7}$$

Therefore, determining the mean concentration in an exact approach, it is necessary to determine the concentration integrated over plane area and time in association with the velocity. However, integral determination of these quantities is generally impossible with current measuring systems.

In practice, because measurements are discrete in space and time, simplifications are necessary. If the concentration c and the velocity v are determined simultaneously at a total of n measurement points in a measurement plane in a measuring interval Δt_i ($\Delta t_i \ll t_\mathrm{s}$, t_s = sampling duration), this produces n pairs of values (c_{ij} , v_{ij}). Then the concentration c_i in the measuring interval Δt_i is given by Equation (G.8):

$$c_i = \frac{\sum_{j=1}^{n} c_{ij}\ v_{ij}}{\sum_{j=1}^{n} v_{ij}} \tag{G.8}$$

The mean concentration based on the total sampling duration of, for example, 30 min is then given as the mean of the individual concentration c_i over the total number N of the measuring intervals (see Equation (G.9)):

$$\bar{c} = \frac{1}{N}\sum_{i=1}^{N} c_i \tag{G.9}$$

If the velocities at the individual measurement points change during the measurement by the same factor (which can be the case for most measurement objectives), the mean concentration $\bar{c}$ can be determined in a simplified manner to the quotient of the sums of the means over time over all measurement points (see Equation (G.10)):

$$\bar{c} = \frac{\sum_{j=1}^{n} \bar{c}_j\ \bar{v}_j}{\sum_{j=1}^{n} \bar{v}_j} \tag{G.10}$$

This means that to calculate the mean concentration over the measurement plane and over the sampling duration, only the mean concentration and the mean velocity at each measurement point need to be determined.

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