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# Stationary source emissions — Determination of low range mass concentration of dust —

Part 1: Manual gravimetric method

The European Standard EN 13284-1:2001 has the status of a  
British Standard

ICS 13.040.40

## National foreword

This British Standard is the official English language version of EN 13284-1:2001.

The UK participation in its preparation was entrusted by Technical Committee EH/2, Air quality, to Subcommittee EH/2/1, Stationary source emissions, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

### Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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This British Standard, having been prepared under the direction of the Health and Environment Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 25 January 2002

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## Stationary source emissions - Determination of low range mass concentration of dust - Part 1: Manual gravimetric method

Emissions de sources fixes - Détermination de la faible concentration en masse de poussières - Partie 1: Méthode gravimétrique manuelle

Emissionen aus stationären Quellen - Ermittlung der Staubmassenkonzentration bei geringen Staubkonzentrationen - Teil 1: Manuelles gravimetrisches Verfahren

This European Standard was approved by CEN on 11 October 2001.

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 Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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## Foreword

This European Standard 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 May 2002, and conflicting national standards shall be withdrawn at the latest by May 2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

This European Standard consists of two parts:

- EN 13284-1, Stationary source emissions – Determination of low range mass concentration of dust – Part 1: Manual gravimetric method
- EN 13284-2, Stationary source emissions – Determination of low range mass concentration of dust – Part 2: Automated measuring systems

The annexes A, B, C, E and F are normative. The annexes D, G and H are informative.

This standard contains a Bibliography.

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

## 1 Scope

This European Standard specifies a reference method for the measurement of low dust concentration in ducted gaseous streams in the concentrations below  $50 \text{ mg/m}^3$  standard conditions. This method has been validated with special emphasis around  $5 \text{ mg/m}^3$  on an average half hour sampling time.

This European Standard is primarily developed and validated for gaseous streams emitted by waste incinerators. More generally, it may be applied to gases emitted from stationary sources, and to higher concentrations.

If the gases contain unstable, reactive or semi-volatile substances, the measurement depend on the sampling and filter treatment conditions.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO 3966:1977, Measurement of fluid flow in closed conduits – Velocity area method using Pitot static tubes.

ISO 5725-2, Accuracy (trueness and precision) of measurement methods and result – Part 2: Basis method for the determination of repeatability and reproducibility of a standard measurement method.

## 3 Terms and definitions

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

### 3.1

#### **dust**

particles, of any shape, structure or density, dispersed in the gas phase at the sampling point conditions which may be collected by filtration under specified conditions after representative sampling of the gas to be analysed, and which remain upstream of the filter and on the filter after drying under specified conditions

### 3.2

#### **filtration temperature**

temperature of the sampled gas immediately downstream of the filter

### 3.3

#### **"in-stack" filtration**

filtration in the duct with the filter in its filter holder placed immediately downstream of the sampling nozzle

### 3.4

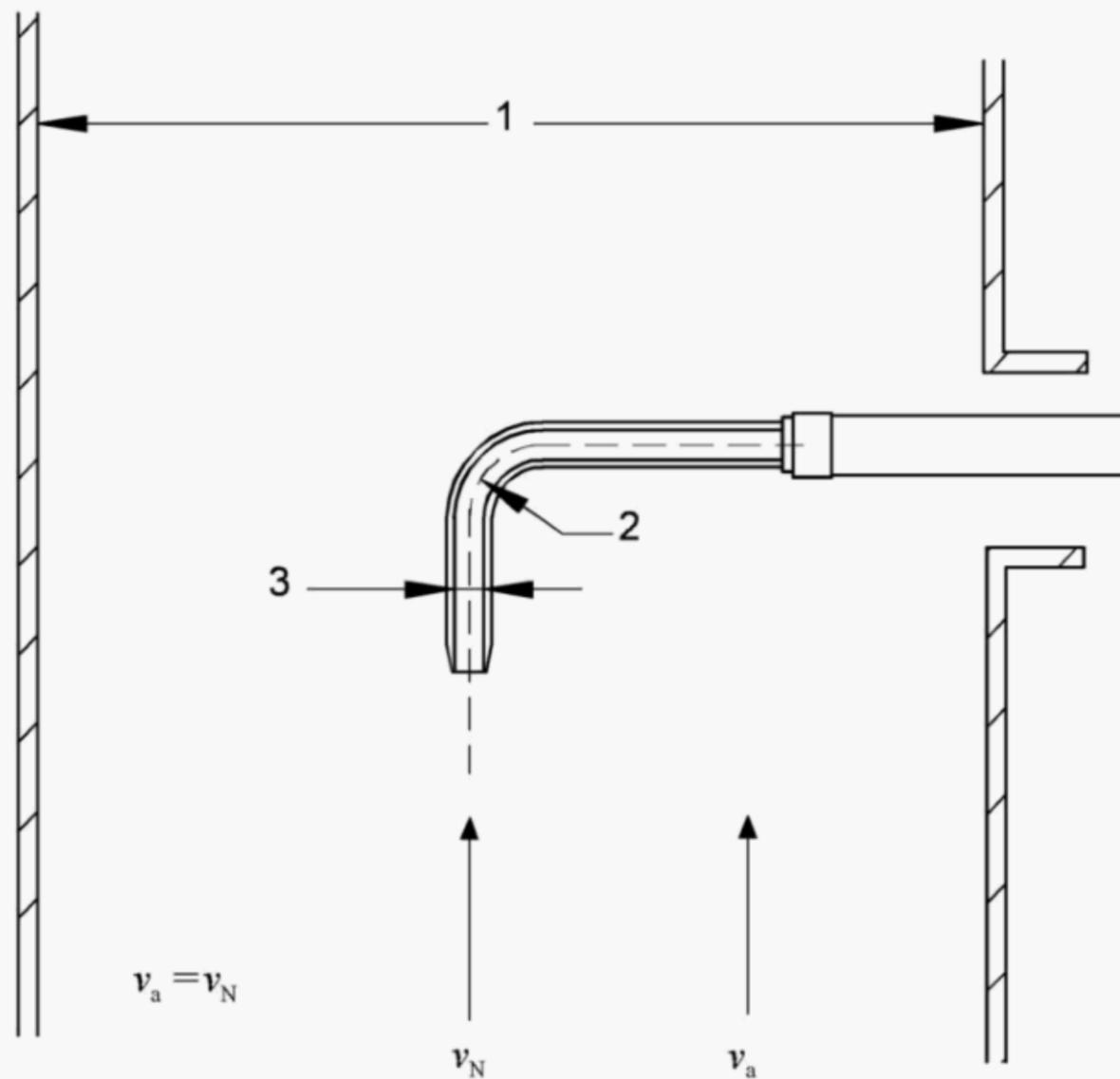
#### **"out-stack" filtration**

filtration outside of the duct with the filter in its heated filter holder placed downstream of the sampling nozzle and the suction tube (sampling probe)

### 3.5

#### **isokinetic sampling**

sampling at a flow rate such that the velocity  $v_N$  and direction of the gas entering the sampling nozzle are the same as the velocity  $v_a$  and direction of the gas in the duct at the sampling point (see Figure 1)



**Key**

- 1 Duct
- 2 Internal diameter  $i$
- 3 Radius of the bend (minimum  $1,5 i$ )

Figure 1 — Isokinetic sampling

**3.6**

**isokinetic rate**

velocity ratio  $v_N / v_a$  expressed in percentage as a characteristics of the deviation from isokinetic sampling (see 3.5)

**3.7**

**hydraulic diameter**

characteristic dimension of a duct cross-section defined by:

$$d = \frac{4}{h} \frac{\text{area of sampling plane}}{\text{perimeter of sampling plane}} \quad (1)$$

**3.8**

**sampling plane (or sampling section)**

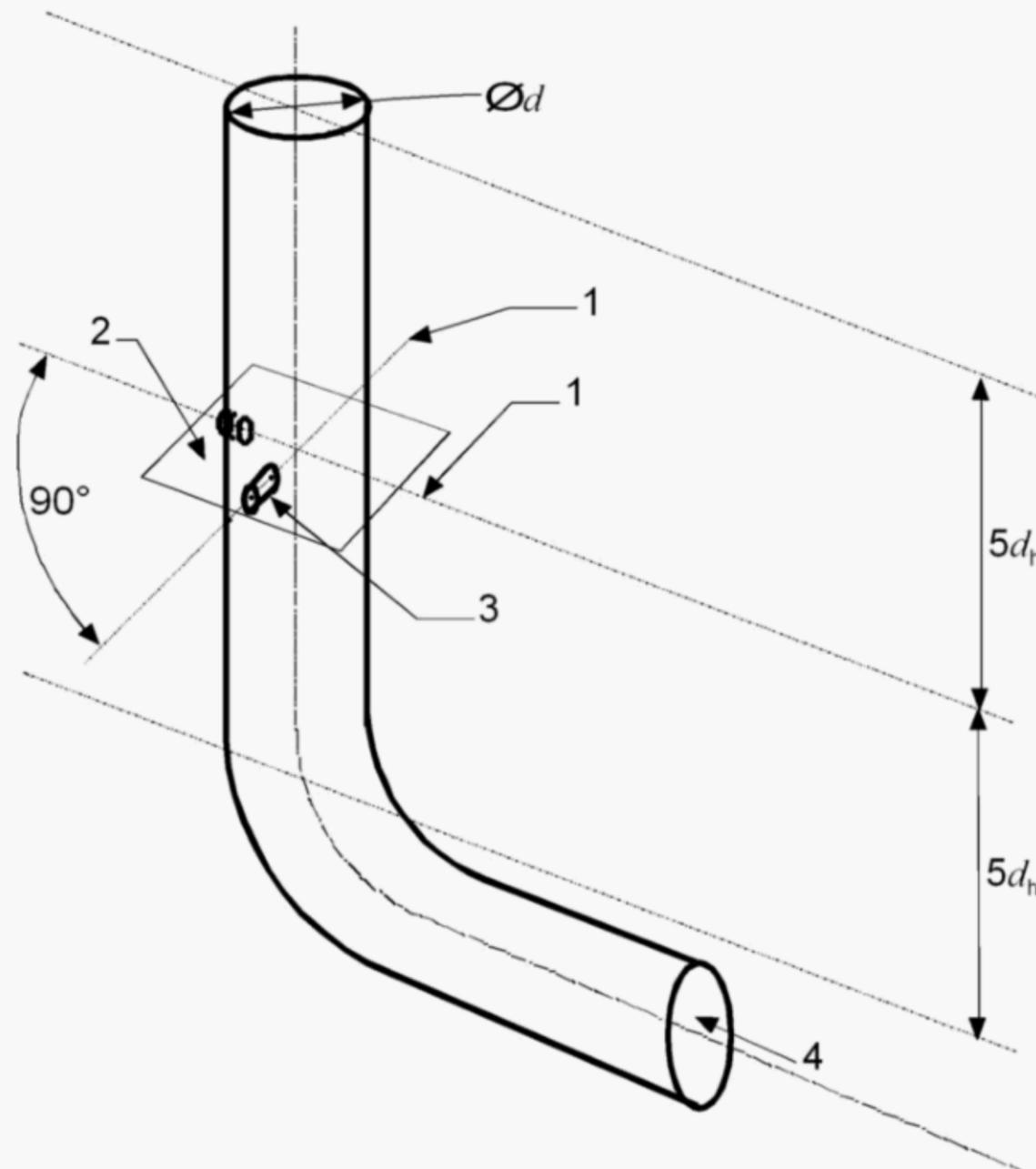
plane normal to the centreline of the duct at the sampling position (see Figure 2)



## 3.9

**sampling lines**

lines in the sampling plane along which the sampling points are located (see Figure 2), bounded by the inner duct wall

**Key**

- 1 Sampling line
- 2 Sampling plane
- 3 Access port
- 4 Flow rate

Figure 2 — Illustration of definitions in relation to a circular duct

## 3.10

**sampling point**

specific position on a sampling line at which a sample is extracted

### 3.11

#### **standard conditions**

reference values for a dry gas at a pressure of 101,325 kPa rounded to 101,3 kPa and a temperature of 273,15 K rounded to 273 K

### 3.12

#### **overall blank**

test sample taken at the plant site in an identical manner to the normal samples in the series, except that no gas is sampled during test duration

Note The measured mass variation provides an estimation of the uncertainties. The overall blank value, divided by the average sampling volume of the measurement series, provides an estimation of the detection limit (in milligrams per cubic metre) of the whole measurement process, as carried out by the operators. The overall blank includes possible deposits on the filter and on all parts upstream.

### 3.13

#### **weighing control**

procedure for the detection/correction of apparent weight variations due to possible changes between pre and post sampling weighing conditions

### 3.14

#### **measurement series**

successive measurements carried out at the same sampling plane, and at the same process conditions

### 3.15

#### **limit value**

dust concentration which is permitted by authorities for the plant process (i.e. average limit value)

Note For purposes other than regulatory uses the measurement value should be compared to a stated reference value.

## 4 Principle

A sample stream of the gas is extracted from the main gas stream at representative sampling points for a measured period of time, with an isokinetically controlled flow rate and a measured volume. The dust entrained in the gas sample is separated by a pre-weighed plane filter, which is then dried and re-weighed. Deposits upstream of the filter in the sampling equipment are also recovered and weighed. The increase of mass of the filter and the deposited mass upstream the filter are attributed to dust collected from the sampled gas, which allows the dust concentration to be calculated.

Two different configurations of the sampling equipment may be used depending on the characteristics of gases to be sampled (see 6.2.2).

Valid measurements can be achieved only when:

- a) the gas stream in the duct at the sampling location has a sufficiently homogeneous and steady velocity profile (see 5.2);
- b) sampling is carried out without disturbance of the gas stream with a sharp edged nozzle facing into the stream under isokinetic conditions;
- c) samples are taken at a pre-selected number of stated positions in the sampling plane, to allow for a non uniform distribution of dust in the duct;
- d) the sampling train is designed and operated to avoid condensation, chemical reactions and to minimise dust deposits upstream of the filter and to be leak free;
- e) dust deposits upstream of the filter are taken into account;
- f) the overall blank value does not exceed 10 % of the daily limit value set for the process;

g) the sampling and weighing procedures are adapted to the expected dust quantities.

## 5 Sampling plane and sampling points

### 5.1 General

Sampling is only possible when a suitable location is available, with sufficiently high and homogeneous gas velocity at the sampling plane.

The sampling plane shall be easily reached from convenient access ports and a safe working platform (see annex A).

Sampling shall be carried out at a sufficient number of sampling points located on the sampling plane.

### 5.2 Sampling plane

The sampling plane shall be situated in a length of straight duct, (preferably vertical) and with constant shape and cross-sectional area. Where possible, the sampling plane shall be 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).

Measurements at all the sampling points defined in 5.3 and annex C shall prove that the gas stream at the sampling plane meets the following requirements:

- a) angle of gas flow less than  $15^\circ$  with regard to duct axis (method for determination is indicated in annex B);
- b) no local negative flow;
- c) minimum velocity depending on the flow rate measuring method used (for Pitot tubes a differential pressure larger than 5 Pa);
- d) ratio of the highest to lowest local gas velocities less than 3:1.

If the above requirements cannot be met, the sampling location is not in compliance with this European Standard (see 10.2).

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

### 5.3 Minimum number and location of sampling points

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

Tables 1 and 2 give 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 C).

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 may arise when selecting more than the minimum numbers of sampling points presented in Tables 1 and 2, for example in cases of unusual duct shape.

**NOTE** When the requirements for the sampling plane (see 5.2) cannot be met it may be possible to improve representative sampling by increasing the number of sampling points above those specified in Tables 1 and 2.

**Table 1 — 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 <sup>a</sup>
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 <sup>2 b</sup> and 4 per m

a Using only one sampling point may give rise to errors greater than those specified in this standard.  
~~b For large ducts, a number of 20 sampling points is generally sufficient.~~

**Table 2 — 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 <sup>b</sup>
0,1 to 1,0	2	4
1,1 to 2,0	3	9
> 2,0	3	at least 12 <sup>2 c</sup> and 4 per m

a Other side divisions may 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 may give rise to errors greater than those specified in this standard.  
 c For large ducts, a number of 20 sampling points is generally sufficient.

**5.4 Access ports and working platform**

Ports shall be provided for access to the sampling points selected in accordance with 5.3 and annex C.

The port dimensions shall allow sufficient space for insertion and withdrawal of the sampling equipment. A minimum diameter of 125 mm or a surface area of 100 mm x 250 mm are recommended, except for small ducts (less than 0,7 m diameter) for which the port size needs to be smaller.

Two examples of suitable access ports are given in annex D.

For safety and practical reasons, the working platform shall comply with the requirements of annex A.

## 6 Equipment and materials

### 6.1 Gas velocity, temperature, pressure and composition measurement devices

Velocity measurements shall be carried out using standardised type L Pitot tubes, as described in ISO 3966:1977, annex A. Alternatively, other measurement devices (e.g. type S Pitot tube) may also be used, provided that they are calibrated against standardised Pitot tubes (see [5]).

The temperature and the pressure in the duct shall be measured in order to calculate the actual density of the gas within  $\pm 0,05 \text{ kg/m}^3$ , also taking the gas composition into account.

When expressing dust concentrations on a dry basis, and/or where the concentrations shall be expressed in relation to a reference oxygen concentration, humidity (moisture) and/or oxygen measurements shall be carried out in the vicinity of the sampling plane.

### 6.2 Sampling equipment

6.2.1 The sampling train principally consists of:

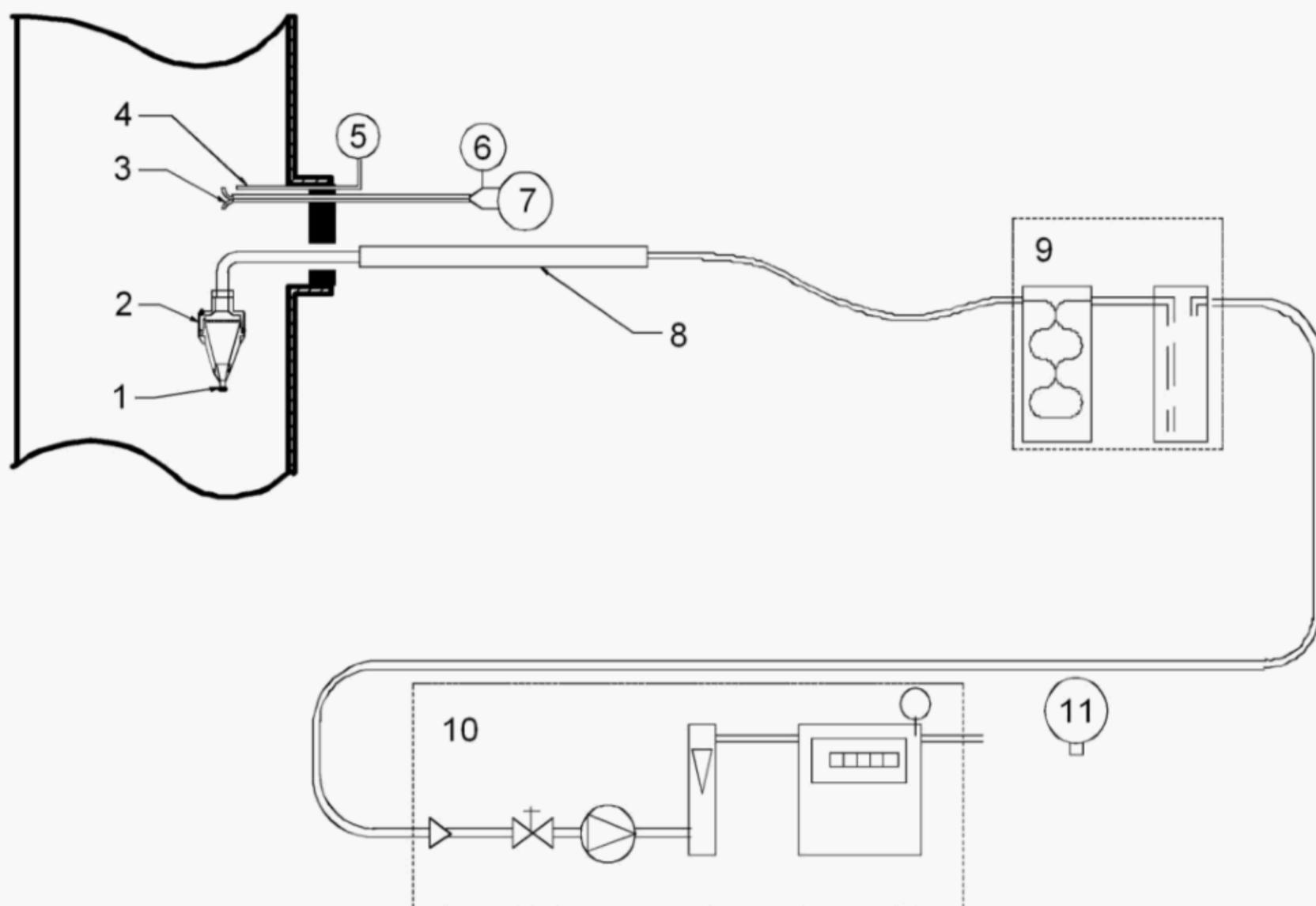
- a) entry nozzle;
- b) filtration device;
- c) suction tube;
- d) gas pump;
- e) system for measurement of sampled gas volume at identified temperature and pressure;
- f) system for controlling isokinetic sampling conditions.

6.2.2 The filtration device is either located in the duct ("in-stack filtration") or placed outside the duct ("out-stack filtration"):

- a) "in-stack" filtration devices (see Figure 3): the part of the tubing between nozzle and filter – should be very short, thereby minimising dust deposits upstream of the filter. Due to available access port dimensions on ducts, the filter diameter is then typically limited to 50 mm, with a sample flow rate of approximately 1 m<sup>3</sup>/h to 3 m<sup>3</sup>/h. Since the filtration temperature is generally identical to that of the gas in the duct, filter clogging may occur if the stack gas contains water droplets.

To allow access to all sampling points in the duct, a leak free rigid tube of sufficient length (support tube) is used downstream of the filter housing for mechanical support of the nozzle and filter housing.

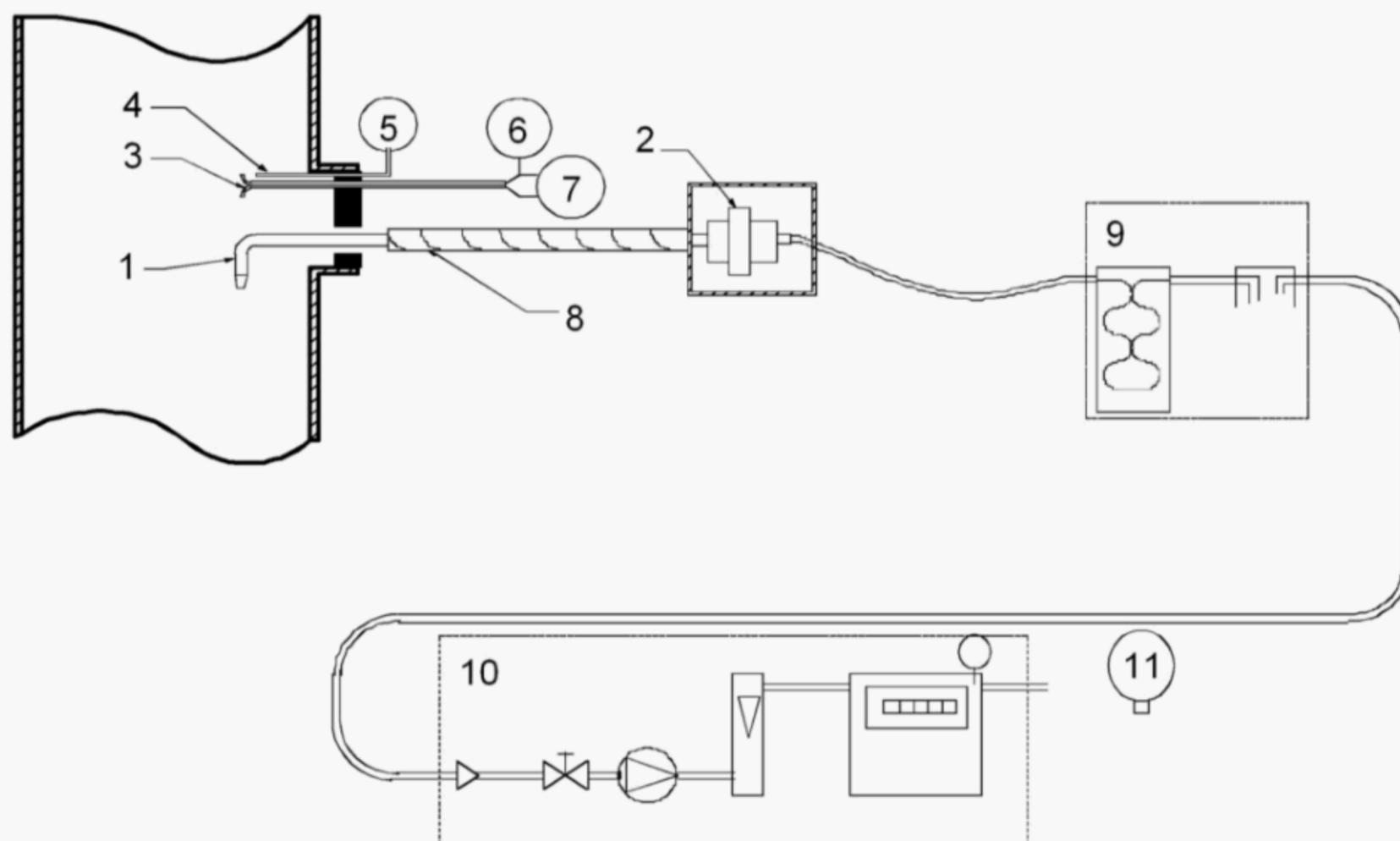
- b) "out-stack" filtration devices (see Figure 4): the part of tubing between the nozzle and the filter (suction tube) shall be of sufficient length to allow access to all sampling points in the duct. The suction tube and the filter holder shall be temperature controlled, which provides evaporation of possible water droplets or avoids filtration difficulties related to high acid dew point gases. Filter diameters between 50 mm and 150 mm are generally used, with associate flow rate of 1 m<sup>3</sup>/h to 10 m<sup>3</sup>/h.



**Key**

- |                               |   |
|-------------------------------|---|
| 1 Entry nozzle                | 7 Dynamic pressure measurement          |
| 2 Filter holder               | 8 Support tube („in stack“ device)      |
| 3 Pitot tube                  | 9 Cooling and drying system             |
| 4 Temperature sensor          | 10 Suction unit and gas metering device |
| 5 Temperature indicator       | 11 Pressure gauge                       |
| 6 Static pressure measurement |   |

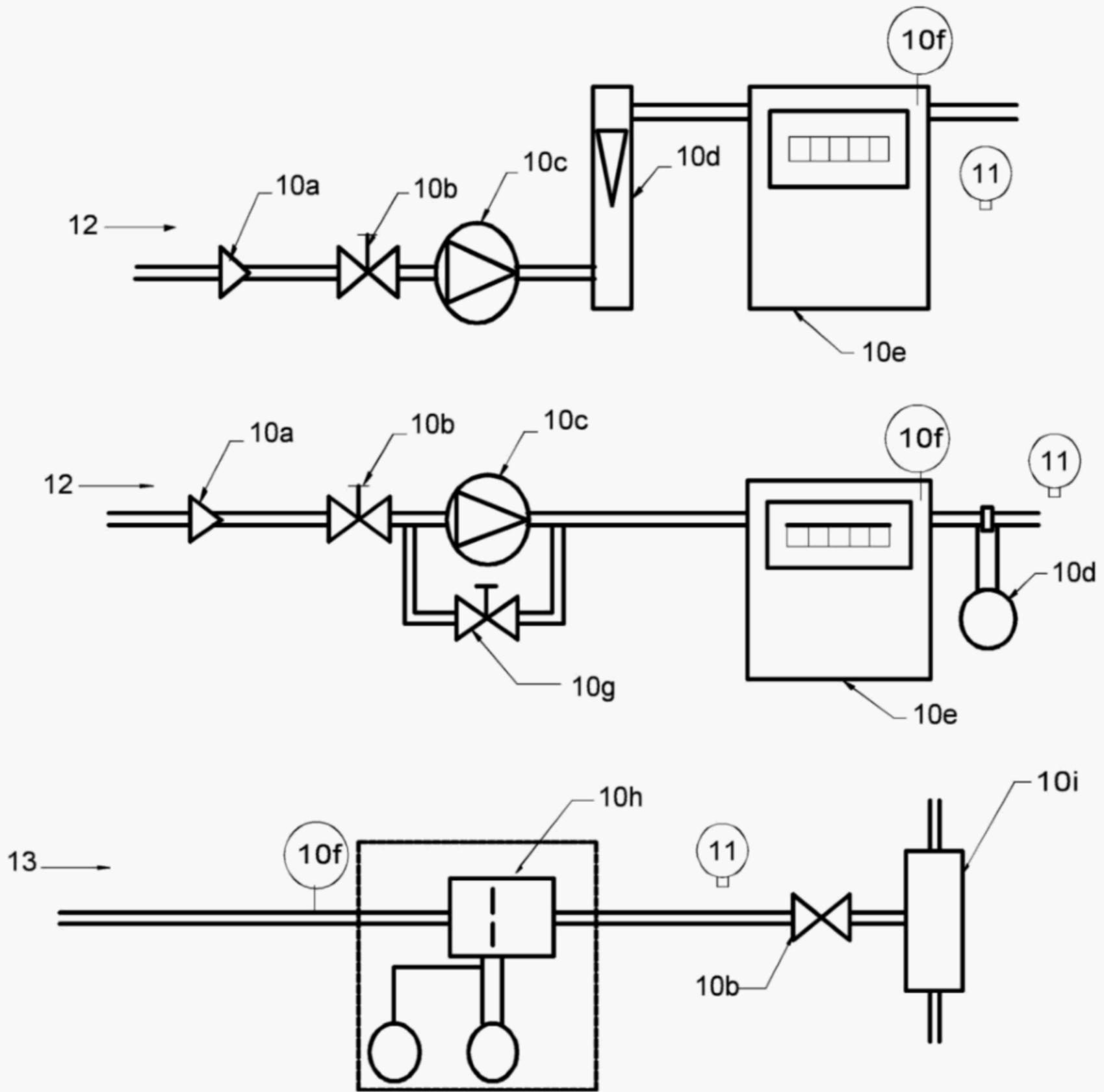
**Figure 3 — Example of "in-stack" filter sampling system**



### Key

- |   |                             |    |   |
|---|-----------------------------|----|---|
| 1 | Entry nozzle                | 7  | Dynamic pressure measurement                        |
| 2 | Filter holder               | 8  | Suction tube („out-stack“ device)                   |
| 3 | Pitot tube                  | 9  | Cooling and drying system                           |
| 4 | Temperature sensor          | 10 | Suction unit and gas metering device (see Figure 5) |
| 5 | Temperature indicator       | 11 | Pressure gauge                                      |
| 6 | Static pressure measurement |    |   |

Figure 4 — Example of "out-stack" filter sampling system



**Key**

- |                           |                            |
|---------------------------|----------------------------|
| 10a Shut off valve        | 10g Orifice plate          |
| 10b Adjustment valve      | 10h Heated diaphragm       |
| 10c Pump                  | 10i Compressed air ejector |
| 10d Flow meter            | 11 Pressure gauge          |
| 10e Dry gas volume meter  | 12 Dry gas                 |
| 10f Temperature indicator | 13 Wet gas                 |

**Figure 5 — Examples of suction unit and gas metering devices**

**6.2.3** The sampling parts of the system have to be made of corrosion resistant and, if necessary, heat resistant material, e.g. stainless steel, titanium, quartz or glass.

NOTE If further analysis of collected dust is to be performed, materials in contact with the sample gas and the filter should be fit for purpose to avoid contamination.

The surfaces of parts upstream the filter shall be smooth and well polished and the number of joints shall be kept to a minimum.

Any changes in bore diameter shall be smoothly tapered and not stepped.

The sampling equipment shall also be designed in order to facilitate the cleaning of internal parts upstream the filter.

All parts of the equipment which come in contact with the sample shall be protected from contamination during handling, transportation, etc.

#### **6.2.4** Entry nozzle

The sample gas stream to be measured enters the sampling equipment via the nozzle. The nozzle is connected either to the suction tube or to the filter holder.

In order to allow isokinetic sampling of gases flowing at a wide range of velocities (e.g. 3 m/s to 50 m/s) without major change of the sampled flow rate, the sampling equipment shall be supplied with a set of nozzles of different diameters.

The entry nozzle shall be sharp in order not to disturb the main gas flow. Annex E details three proven designs. Other designs are allowed, provided they are validated to give equivalent results.

Since it is necessary, for mechanical reasons, to have sufficient thickness of the nozzle bevel, this leads to an uncertainty on the effective sampling area which should be less than 10 % in order to fulfil isokinetic sampling criteria. For this reason, it is recommended to use nozzles of inside diameter exceeding 8 mm, and diameters less than 6 mm shall be avoided.

In order to minimize disturbance of the gas flow near the nozzle tip, the following requirements shall also apply:

- a) constant internal diameter of the nozzle for a minimum length of one internal diameter, or at least 10 mm from the nozzle tip whichever is the greater;
- b) any change in bore diameter shall be tapered and of conical angle less than 30°;
- c) bends are allowed only after a minimum straight length of 30 mm; their radius shall be at least 1,5 time the internal diameter;
- d) any change in the external diameter of the sampling equipment parts located at less than 50 mm from the nozzle tip shall be tapered and of conical angle less than 30°;
- e) obstacles related to the sampling equipment are:
  - 1) prohibited upstream the nozzle tip;
  - 2) allowed besides and downstream of the nozzle tip when situated at more than 50 mm or at least one time the size of the obstacle whichever is the greater.

#### **6.2.5** Suction tube (Out-stack filtration devices)

The suction tube shall have a smooth and well-polished internal surface, and shall be designed to facilitate inspection and mechanical cleaning. The tube shall be temperature controlled to maintain the planned conditions for the filtration of the gases.

### 6.2.6 Filter holder

The filter holder is a casing in which the filter support and the filter are mounted. When the filter holder is placed "out-stack" it shall be temperature controlled to maintain filtration conditions and to avoid condensation.

The parts to be weighed before and after sampling shall be either:

- a) the filter, or the filter support and the filter in which case the dust deposits at the inlet of the filter holder shall be recovered and weighed (see 10.4). The use of a filter holder with a conical inlet of an angle less than 30° helps to minimize dust deposits;
- b) the filter, inlet part of the filter holder and the upstream parts (e.g. nozzle), in which case dust deposits upstream of the filter are taken directly into account. The outside surfaces shall be cleaned prior to weighing. It is necessary to check whether the parts to be weighed are compatible with the range of the balance (see 7.2).

The filter holder and the filter support shall be designed in such a way that no gas turbulence will occur near the joints.

To reduce the filter pressure drop and to improve the distribution of dust on the filter, a coarse grain filter support (e.g. fibre mesh) should be used.

### 6.2.7 Filters

The filters to be used shall comply with the following minimum requirements:

- a) plane filter efficiency better than 99,5 % on a test aerosol with a mean particle diameter of 0,3 µm, at the maximum flow rate anticipated, (or 99,9 % on a test aerosol of 0,6 µm mean diameter). This efficiency shall be certified by the filter supplier;
- b) the filter material shall not react with or adsorb gaseous compounds contained in the gas to be sampled, and shall be thermally stable, taking into account maximum temperature anticipated (conditioning, sampling etc.).

The choice of the filter should also take into account the following considerations:

- a) the pressure drop of the filter, and increase due to the collection of the dust while sampling. This depends on the kind of filter. As an example the pressure drop can be between from 3 kPa to 10 kPa for a filtration velocity in the range of 0,5 m/s;
- b) when using filters with organic binders, care shall be taken of possible weight variations due to binder losses by evaporation when heating;
- c) glass fibre filters may react with acidic compounds such as SO<sub>3</sub>, which leads to an increase in weight; their use is not recommended;
- d) despite their weak mechanical properties quartz fibre filters are proven to be efficient in most cases;
- e) PTFE filters are also proven to be efficient, however the maximum allowable temperature of the gas passing through the filter shall not exceed 230 °C (refer to filter suppliers information).

NOTE 1 The overall blank value of the measurement (see 10.6) depends on the choice of the filter (mechanical properties, affinity for humidity, etc.).

NOTE 2 If it is anticipated to determine the composition of the dust collected, the choice of the filter material should take into account the blank filter value for the relevant compounds.

NOTE 3 When weighing filters, care should be taken to avoid errors due to electrostatic charges.

NOTE 4 Fibre losses can occur from the filter during the initial sampling period which might affect the overall uncertainty.

### 6.2.8 Suction unit and gas metering devices

The suction unit shall be tight, corrosion-proof and shall be capable of extracting the maximum rated flow rate in the sampling conditions (vacuum of the suction side up to e.g. 40 kPa). Wide adjustments of sampled flow rate shall be controlled by a regulating valve and/or by-pass. A shut off valve shall also be available to shut-off the gas flow through the sampling train.

Examples of two kinds of gas metering systems that may be used are as follows:

a) flow rate measurements on a dry basis (see Figure 3):

- 1) condenser and/or gas drying tower providing a residual humidity less than 10 g/m<sup>3</sup> at the maximum flow rate;
- 2) gas-tight pump;
- 3) flow meter, in order to facilitate the flow rate adjustment, calibrated against the dry gas volume meter;
- 4) dry gas volume meter (uncertainty less than 2 % at the anticipated flow rate) with associated absolute pressure and absolute temperature measurement (uncertainty less than 1 %);

b) flow rate measurements on a wet basis (see Figure 4):

- 1) heated tubing, in order to prevent upstream condensation of the sample gas;
- 2) orifice plate or equivalent device (flow meter), calibrated within 2 % of the anticipated flow rate; the uncertainty of temperature, pressure (absolute and differential) measurement shall be less than 1 %;
- 3) compressed air ejector acting as suction device;
- 4) atmospheric pressure measuring device.

Other types of systems are allowed, provided that the component parts meet the requirements of annex F.

NOTE If side stream sampling is used for measurement of other components, the side stream flow rate is taken into account for the calculation of isokinetic sampling, and for the calculation of total sampled gas volume.

### 6.3 Dust deposit recovery accessories

- a) purified water (de ionised and filtered) and acetone (pA grade having a dry residue less than 10 mg/l);
- b) clean containers of appropriate size (e.g. 250 ml) for storage and transportation of the rinsing solution;
- c) plugs (acetone resistant) to close the suction tube.

### 6.4 Equipment for conditioning and weighing

- a) weighing containers for the drying procedure of the rinsing solutions. The mass shall be in accordance with the balance to be used. Glass and ceramic have proven to be suitable materials. Plastic materials are not recommended;
- b) desiccators: located in the weighing room, with a desiccating agent (silica gel, calcium chloride);
- c) drying oven: laboratory drying oven, thermally controlled within  $\pm 5$  °C;
- d) balance: resolution from 0,01 mg to 0,1 mg, the range is to be compatible with the mass of parts to be weighed (see 6.2.6). Depending on the balance room location, specific care shall be required to avoid reading instability related to vibrations, air draughts and temperature variations;

NOTE The weighing uncertainty is not only related to the balance characteristics but to the whole procedure see annex G.

- e) thermometer and humidity meter near the balance;
- f) pressure gauge;
- g) depending on the evaporation procedure, an extraction hood and heating plate for the evaporation of rinsing solution shall be provided.

## 7 Weighing procedure

### 7.1 General aspects

Depending on the kind of sampling device to be used, the parts to be weighed can be the filter with or without its support, or may also include all upstream parts from the filter.

Depending on the procedure to be used the rinsing solutions can be evaporated and weighed in the same container or transferred to a smaller container for weighing.

### 7.2 Pre-sampling conditioning

Weighed parts shall be dried in a drying oven for at least 1 h, at a minimum of 180 °C (see clause 9).

The filters and/or the weighing containers are cooled down to ambient temperature in a desiccator located in the weighing room for at least 4 h. For larger parts e.g. weighing containers up to 12 h may be necessary. If the humidity is controlled and dust is not hygroscopic the filters and/or the weighing containers may be equilibrated in the weighing room.

### 7.3 Weighing

Since dust concentration is determined by difference between weights often obtained at one or two weeks interval, special care is required in order to avoid weighing errors related to balance drift, to insufficient temperature equilibrium of parts to be weighed, and to climatic changes (see examples in annex H). Therefore, before performing any measurement, the user shall validate their weighing procedure (see 7.6). It is strongly recommended to use the same balance for both pre-weighing and past weighing.

Before each weighing series:

- a) the balance shall be checked against standard weights;
- b) additional check shall be carried out by weighing control parts, identical to the parts to be used in the measurement, pre-treated in the same temperature and humidity control conditions and kept free from contamination;
- c) record the climatic conditions in the room.

When weighing large volume parts (e.g. beakers), the temperature and barometric pressure may influence the apparent weight, this may be detected using the reference weight of the control parts. In these conditions, weighing corrections shall be applied, based on the apparent weight modification of three identical control parts of each type (filter incl. support, container etc.).

Attention has also to be drawn on an increase or decrease in weighing due to:

- a) electrostatic charges, which give erratic readings and which may have to be discharged/neutralised (metallic plate, ion gun);

- b) hygroscopic characteristics of the filter material and/or dust. Weighing shall be carried out within 3 min after removal from the desiccator. Three readings shall be taken at 1 min, 2 min and 3 min. If a significant increase is detected, the sample shall be put back into the desiccator for at least 4 h and then the weighing procedure shall be repeated. The dry reference weight shall then be calculated by extrapolation to zero time;
- c) small differences in temperature between the part to be weighed and the environment may disturb the balance.

#### 7.4 Post-sampling treatment of weighed parts

Weighed parts shall be dried in an oven for at least 1 h at 160 °C (see also clause 9 for specific cases).

Afterwards they will be equilibrated to ambient temperature as described in 7.2.

#### 7.5 Post-sampling treatment of the rinsing solutions

All the rinsing solutions (water and acetone) from all parts upstream of the filter as described in 8.5 are taken to the laboratory for the further treatment. Care shall be taken that no contamination occurs.

The solutions are transferred carefully to the dried and pre weighed containers (see 7.2). During the evaporation the solvent mixture shall not be boiled. As the volume of solution is reduced through the evaporation process, small vessels may be used before the final weighing container.

NOTE Proven methods for evaporation of rinsing solutions are:

- 1) evaporate in an oven at 120 °C at ambient pressure. It is recommended to use air or nitrogen to dilute the acetone vapour to a safe level;
- 2) evaporate in a closed system (desiccator). The initial temperature is set to 90 °C and the pressure is reduced to 40 kPa (absolute). From time to time the temperature is increased and the pressure is decreased. For the last period they are kept at 140 °C and 20 kPa (absolute).

After evaporation the weighing containers are placed in the drying oven for 1 h at 160 °C (see clause 9 for specific reasons), then cooled down to ambient temperature as described in 7.2.

Due to the relative large mass and the volume of the weighing containers compared to the deposits under investigation changes of the barometric pressure may influence the weighing. Therefore at least three empty weighing containers of equal size shall be weighed with each series.

From the solvents used at least one blank value from the same volume is determined, for possible correction.

#### 7.6 Improvement of the weighing procedure

Experience has shown that weighing uncertainties are not only related to the balance performance but to the whole procedure applied. Therefore, before performing any measurement, the user shall establish and validate its own procedure, taking into account the sampling equipment and filters to be used.

Repeated weighing of the same parts, spread over several weeks in various conditions, i.e. external temperature humidity etc., provide, through the standard deviation, an estimation of the actual precision of weighing, including the uncertainties related to the manipulation of the filters, equilibrium time, etc.

The results are used as a first estimate of the overall blank value and provide a means of calculation of the gas volume to be sampled, in order to get significant data, taking into account the anticipated range of dust concentrations (see annex G).

## 8 Sampling procedure

### 8.1 General aspects

- a) Before carrying out any measurements, the purpose of the sampling and the sampling procedures shall be discussed with the plant personnel concerned. The nature of the plant process, e.g. steady state or cyclic, can affect the sampling programme. If the process can be performed in a steady state, it is important that this is maintained during sampling;
- b) dates, starting times, duration of survey and sampling periods, as well as plant operating conditions during these periods shall be agreed with the plant management;
- c) preliminary calculations are to be made on the basis of expected dust concentration in order to verify that expected sampled dust quantities are consistent with attainable overall blank values, and that no overloading of the filter will occur (see annex G);

For sampling times limited to 30 min, required for certain trial or regulatory purposes, the uncertainty of measurement is in the range of 2 mg/m<sup>3</sup> (see 12.2). Furthermore, completion of sampling along two diameters within 30 min necessitates, even for medium size ducts, simultaneous sampling with two teams, one on each sampling line.

Where possible, the sampling time can be extended, which decreases the detection limit to more practicable conditions (see annex G). The sampling time should be determined, to minimize the effect of non steady state conditions of the stationary source and chemical reactions on collected dust on the filter.

- d) taking into account the objective of the measurements and the conditions of waste gases to be sampled, the user has:
  - 1) to choose between an in-stack or an out-stack filtration device. If gases in the duct are saturated (water, SO<sub>3</sub>, etc.), out-stack filtration devices shall be used;
  - 2) in certain cases to choose a temperature for filtration and conditioning/drying of the filter before and after sampling (see clause 9);
- e) an overall blank sample shall be taken (see 8.6).

### 8.2 Preparation

The equipment shall be cleaned, prepared and checked before moving to site. Care shall be taken not to reuse any part of a sampling train previously used for high dust concentration sampling without dismantling and thorough cleaning.

The equipment shall be mechanical cleaned and rinsed before the measuring series.

Depending on the measurement programme, filters and associated parts to be weighed shall be prepared for each measurement series. This includes the parts for the overall blank tests and spare parts e.g. filters, filter holder, nozzles, etc., to cope with process and equipment malfunctions.

Perform weighing of the parts in accordance with clause 7.

All the weighed parts, the suction tube and the other parts of the equipment which will come in contact with the sample (and will be rinsed later) shall be protected from contamination during transportation and storage.

### 8.3 Pre measurements

Depending on the dimensions of the duct, which are to be verified, select the number and location of sampling points, in accordance with 5.3 and annex C.



NOTE 2 The filter load and the maximum gas velocity should not exceed the filter manufacturers recommendation.

j) on completion of sampling run at all points:

- 1) remove the sample train after closing the shut off valve and suction device;
- 2) leak check the equipment as under 8.4 a) if leakage has not been monitored during sampling;
- 3) dismantle the sampling equipment and check visually the filter and the filter holder, for signs of breakage or stains due to pressure or to the concentration of moisture (sampling equipment operated below or too close the dew point). In such cases, the test is not valid. Check also non uniform distribution of dust on the filter.

k) measure and record the barometric pressure.

l) put the parts to be weighed in a closed electrostatic free container for transport to laboratory for weighing (see clause 7).

### 8.5 Recovery of deposits upstream of the filter

All the non weighed parts upstream of the filter which are in contact with the gas sample shall be rinsed to recover the deposits unless the quantification of possible deposits is not required (see 10.5).

Special care has to be taken to avoid contamination if the rinsing is done on site. Rinsing shall be done in accordance with the following procedure:

- a) rinse the nozzle, elbow and the other parts upstream of the filter carefully with water into a storage container, taking care that nothing from the outside may fall into the container. The procedure is repeated with a second rinsing of water followed by acetone into the same container;
- b) to rinse the suction tube seal one end and fill enough water to wet and clean the inner surface (1/3 to 1/2 of the volume of the suction tube) and then seal the other end. The tube is cleaned by rotating and tilting several times. Transfer the solution to the transport storage container. The procedure is repeated with a second rinsing of water followed by acetone into the same container.

No mechanical cleaning shall be applied to recover dust deposits upstream of the filter.

The upstream parts shall be rinsed at least after each measurement series on the same sampling plane and at least once a day. The recovered mass shall be attributed to individual tests in proportion to the mass collected on each filter.

### 8.6 Overall blank sample

An overall blank sample shall be taken after each measurement series or at least once a day, following the sampling procedure described in 8.4 without starting the suction device. This leads to an estimation of the dispersion of results related to the whole procedure as carried out by the operators for a near zero dust concentration i.e. contamination of filters and of rinsing solutions during handling on site, transport, storage, handling in the laboratory and weighing procedures. All overall blank values shall be reported individually.

## 9 Thermal behaviour of dusts

Emitted dusts are generally thermally stable. However, on some processes the gases to be sampled contain unstable or semi-volatile compounds (i.e. in particulate form at low temperature, in gaseous form at higher temperature). In such a case the measured concentration depends on the filtration temperature and/or on the drying temperature before final weighing.

Such phenomena have been reported in various industries:

- a) power plant equipped with desulphurisation processes, because the occurrence of hydrates;

- b) heavy fuel oil power plants or diesel engines, because SO<sub>3</sub> and/or organic compounds;
- c) glass furnaces, because the occurrence of semi volatile boron compounds has been experienced;
- d) waste incinerators with wet and semi-dry gas treatment processes.

Differences in the measured dust concentrations (up to factor 10) have been experienced and therefore in such cases the measured results shall be associated with a stated temperature (i.e. the highest temperature sustained by the sampled dust before weighing).

Because of the extreme variety of the situations, which may be encountered, it is not possible to find a conventional temperature which can be relevant in all the cases.

However, since the complete trapping of volatile compounds would necessitate a very low filtration temperature and special care during sampling, more reproducible results may be achieved if these compounds are not trapped or are further evaporated when drying. It is the reason why a conventional temperature of 160 °C, which leads to avoid trapping of most volatile compounds and to decompose most of hydrates is generally convenient.

In accordance with this convention, parts of the sampling train to be weighed should therefore be:

- a) conditioned at 180 °C before sampling;
- b) set at any temperature equal or less than 160 °C during sampling;
- c) conditioned at 160 °C after sampling.

Depending on eventual regulatory requirements and plant authorisation, or on special kind of effluent or on specific objective of the measurement, other conventional temperature can be adopted: e.g. the temperature should be reduced during post-sampling treatment if aerosols or condensable compounds are to be taken into account.

In any case:

- a) the weighed parts shall be conditioned before sampling (see 8.1) at a temperature at least 20 °C above the maximum temperature reached during sampling and post-sampling treatment;
- b) the temperature used while sampling and while conditioning before weighing shall be indicated in the test report.

## 10 Validation of results

### 10.1 General

Annex F provides a summary of the requirements mentioned in this European Standard.

### 10.2 Parameters depending on the stationary source

If no suitable location (see 5.1) exists in the plant, and/or that measurements have been carried out during non steady state conditions of the plant, which leads to an increase of the uncertainty of the measurements, it shall be stated in the report that the measurement is not in accordance with this standard and why.

Details on the characteristics of the flow at the sampling location and/or on the variations of the flow rate in the duct while sampling shall be stated in the test report.

### 10.3 Leak check

The sampling equipment shall be leak checked as errors are caused by the occurrence of leaks. Leakage shall be less than 2 % of the normal flow rate as prescribed in 8.4 a).

**10.4 Isokinetic rate**

If the mean actual isokinetic rate during the sampling at the sampling plane differs for more than -5 % to +15 %, the measurement is not valid.

If this criterion is not fulfilled due to frequent variation of the flow rate in the duct, see 10.2.

**10.5 Deposits of dust on non-weighed parts upstream the filter**

Experimental work carried out when preparing this European Standard proved that dust deposits upstream of the filter are often in the range of 10 % to 30 % of the total dust when sampling gases from waste incinerators at concentration around 5 mg/m<sup>3</sup>.

These deposits depend probably on the design of the sampling equipment, and on the kind of dust to be sampled, but no efficient means was found to keep them at a negligible level. For this reason all non weighed parts of the sampling equipment prior to the filter shall be rinsed. The mass of dust on non-weighed parts upstream of the filter shall be indicated in the test report, besides the mass on the filters used during the same measurement series.

When sampling with in-stack filtration devices with no bends between the nozzle and filter holder (see annex E) on non saturated gases, with a temperature well above the stack gas dew point, the upstream deposits do not have to be quantified provided that validation has been carried out at similar conditions as the process to prove that the deposits, expressed in the same units as the measurement results (e.g. in milligrams per cubic metre) do not exceed 10 % of the daily average limit value set for the process.

**10.6 Overall blank**

The overall blank shall not exceed 10 % of the daily limit value set for the process.

No result below the overall blank value is valid.

Weighing uncertainties (see 7.6) contribute to the overall blank, therefore the weighing uncertainties shall be less than 5 % of the daily limit value.

**11 Calculation**

**11.1 Sampling volumetric flow rate**

In order to perform isokinetic sampling, calculate the required sampling flow rate, taking into account the velocity of the gas in the duct at the sampling point (see annex B), and the effective diameter of the sampling nozzle.

Because sampling flow rate is measured in conditions (temperature, pressure, humidity) which generally differ from the actual conditions of gas in the duct, it shall be corrected as follows:

$$Q_m = Q_a \frac{100 H_a T_m p_a}{100 H_m T_a p_m} \tag{2}$$

where

- $Q_m$  is the measured sampling flow rate at gas meter conditions;
- $Q_a$  is the sampling flow rate, expressed in the actual conditions in the duct;
- $H_m$  is humidity, in percentage volume, of gases in measurement conditions m;
- $H_a$  is humidity, in percentage volume, of gases in actual conditions a;

$T_m$  is the temperature of gases in measurement conditions  $m$ , in Kelvin;

$T_a$  is the temperature of gases in actual conditions  $a$ , in Kelvin;

$p_m$  is the absolute pressure of gases in measurement conditions  $m$ ;

$p_a$  is the absolute pressure of gases in actual conditions  $a$ .

Compare the  $Q_a$  target value to the  $Q_a$  performed during test, in order to check for isokinetic sampling compliance.

## 11.2 Dust concentration

For each test, calculate:

- the sample volume  $V$ , specifying whether on a dry or wet basis and under standard conditions;
- the total mass  $m$  of dust collected upstream of the filter (rinsing) and on the filter;
- the dust concentration  $c$ .

$$c = \frac{m}{V} \quad (3)$$

It is sometimes necessary to express dust concentrations to a reference  $O_2$  concentration, to correct for dilution effect. The measured dust concentration is to be multiplied by the correction factor  $f_c$ :

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}} \quad (4)$$

where

$O_{2,ref}$  is the oxygen reference concentration in percentage volume of dry gas under standard conditions;

$O_{2,m}$  is the oxygen concentration in percentage volume of dry gas, measured in the duct.

## 12 Performance characteristics of the method

### 12.1 General aspects

Because waste gas composition varies in time, it is not possible to determine the repeatability and reproducibility of the method in accordance with ISO 5725-2.

However, if one team performs successive parallel sampling tests with two identical sampling systems, such a procedure allows statistical comparison between paired values  $x_1$  and  $x_2$  to be calculated.

The standard deviations  $s$  of the paired values are:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_{i,1} - x_{i,2})^2}{2n}} \quad (5)$$

where



$n$  is the number of sample pairs  $x_1$  and  $x_2$

The standard deviation may be used for the calculation of:

- a) the internal uncertainty  $u$  (or internal confidence interval) linked to an individual measurement carried out by that team:

$$u = t_{0,95; n-1} \frac{s}{\sqrt{n}} \quad (6)$$

where

$t_{0,95; n-1}$  is the student factor for a 95 % confidence and the degrees of freedom  $n - 1$ .

- b) the repeatability  $r$  (in accordance with ISO 5725-2), i.e. the maximum difference between i.e. two measurements by the same team, for a 95 % confidence level:

$$r = 2 t_{0,95; n} s \quad (7)$$

These data are to be considered as tools for measuring institutes in the framework of quality assurance.

When data is provided by several independent teams operating together, similar calculations can be achieved and provide an estimation of:

- a) the external uncertainty linked to an individual measurement carried out by any team fulfilling the requirements of the standard. This uncertainty is to be taken into account when comparing the measured values to the emission limit value;
- b) the reproducibility  $R$  (in accordance with ISO 5725-2), i.e. the maximum difference  $R$ , which can be expected, at a 95 % confidence, between two measurements by different teams working in accordance with the standard, at the process conditions.

When doing measurements at low level concentrations, the detection limit may be estimated:

- a) by parallel measurements and calculation of the uncertainty;
- b) by successive measurements at near zero concentration. The detection limit is assumed to be three times the standard deviation.

## 12.2 Experimental data

Validation tests were performed in two municipal waste incinerators equipped with different kinds of gas treatment:

- a) plant A: semi dry process with a fabric filter, stack gas temperature: 140 °C;
- b) plant B: electrostatic precipitator, with a scrubber, stack gas temperature: 60 °C, water saturated.

Sampling duration was limited to 30 min.

The results are given in Table 3.



Table 3 — Results of validation test

	Plant		
	A		B
Number of teams in parallel	4		3
Number of out-stack/in-stack devices	1/3		3/0
Number of successive tests	32		16
	Dust on filter only mg/m <sup>3</sup>	Total dust including rinsing mg/m <sup>3</sup>	Total dust mg/m <sup>3</sup>
Dust concentration mean:	4,7	6,4	2,5
extreme values:	2 to 17	3 to 19	0,3 to 6,8
Repeatability	1,7	2,1	1,9
External uncertainty	2,4	4,0	1,8
Reproducibility	3,4	5,7	2,6
Source: See document CEN/TC 264/WG 5 N 151			

The detection limit was estimated from results by one team, to be:

- a) for dry gases: approximately 0,3 mg/m<sup>3</sup> (dust on filter only);
- b) for water saturated gases: approximately 2 mg/m<sup>3</sup> (total dust).

### 12.3 Comments

During the above tests, some high overall blank values were reported ( $\pm 1$  mg/m<sup>3</sup> or higher) due to weighing uncertainties of rinses dry extracts (use of vessels of improper material, etc).

Further investigation showed that these uncertainties can be reduced to less than 0,5 mg/m<sup>3</sup>, leading to an improvement of repeatability and reproducibility.

Increased sampling time to 60 min or to 90 min would improve significantly the reproducibility of measurements.

## 13 Test report

The test report shall refer to this European Standard, and shall include the following information.

**13.1 Identification of the customer**, identification of the persons responsible for and involved in the measurements.

**13.2 Description of the purpose of tests**, identification of the site, date of sampling.

**13.3 Description of the operating conditions of the plant process**, and any variation during measurements.

**13.4 Identification of the sampling location**, and gas parameters in the duct:

- a) duct dimensions, number and position of sampling lines and sampling points;

- b) velocity and temperature profile;
- c) O<sub>2</sub>/CO<sub>2</sub>, humidity, volumetric mass of gases;
- d) compliance with 5.2 requirements.

### 13.5 Measurement procedures

- a) velocity measurement (calibration of velocity measurement devices other than standardised Pitot-tubes etc.);
- b) characteristics of sampling equipment:
  - 1) nozzle diameter;
  - 2) characteristics of the filter (material, sizes, etc.);
  - 3) calibration of volume or flow rate measurement devices;
  - 4) filtration temperature;
- c) weighing procedures:
  - 1) conditioning temperature;
  - 2) correction of apparent weights.

### 13.6 Test results

- a) number of tests;
- b) for each test:
  - 1) date, time and duration;
  - 2) sampled volume and average flow rate;
  - 3) dust mass on the filter and in the rinse solutions;
  - 4) raw results (dust on filter, dust in rinses) and corrected results (standard conditions);
  - 5) any special circumstance or incidents.

Raw data e.g. gross weight, average temperature during sampling, average duct pressure during sampling, etc.) shall be included in the report or they shall be available for inspection.

### 13.7 Quality assurance

- a) leak tests results;
- b) overall blank value;
- c) compliance with the isokinetic criterion.

### 13.8 Comments

- a) the test report shall also indicate any special circumstances which might have influenced the results, and any information concerning the uncertainty of the results;

- b) if it has been necessary to modify the method for any reason, then this modification and corresponding validation data shall be reported.

## Annex A (normative)

### Requirements related to the working platform

For safety reasons, the permanent and temporary working platform:

- a) shall have an adequate working area, normally not less than 5 m<sup>2</sup>;
- b) shall be able to bear at least 400 kg point load;
- c) shall have handrails (approximately 0,5 m and 1 m high) and vertical base boards (approximately 0,25 m);
- d) shall have handrails with removable chains across the top of the ladders or self-closing gates;
- e) electrical sockets, plugs and equipment shall be waterproof if they are to be exposed to the weather.

For practical and quality reasons, the working platform:

- a) shall be positioned relative to the access ports in such a way that the handrail will be clear of the apparatus to be used and shall be free from obstructions that would hamper insertion and removal of the sampling equipment (the length of which exceed 4 m for large ducts);
- b) shall have a minimum length in front of the access port of 2 m or the length of the probe (which includes nozzles, suction/support tubes and associated filter holders) plus 1 m, whichever is greater, and a minimum width of 2 m.

The measuring site shall have artificial lighting and be ventilated. Provisions shall be made for requisite electric power, at request also water and compressed air, etc.. Hoists for raising and lowering of equipment may be needed.

Suitable protection shall also be considered for personal and equipment if the platform is exposed to weather.

NOTE An European Standard in four parts is under preparation (see [1] to [4]).

## Annex B (normative)

### Determination of flow direction with Pitot tubes

#### B.1 Type L Pitot tube

The type L Pitot tube provides an accurate measure of gas velocity when the Pitot tube is aligned (yawed) within  $15^\circ$  of the direction of the gas flow. However, the pressure difference between the two pressure-sensing orifices decreases sharply when misalignment exceeds  $15^\circ$ , until a negative response occurs when the head is at  $90^\circ$  to the gas flow. This provides a simple method for estimating gas flow direction and may be used to test for the presence of swirling flow within the duct.

#### B.2 Type S Pitot tube

The type S Pitot tube accurately measures the gas velocity to within 4 % when the Pitot tube is aligned (yawed) within  $15^\circ$  of the direction of the gas flow. However, when the planes of the Pitot tube pressure-sensing orifices are parallel to the stack flow, a null (zero) reading is obtained. Thus, the direction of swirling flow can be determined by rotating the type S Pitot tube (with the manometer properly zeroed and levelled) until a null reading is obtained. The direction of flow shall be parallel to the pressure-sensing orifice planes.

## Annex C (normative)

### Methods for determining the positions of sampling points in circular and rectangular ducts

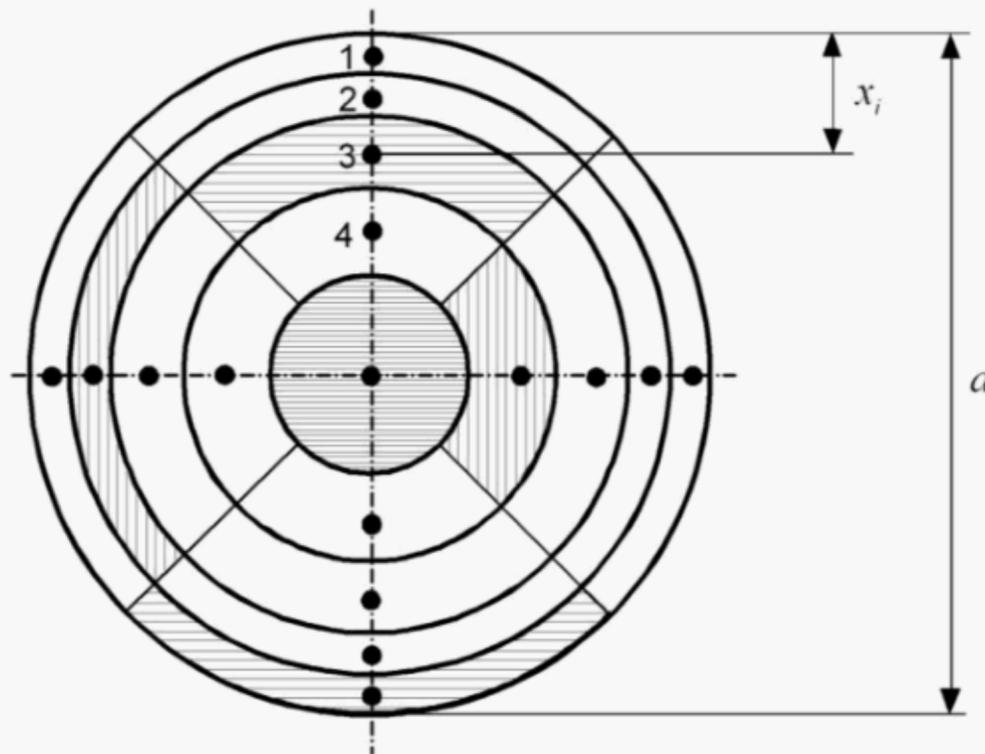
#### C.1 Method for circular ducts

##### C.1.1 General

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

##### C.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 C.1).



**Figure C.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.

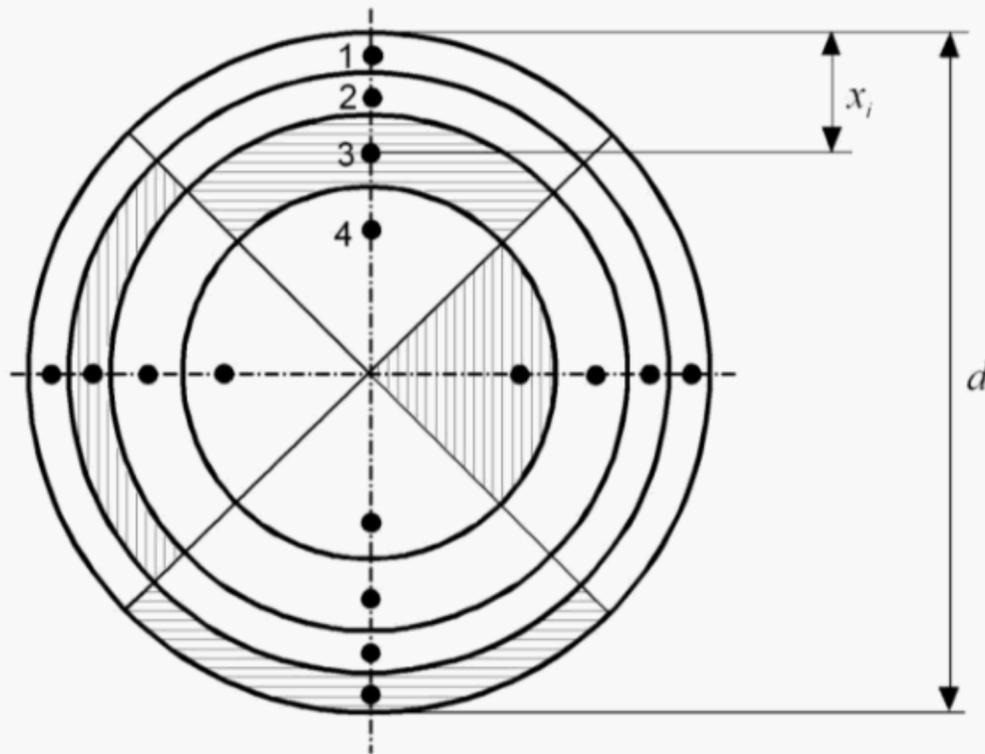
For circular ducts two sampling lines (diameters) are sufficient, the distance of each sampling point from the duct wall may be expressed as:

$$x_i = K_i d \tag{C.1}$$



**C.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 C.2).



**Figure C.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 of each sampling point from the duct wall may conveniently be expressed as:

$$x_i = K_i d \tag{C.5}$$

where

$K_i$  is the value, as a percentage, accordingly to Table C.2.

Table C.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.



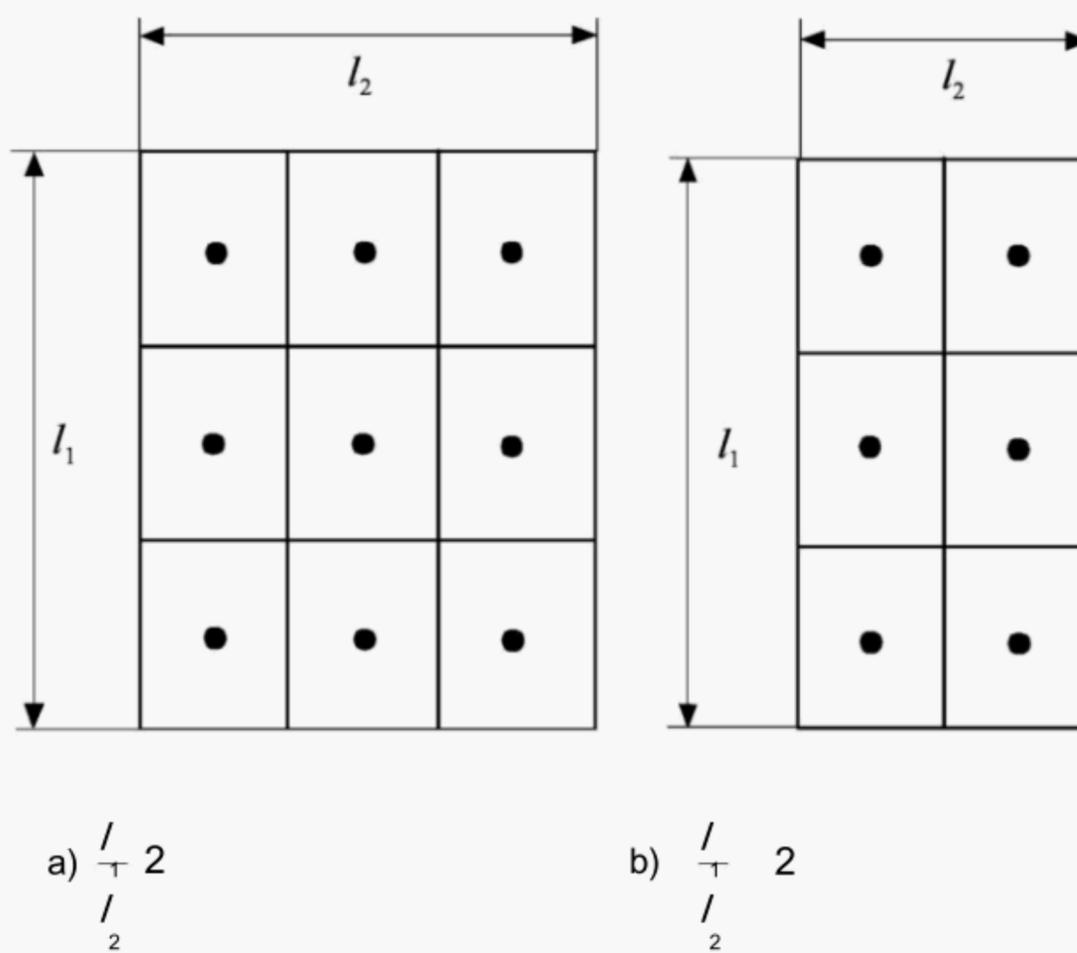
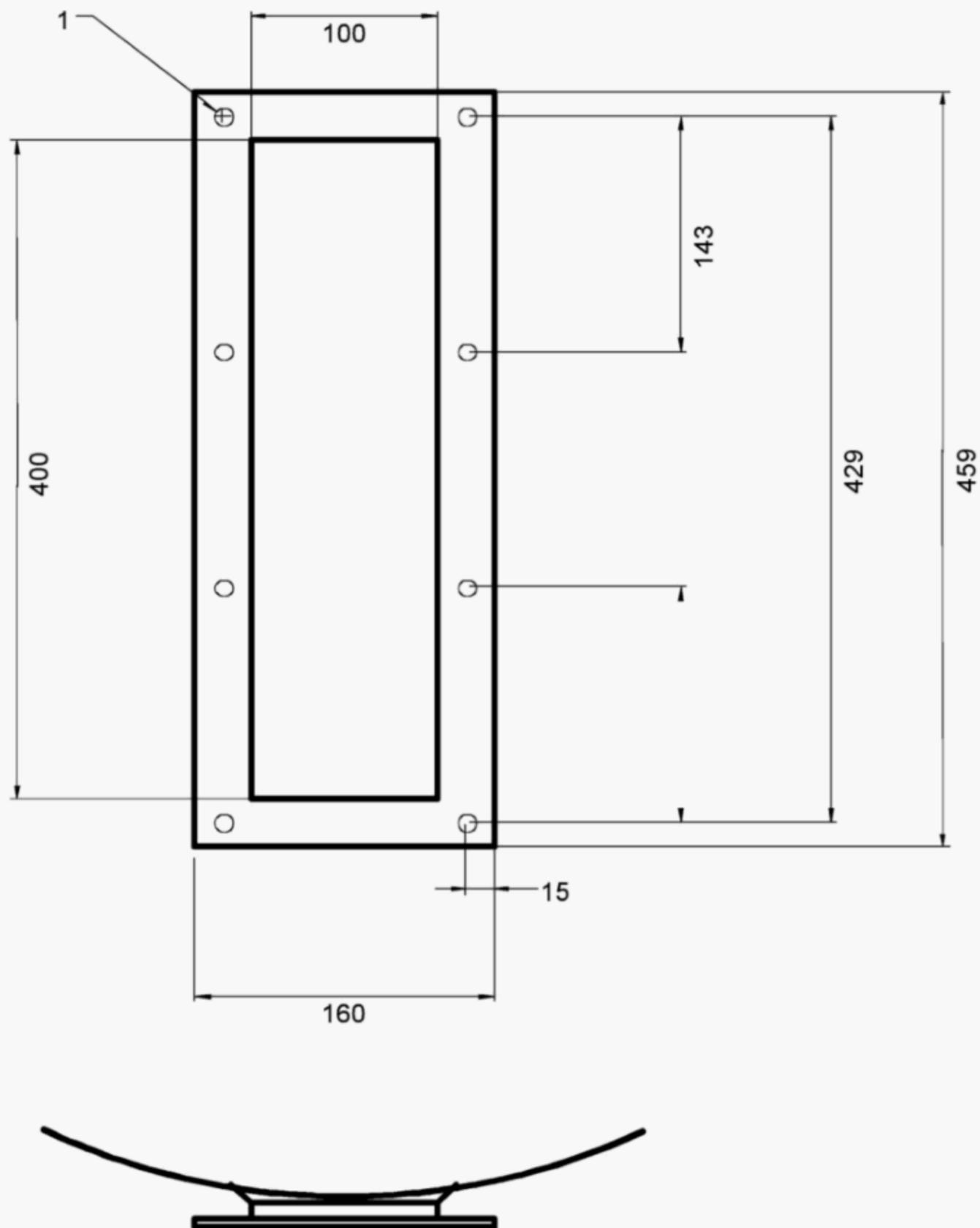


Figure C.3 — Illustrations of sampling point positions in rectangular ducts

## Annex D (informative)

### Examples of suitable access ports for sampling equipment

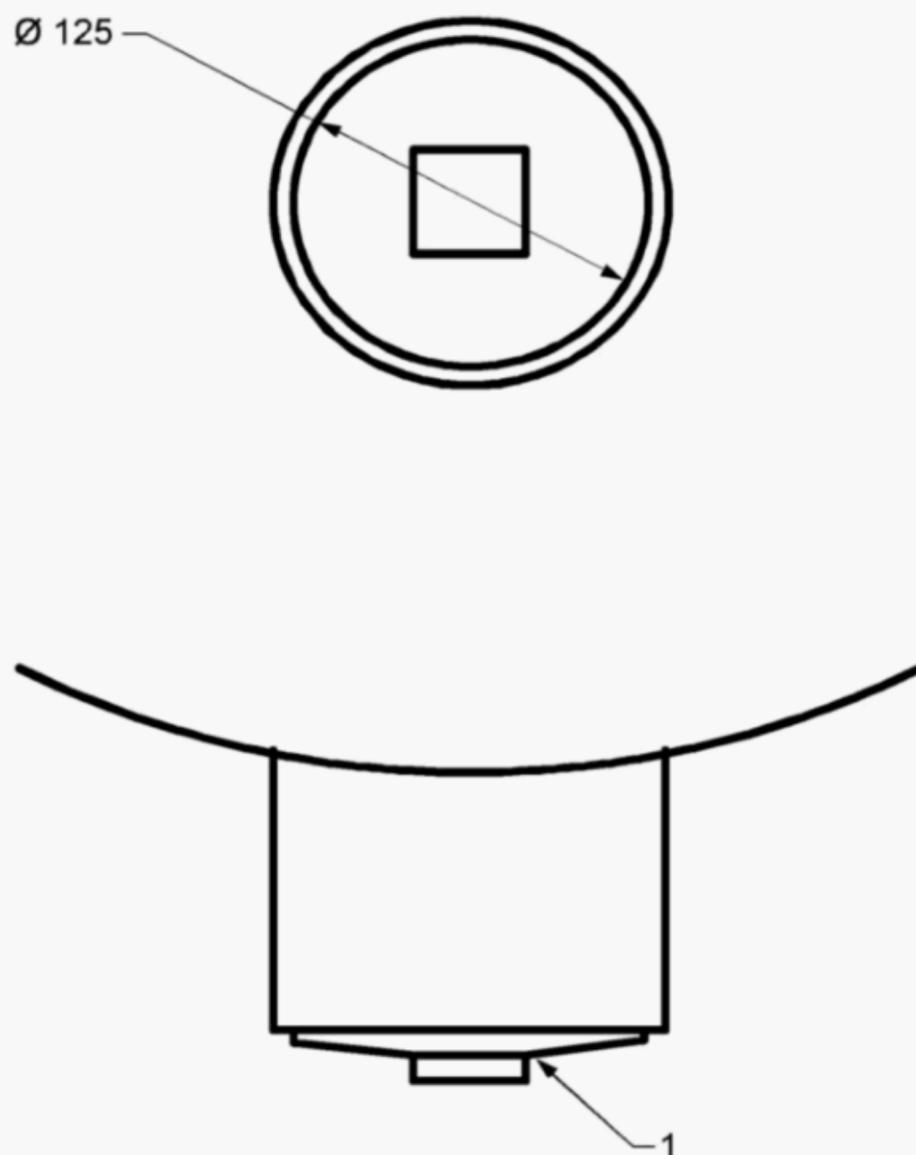
Dimensions in millimetres



#### Key

1 8 holes 9 mm

Figure D.1 — Example of rectangular access port



Key

1 Cap

Figure D.2 — Example of circular access port

## Annex E (normative)

### Proven design of the entry nozzles

Figures E.1 and E.2 show three designs of the entry nozzles, where:

- $e$  is the thickness of the side of the nozzle;
- $D_i$  is the internal diameter of the entry nozzle;
- $R$  is the radius of the nozzle entry edge;
- $L$  is the length with constant internal diameter.

a) Figure E.1:

- 1)  $e < D_i/12$  but at least 0,8 mm;
- 2)  $L$  10 mm;
- 3)  $R$  0,2 mm.

Effective diameter  $D_{\text{eff}} = D_i + 2R$ .

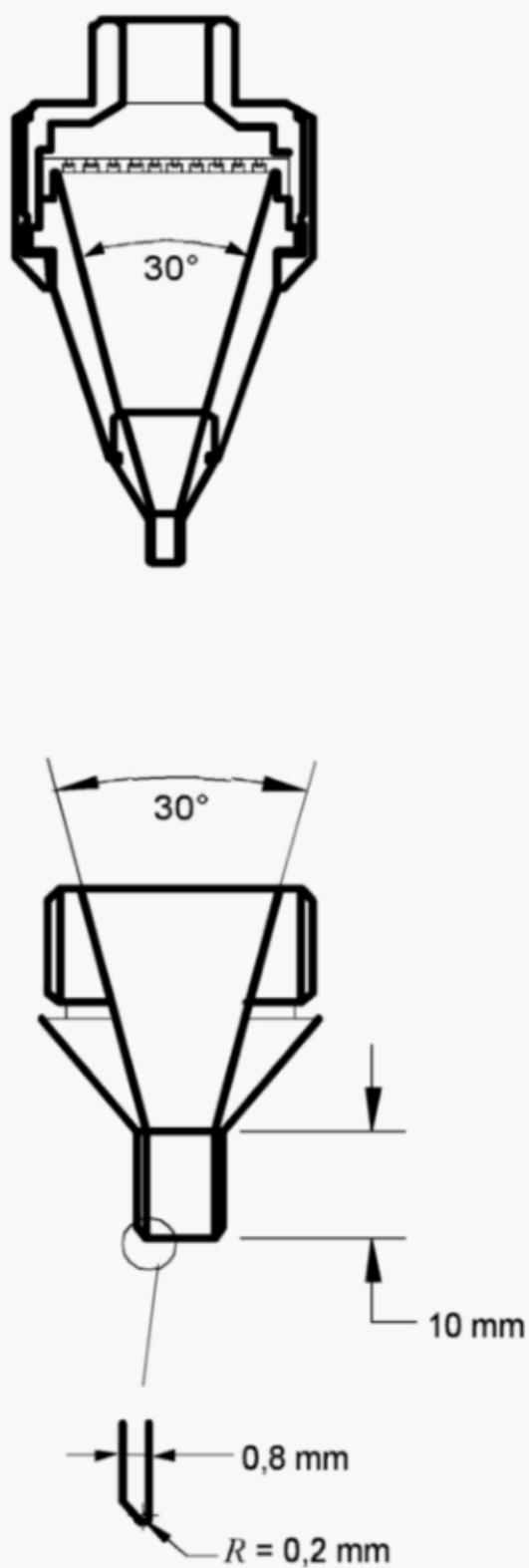


Figure E.1 — Example of „in-stack“ filter holder with proven integral nozzle

b) Figure E.2:

$e$  0,2 mm.

Effective diameter  $D_{\text{eff}} = D_i + e$ .

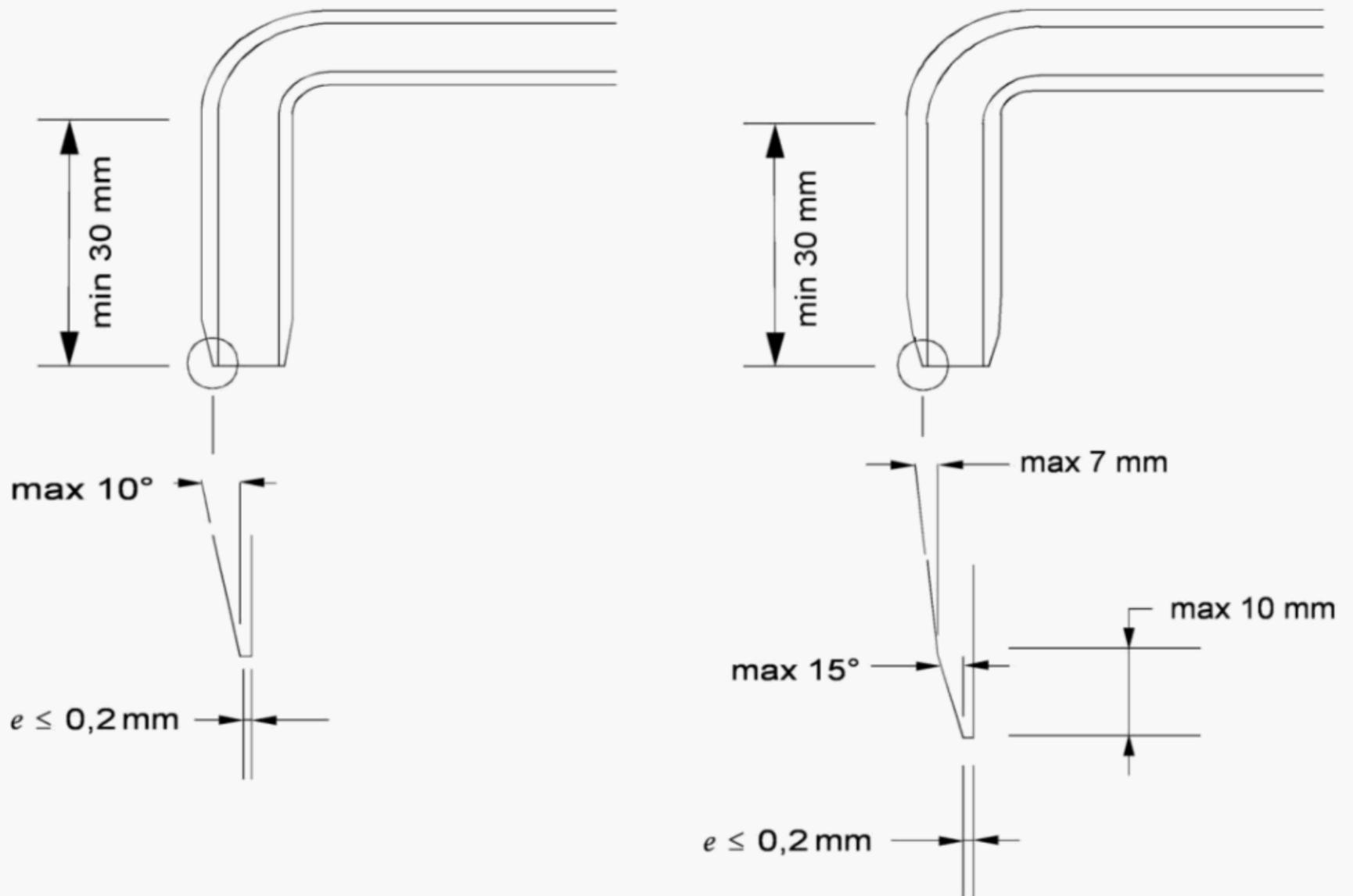


Figure E.2 — Example of proven entry nozzles

## Annex F (normative)

### Summary of the requirements

Table F.1

Equipment	Value	Paragraph
Nozzle: internal diameter	> 6 mm	6.2.4
Nozzle: uncertainty of area at nozzle entry	10 %	6.2.4
Nozzle: length with constant internal diameter	> 10 mm	6.2.4
Nozzle: change in diameter angle	< 30°	6.2.4
Nozzle: radius of the bend	> 1,5 times internal diameter	6.2.4
Nozzle: straight length before the first bend	> 30 mm	6.2.4
Filter holder: distance to obstacles	> 50 mm	6.2.4
Filter:		
– efficiency on test aerosol of 0,3 µm	> 99,5 %	6.2.7
– efficiency on test aerosol of 0,6 µm	> 99,9 %	6.2.7
Filter: filter material	No reaction and no absorption of the components	6.2.7
Condenser, drying tower: residual gas moisture	< 10 g/m <sup>3</sup>	6.2.8
Gas meter:		
– uncertainty of gas volume	2 %	6.2.8
– uncertainty of absolute pressure	1 %	6.2.8
– uncertainty of absolute temperature	1 %	6.2.8
Angle of the nozzle with regard to gas flow	< 10°	8.4
Isokinetic rate	95 % to 115 %	8.4
Leak rate	< 2 %	8.4
Balance: resolution	0,01 mg to 0,1 mg	6.4
Weighing uncertainties	< 5 % of the LV <sup>a</sup>	10.6
Weighing: temperature equilibrium duration	4 h to 12 h	7.2
Overall blank value	< 10 % of the LV <sup>a</sup>	10.6
Sampling location		
Duct gas flow: angle with regard to duct access	< 15°	5.2
Duct gas flow: negative velocity	not permitted	5.2
Duct gas flow: differential pressure at Pitot tube	> 5 Pa	5.2
Duct gas flow: ratio of max. to min. velocity	< 3:1	5.2
Straight length before the sampling plane	> 5 hydraulic diameters (recommended)	5.2
Straight length after the sampling plane	> 2 hydraulic diameters (recommended)	5.2
Straight length before emission point	> 5 hydraulic diameters (recommended)	5.2
Number of sampling points	See 5.3	5.3
Flue gas characteristics		
Flue gas density: uncertainty	0,05 kg/m <sup>3</sup>	6.1
<sup>a</sup> LV: Limit value set for the process.		

## Annex G (informative)

### Sampling volume, flow rate and duration

#### G.1 General

The minimum gas volume to be sampled is derived from the uncertainties in dust weighing and the reference dust concentration (Limit Value set for the process, LV).

#### G.2 Weighing uncertainties

These uncertainties are not only related to the balance performances but to the whole weighing procedure. In accordance with 7.6, they are determined by repeated weighing of filters and weighing containers.

The mass of dust  $m$  to be collected when sampling at LV concentration  $L$  is at least 20 times the weighing uncertainties (see 10.6).

#### G.3 Sampling volume

The necessary minimum sampling volume  $V_{\min}$  is then determined by the following equation:

$$V_{\min} = \frac{m}{L} \quad (\text{G.1})$$

#### G.4 Sampling flow rate and duration

When the sampling duration  $t_s$  is limited (e.g. 30 min), the minimum sampling flow rate  $Q_{\min}$  is:

$$Q_{\min} = \frac{V}{t_s} \quad (\text{G.2})$$

where

$Q_{\min}$  is compared to the practical flow rate which can be achieved by the used sampling equipment (filter pressure drop, pump characteristics, etc.).

## Annex H (informative)

### Examples of weighing bias

#### H.1 General

Weighing bias related to insufficient temperature equilibrium, and to climatic changes between pre- and post sampling weighing, are illustrated in the following example.

In this example, the filter is placed in a closed glass Petri box, mass 25 g, inside air volume 40 ml. The balance is calibrated against a standard mass 25 g (volumic mass 8 g/ml). Volumic mass of glass 2 g/ml, of air 1,2 mg/ml.

#### H.2 Effect of insufficient temperature equilibrium

Because of too low equilibrium time after drying, the inside air of the Petri box is supposed to have a temperature 2 K higher than that of the room balance (300 K). The difference of air temperature leads to an apparent mass variation of:

$$40\text{ml} \cdot 1,2 \frac{\text{mg}}{\text{ml}} \cdot \frac{2\text{K}}{300\text{K}} = 0,3\text{mg} \quad (\text{H.1})$$

#### H.3 Effect of temperature variations

The room balance temperature is 15 °C when weighing before sampling, and 25 °C when weighing after sampling.

The difference between the volume of air displaced by the standard mass (25 g, volume 3,1 ml) and by the Petri box (25 g, volume 12,5 ml) is 9,4 ml.

Due to the temperature change (10 K) this air volume leads to an apparent weight modification of:

$$9,4 \text{ ml} \cdot 1,2 \frac{\text{mg}}{\text{ml}} \cdot \frac{-10 \text{ K}}{300 \text{ K}} = -0,4 \text{ mg} \quad (\text{H.2})$$

#### H.4 Effect of barometric pressure variations

The barometric pressure is supposed to be:

- a) when weighing before sampling 98,5 kPa;
- b) when weighing after sampling 104 kPa .

Therefore a relative variation of 5,5 %.

Due to this relative variation, the 9,4 ml air volume leads to an apparent weight modification of:

$$9,4 \text{ ml} \cdot 1,2 \frac{\text{mg}}{\text{ml}} \cdot 0,055 = 0,6 \text{ mg} \quad (\text{H.3})$$

#### H.5 Conclusions

- a) When weighing parts with large internal volume, it is mandatory, that the temperature equilibrium has been reached before weighing;

- b) there is no need for correction of temperature effects if the room where the balance is situated is thermally controlled. But it remains necessary that the effect of barometric pressure variations will be taken into account, especially if the volumic mass of parts to be weighed is very different from those of standard masses used for calibration. The required correction may be done by weighing the "control parts", as indicated in 7.3.

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- [5] ISO 10780 Stationary source emissions – Measurement of velocity and volume flow rate of gas streams in ducts.



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