INTERNATIONAL STANDARD

ISO 10397

First edition
1993-08-01

Stationary source emissions — Determination of asbestos plant emissions — Method by fibre count measurement

Émissions de sources fixes — Détermination des émissions par des usines d'amiante — Méthode par comptage des fibres

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Contents

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Annexes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10397 was prepared by Technical Committee ISO/TC 146, *Air quality*, Sub-Committee SC 1, *Stationary source emissions*.

Annexes A, B, C, D and E of this International Standard are for information only.

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Introduction

This International Standard is essentially made up of two parts:

— sampling of asbestos-containing emissions to the atmosphere;

— fibre counting.

Unfortunately the accuracy of the analysis (fibre counting) is such that it adversely affects the accuracy of the whole method. Therefore, it is vitally important that the analytical side be carried out by experienced analysts who have been specially trained in conjunction with an approved quality control scheme.

Although this method has been designed to deal specifically with fibre emissions from asbestos works, it can also be applied to other processes dealing with fibrous materials. Indeed, many asbestos works use substitute fibres and therefore may contain mixed fibre emissions at times. Where this is probable, or where there is a need to identify which fibres are asbestos and which are not, it will be necessary to employ more sophisticated techniques for fibre identification (see ISO 10312). This is not covered in this International Standard.

It should be noted that differences exist at present in the way asbestos fibres and non-asbestos fibres are assessed, especially in the workplace. However, these differences should not affect the way this method is used to assess the effectiveness of the arrestment plant.

This International Standard is intended not only to be used to give a quantitative concentration of fibres in emissions from asbestos works, but also as a means of showing the effectiveness or otherwise of the operation of dust and fibre collection equipment.

Because of the relatively short duration of sampling, this method is fairly sensitive to process fluctuations, and therefore a full record of test parameters is required.

The analytical technique for fibre counting used in this method follows that described in ISO 8672.

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WARNING — SAFETY PRECAUTIONS

GENERAL

Sampling operations may involve a variety of hazards depending on the circumstances. Management, sampling operators and control authorities, shall consider the likely hazards well before sampling commences. The sampling site shall be assessed prior to sampling. If hazards cannot be eliminated, appropriate safety arrangements shall be made with regard to any specific local, national or international regulations or codes of practice. Special care is needed concerning asbestos and the method should be carried out by experienced personnel.

The hazards that may be encountered and advice on ways to alleviate them are given below.

PLANT MANAGEMENT

It is essential that plant management and plant operators be made aware that sampling is taking place. Also plant safety procedures shall be followed, e.g. work permits, etc.

HAZARDS TO SAMPLING OPERATORS

a) Exposure to asbestos and other substances: Consider visual inspection and/or cleaning of site, monitoring or personal protective equipment.

b) Inadequate sampling facilities: Provide sufficient workspace for sampling equipment and operators, consider appropriate services, electricity, compressed air, lighting, weather protection, hoists, etc.

c) Working at heights or in remote locations: Consider means of escape, guard rails, warning systems and the need for communications.

d) Exposure to toxic, corrosive, hot or pressurized gases: Consider sampling location, monitoring or warning systems, personal protective equipment, etc.

e) Electrical hazards: Consider equipment protection, earthing, earth leakage circuit breakers and national safety standards, etc.

f) Noise and heat: Consider protective measures.

HAZARDS TO OTHER PERSONNEL

a) Objects falling from the platform: Consider warning signs, barricading, etc.

b) Presence of temporary equipment, e.g. cables causing trip hazards: Consider warning signs, etc.

HAZARDS TO PLANT/PROPERTY

a) Ignition of flammable gases: Consider using non-electrical equipment and non-sparking tools, etc.

b) Equipment dropping into duct: Ensure that equipment is properly assembled.

1 Scope

This International Standard specifies a method, using a fibre count technique, for the assessment of fibre concentrations in flowing gas streams in ducts, chimneys or flues from industrial processes using asbestos.

This method may be used to determine fibre concentrations from a wide range of processes where it is known that "regulated" fibres are present in emissions. No attempt is made to identify asbestos fibre types separately from other fibres.

NOTES

1 If fibre identification is required, reference should be made to ISO 10312.

2 This method may be used to check that dust collection equipment, used to trap or prevent asbestos fibres escaping into the atmosphere, is working properly and effectively.

3 This International Standard may be used to measure fibre concentrations as described in European Community Council Directive No. 87/217/EEC on the prevention and reduction of environmental pollution by asbestos.

The range of application of the method for concentrations of fibres in ducts is about 0,05 fibres/cm^3 to 10 fibres/cm^3, although this range may vary according to the sampled volume which in turn will depend on duct velocities and the sampling apparatus used.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

ISO 8672:1993, *Air quality — Determination of the number concentration of airborne inorganic fibres by phase contrast optical microscopy — Membrane filter method.*

ISO 9096:1992, *Stationary source emissions — Determination of concentration and mass flow rate of particulate material in gas-carrying ducts — Manual gravimetric method.*

ISO 10312:—[1], *Ambient air — Determination of asbestos fibres — Direct transfer transmission electron microscopy method.*

3 Definitions

For the purposes of this part of ISO 10397, the following definitions apply.

3.1 aspect ratio: Ratio of the length of the fibres to their diameter.

3.2 access port: A hole in the duct, provided with a flanged or threaded socket, through which the sampling probe is inserted along the sampling line.

3.3 cumulative sampling: The collection of a single composite sample obtained by sampling for the required period at each sampling point in turn.

3.4 duct: A chimney stack or ducting at the outlet of dust collecting equipment carrying asbestos-fibre laden gases.

3.5 fibre concentration: The number of "regulated" fibres per normal cubic centimetre of gas.

3.6 fibre count technique: A method for counting the number of "regulated" fibres present on a membrane filter and the calculation of fibre concentrations. [ISO 8672]

3.7 isokinetic sampling: Sampling at a rate such that the velocity and direction of the gas entering the sampling nozzle is the same as that of the gas in the duct just prior to the sampling point.

3.8 pump: A fan, vacuum pump or other apparatus used for extracting a sample of gas from ducts or chimneys.

3.9 "regulated" fibres: Fibres that meet the following criteria:

length $\geqslant$ 5 µm,

diameter $\leqslant$ 3 µm,

minimum aspect ratio 3:1.

3.10 hydraulic diameter D_1: The equivalent diameter of a rectangular duct given by the formula

$$D_1 = \frac{4 \times \text{Area of the sampling plane}}{\text{Perimeter of the sampling plane}}$$

1) To be published.

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4 Symbols with their corresponding units and subscripts

See table 1 for symbols and their corresponding units and table 2 for subscripts.

Table 1 — Symbols and their corresponding units

Symbol	Meaning	Unit
A_F	Effective filtering area of the membrane filter	mm^2
C	The concentration of fibres in the stack	fibres/cm^3
D_G	Diameter of the Walton-Beckett graticule	µm
D_F	Diameter of the exposed area of filter	mm
d	Diameter of the filter nozzle	mm
f	Fibres (see 3.1)	
K	Calibration factor for Pitot-static tube	
k	Simplified calibration factor for Pitot-static tube	
N	Total number of fibres counted	
n	Number of graticule areas examined	
P	Absolute pressure	Pa
δp	Differential pressure (Pitot-static readings)	Pa
R	Sampling rate	m^3/min
T	Absolute temperature	K
t	Temperature of the duct gases	°C
v	Gas velocity at a sampling point	m/s
V	Volume of sampled gas	m^3
ρ	Density of duct gas	kg/m^3
Θ	Duration of sampling	s

Table 2 — Subscripts

Subscript	Meaning
S	Standard conditions of 1,013 bar and 0 °C
F	Filter
G	Graticule
I	Integrating meter
T	Total

5 Principle

The apparatus is inserted into a moving gas stream and a known volume is withdrawn isokinetically. The sampled gas is passed through a filter medium which removes particulate matter (including fibres) from the gas stream. The filter is treated to make it transparent when viewed under a microscope, and the number of fibres are counted, in a precise number of fields viewed using a phase-contrast optical microscope.

Knowing the volume of gas sampled, the cross-sectional area of the filter, the number of "regulated" fibres counted, and the cross-sectional area of each field, the concentration of fibres in the moving gas stream can then be calculated.

6 Summary of method

The method specifies the apparatus and the way in which it is to be used to take a sample, in order that the concentration of fibres emitted in a gas stream from an asbestos process can be determined by measurement and calculation. This enables an assessment to be made of the effectiveness of the measures being taken to prevent pollution.

The sampling train shown schematically in figure 1, consists of the following:

— probe with nozzle and fibre collector;

— flow regulation equipment;

— volume measurement apparatus;

— pump.

The analytical equipment consists of:

— a phase contrast microscope;

— filter "clearing" equipment;

— flow and temperature measurement apparatus.

This is a sensitive method which requires small samples and relatively short sampling times, which enables several samples to be taken, thus improving the precision of the method. In practice, a preliminary sample and two definitive samples will normally be taken.

Initially, before sampling can begin, it will be necessary to take note of all plant operating parameters and dimensions at the sampling plane. Then, the flow rate and temperature of the gases in the duct are measured and the atmospheric pressure is noted.

Once these preliminaries have been dealt with, the sampling train is assembled, selecting the appropriate nozzle to ensure that isokinetic sampling can be carried out.

The sampling probe is inserted in sequence into the access holes in the duct and a sample is withdrawn isokinetically from the four points at the centre of four equal areas. The sample volume is then recorded. The

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sample, which is collected on a membrane filter, is transported to a laboratory where it is treated to enable the counting of the fibres under a phase-contrast microscope.

From the recorded data, the concentration of fibres in the duct can be calculated.

7 Apparatus

7.1 General

Use a sampling train for sampling regulated fibres as shown in figure 1. The apparatus to be used is listed in table 3. The items of apparatus provided shall be constructed of materials (e.g. stainless steel) capable of withstanding the conditions under which they will be used, shall be portable or transportable, and shall be capable of sampling isokinetically (see 12.3) at a steady rate.

NOTES

4 Access ports on the duct will be needed to enable sampling to take place.

5 A well established and accepted laboratory to undertake analytical work will be required. The laboratory should be part of a quality control system.

Table 3 — Sampling and analytical apparatus

Number (see figure 1)	Apparatus	Design	Requirements
1	Sample nozzle and filter holder	See figure 3	See 7.3 and figure 3
2	Probe tube and support	Rigid and tubular to support filter holder and sample nozzle and to seal duct	See 7.3 and figure 2
3	Fibre collector	Membrane filter (mixed esters)	Efficiency of > 98 % for 3 µm size particles
4	Flowmeter for sampling	Orifice plate, variable flow orifice	Volumetric flow rate accurate to within ± 2 %
5	Regulator for sampling	Control valve or equivalent method for adjusting flow	Capable of maintaining isokinetic sampling (see 12.3)
6	Pump	Vacuum pump or fan, or equivalent with smooth flow characteristics	Suitable for isokinetic sampling and shall be gas-tight when an integrating gasmeter is employed
7	Device for measuring sample volume	Integrating dry gasmeter or equivalent (see annex B)	Gas volume measured with an accuracy of ± 2 %
8	Device for measuring temperature (in duct)	Thermocouple or equivalent	Accurate to ± 1 % of absolute temperature
9	Device for measuring flow	Pitot-static tube (see annex B) connected to a device for measuring differential pressure	Complying with ISO 3966
10	Sample containers	Sealable	Large enough to contain filter holder
11	Optical microscope	Phase contrast	Complying with ISO 8672
12	Filter clearing apparatus	Acetone/triacetin (see figure 4)	Complying with ISO 8672
13	Timing device	Stopwatch	To read to the nearest 1 s
14	Device for measuring duct dimensions	Calibrated rod, reliable drawings or equivalent (see clause 8)	Internal dimension of duct measured to ± 1 %
15	Device for measuring atmospheric pressure	Barometer or equivalent	Accurate to ± 1 %

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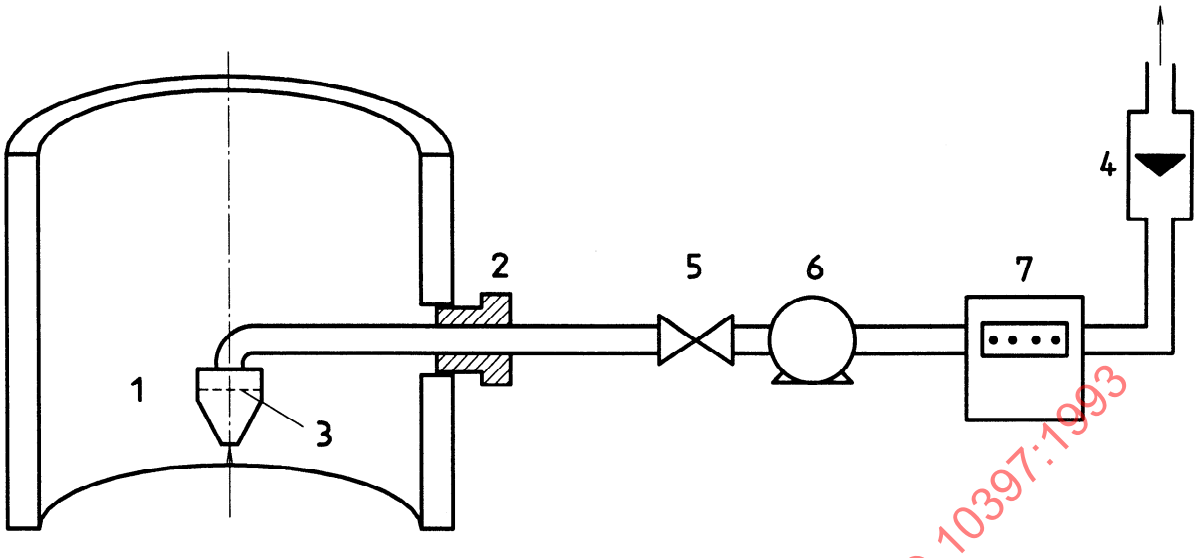

NOTE — The numbers in this figure correspond to items of apparatus listed in table 3.

Figure 1 — Typical sampling train

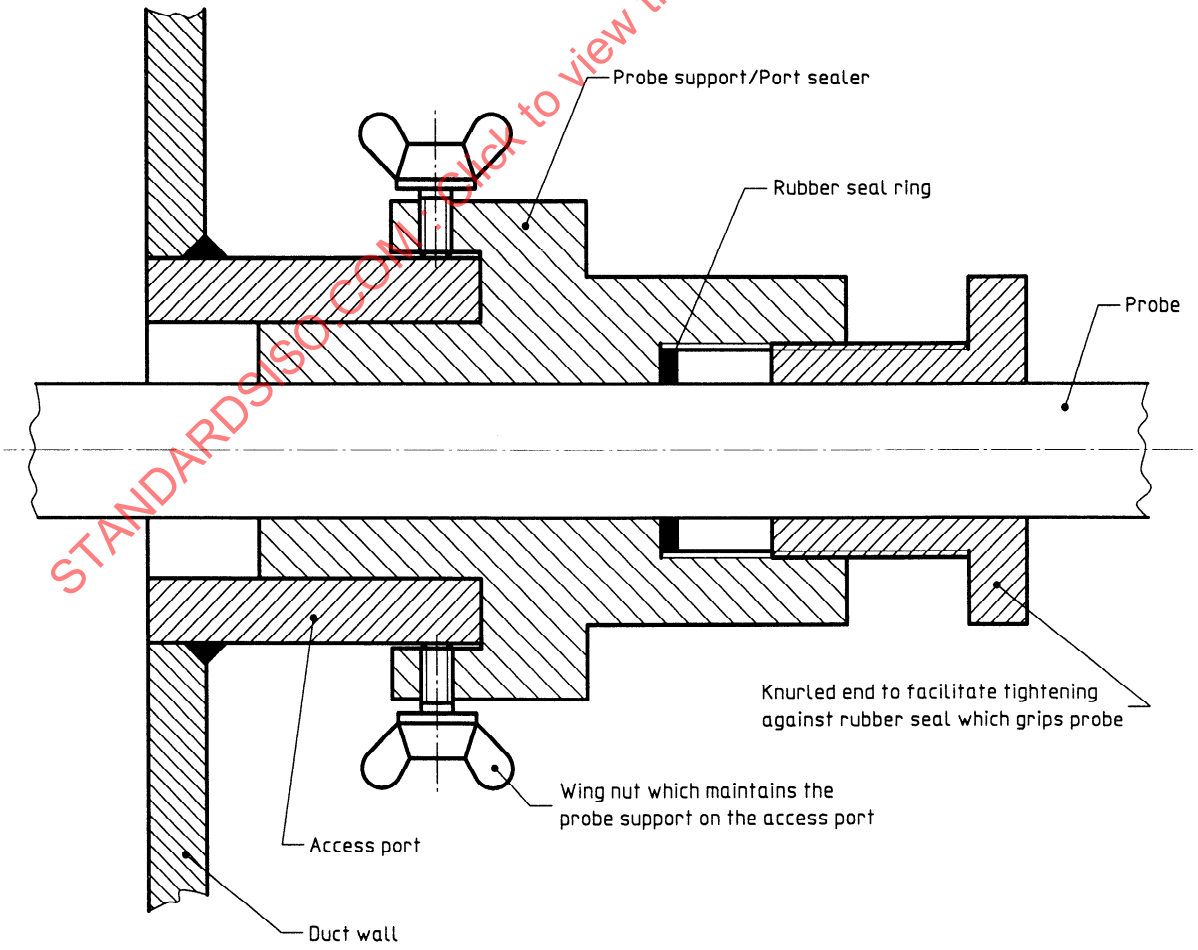

Figure 2 — Typical access port with probe support/port sealer

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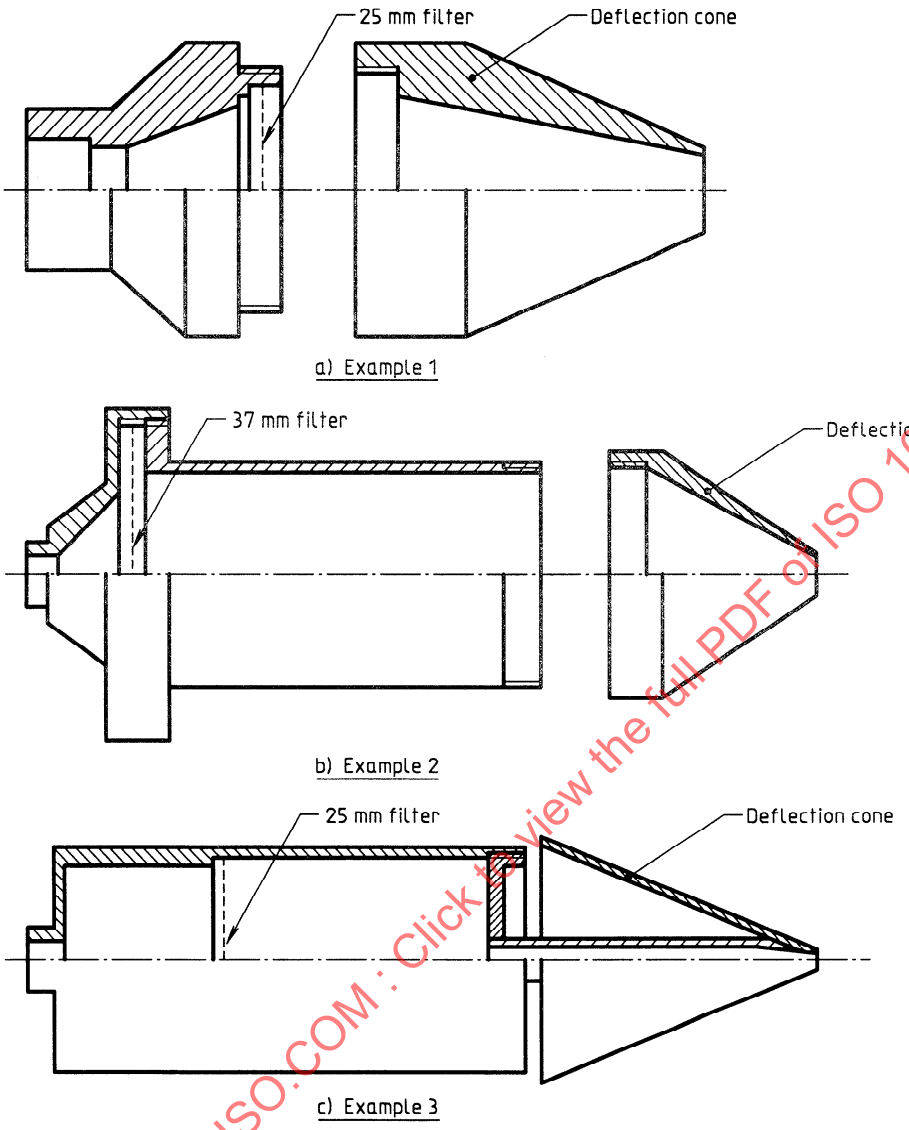

Figure 3 — Typical sample nozzle and filter holder designs

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7.2 List of apparatus

A full list of apparatus is given in table 3. The numbers assigned to the first seven of apparatus refer to those shown in figure 1, which shows a typical sampling train. All the apparatus used for sampling and analysis shall comply with the requirements given in table 3.

7.3 Sampling probe (including nozzle and fibre collector)

The probe tube shall be attached to the sample nozzle and filter holder and be long enough to enable these to be inserted into the duct through an access port, at the sampling point. It shall be provided with a mechanism for sealing the access port in such a way that entrance of ambient air or escape of duct gases are kept to a minimum.

NOTE 6 This sealing mechanism can also act as a support and a means for securing the probe in the correct sampling positions. A typical design is shown in figure 2.

The sample nozzle (see figure 3) shall be sharp edged in principle, but short enough to minimize the possibility of fibre deposition. Also, it shall be robust enough to prevent damage during general use.

NOTE 7 The designs shown in figure 3 have been evaluated to ensure even distribution of fibres over the membrane filter.

The diameter of the nozzle at the entrance shall be not less than 4 mm.

Dimensions in millimetres

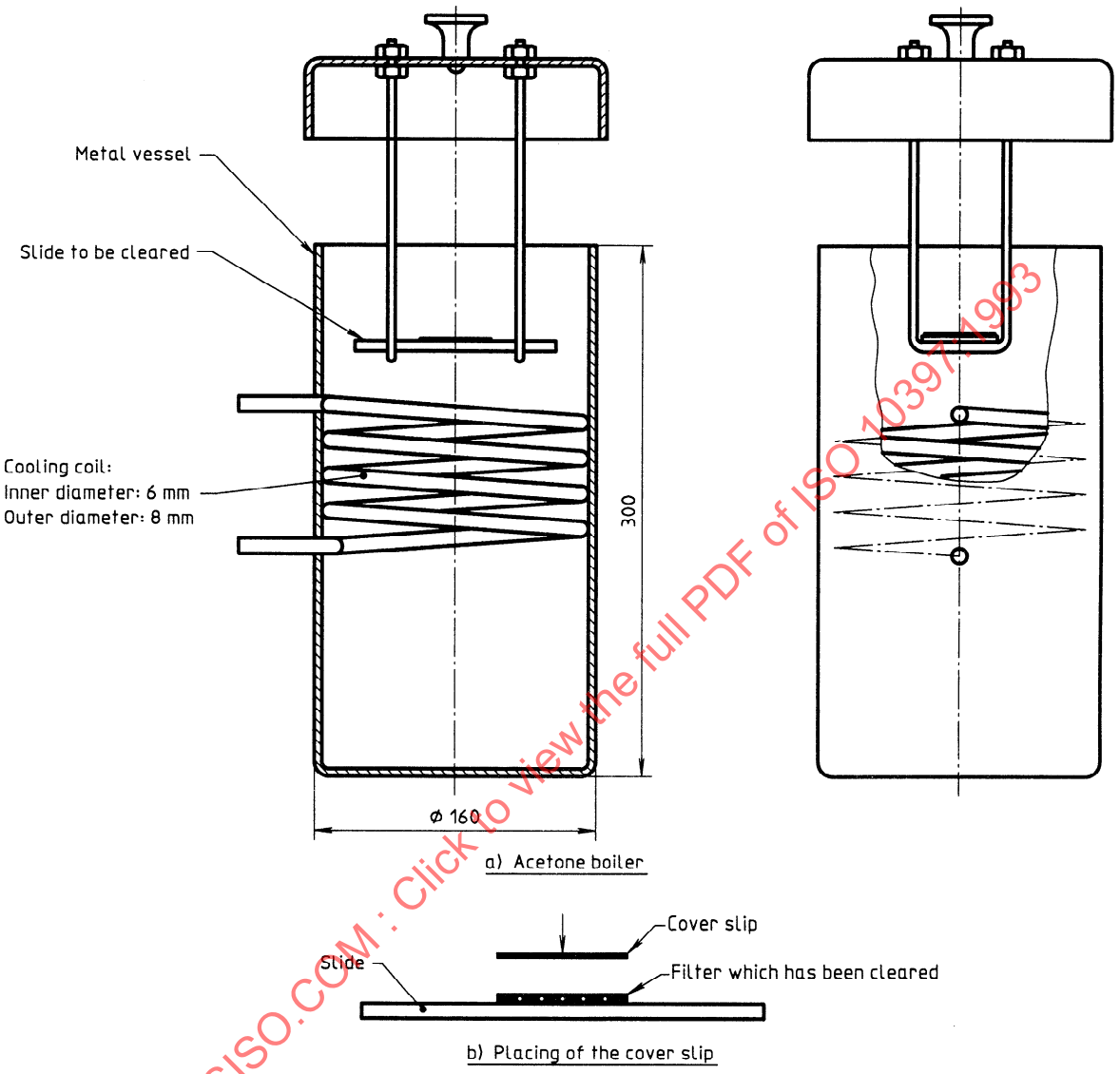

Figure 4 — Typical filter clearing appratus

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Where it has been proven by research that isokinetic sampling can be maintained, nozzles down to 2 mm can be used.

No reduction shall be made in the internal diameter over a distance of one diameter of the entry section. Any subsequent changes in bore diameter shall be tapered rather than stepped, and joints shall be smooth to prevent fibre deposition. Any bends in this section shall have a minimum radius of 1,5 times the nozzle bore diameter. The internal surfaces of the nozzle and any tubing prior to the filter shall be smooth (i.e. a roughness of $\leqslant$ 0,2 µm) to prevent deposition of fibres.

A range of different sized nozzles shall be available, so that samples can be withdrawn isokinetically from the gas streams in ducts over a range of velocities.

The fibre collector shall be of the membrane filter type, situated as close behind the sample nozzle as is convenient, to minimise deposition in unwanted areas. (See typical designs in figure 3.)

7.4 Sampling rate and volume

The pump used for extraction of the sample shall be capable of maintaining isokinetic sampling in all situations (see 12.3). It shall therefore be capable of overcoming the pressure drop created by the sam-

pling apparatus and that within the duct, and shall provide a continuous smooth flow.

Adjustment of the sampling rate shall be carried out by the use of a control valve, although voltage control of the suction unit is permissible if this is sensitive enough.

NOTE 8 In most circumstances, variable flow orifices have been found suitable for flow control, but orifice plates etc. have also been used. Although variable flow orifices are used to control the sample flow rate for isokinetic sampling, it is necessary to have an accurate measure of the volume of gas sampled.

7.5 Flow and temperature measurement in the duct

Use a Pitot-static tube meeting the requirements of ISO 3966 for measuring the flow of the gases in the duct. However, if very wet conditions are encountered which interfere with the use of this instrument, the use of a calibrated Stauschibe Pitot tube is permissible (see ISO 9096).

NOTES

9 Moisture in gas streams will adversely affect the membrane filter, and can cause clogging up and even rupture.

10 Most thermocouples are accurate enough for temperature measurement.

8 Facilities at the sampling site

8.1 General

Before attempting to conduct sampling at the asbestos site, ensure that sampling facilities are suitable by checking the accessibility of the sampling platform, safety aspects (see page 1), electrical supply and flow profile (see 8.2) in the duct.

However, if sampling has not been carried out before, determine the best sampling location downstream of the dust collection equipment (see 8.2).

8.2 Requirements for a suitable sampling location

For the sampling location to meet the requirements of this International Standard the following conditions shall apply:

a) the angle of gas flow shall be less than 15° with regard to the duct axis;

b) there shall be no reverse gas flows at any sampling point;

c) the pressure drop when using standard Pitot tubes shall be not less than 5 Pa;

d) the ratio of the highest to lowest gas velocities shall be less than 3:1;

e) the absolute temperature at any point shall be less than ± 5 % of the mean absolute temperature.

If these criteria cannot be met, try other locations until they are.

In order to see whether these criteria can be met, measure the differential pressure using a Pitot tube at ten equally spaced points along each sampling line (see figure 5). Readings should not be taken in the region close to the wall of the duct (i.e. not within 3 % of the effective duct diameter, or 30 mm, whichever is the greater). Similarly, the temperature at each of these points shall be measured.

NOTES

11 The sampling location should be situated in a length of straight duct with constant shape, preferably vertical, as far downstream as practicable from any obstruction which may cause a disturbance and produce a change in the direction of flow (e.g. a bend, a fan, a partially closed damper). The sampling location should also have a clear length of duct downstream from it, preferably several duct diameters in length, in order that conditions a) to e) can be met. Where these conditions cannot be met, refer to annex A.

If sampling in horizontal ducts is unavoidable, give consideration to having access ports situated on the upper section of a duct.

12 Before installing proper access ports, it is sensible to drill small holes in the duct at the possible sampling location and to undertake a preliminary flow and temperature survey.

8.3 Location of access ports

Access ports shall be sited at the end of each sampling line as shown in figure 5.

Sampling points are located on the sampling lines which are in the same plane. The lines are either at right angles to one another or parallel to one another, depending on the shape of the duct.

8.4 Sampling platform

Where sampling takes place at height on a chimney, a sampling platform will be required to enable sampling personnel to undertake their work and to accommodate the sampling equipment.

The platform shall be provided with all the necessary safety features required in national standards. Advice on the safety features to be considered on site is given on page 1.

NOTE 13 Where sampling can be undertaken at ground level, a sampling platform may not be required.

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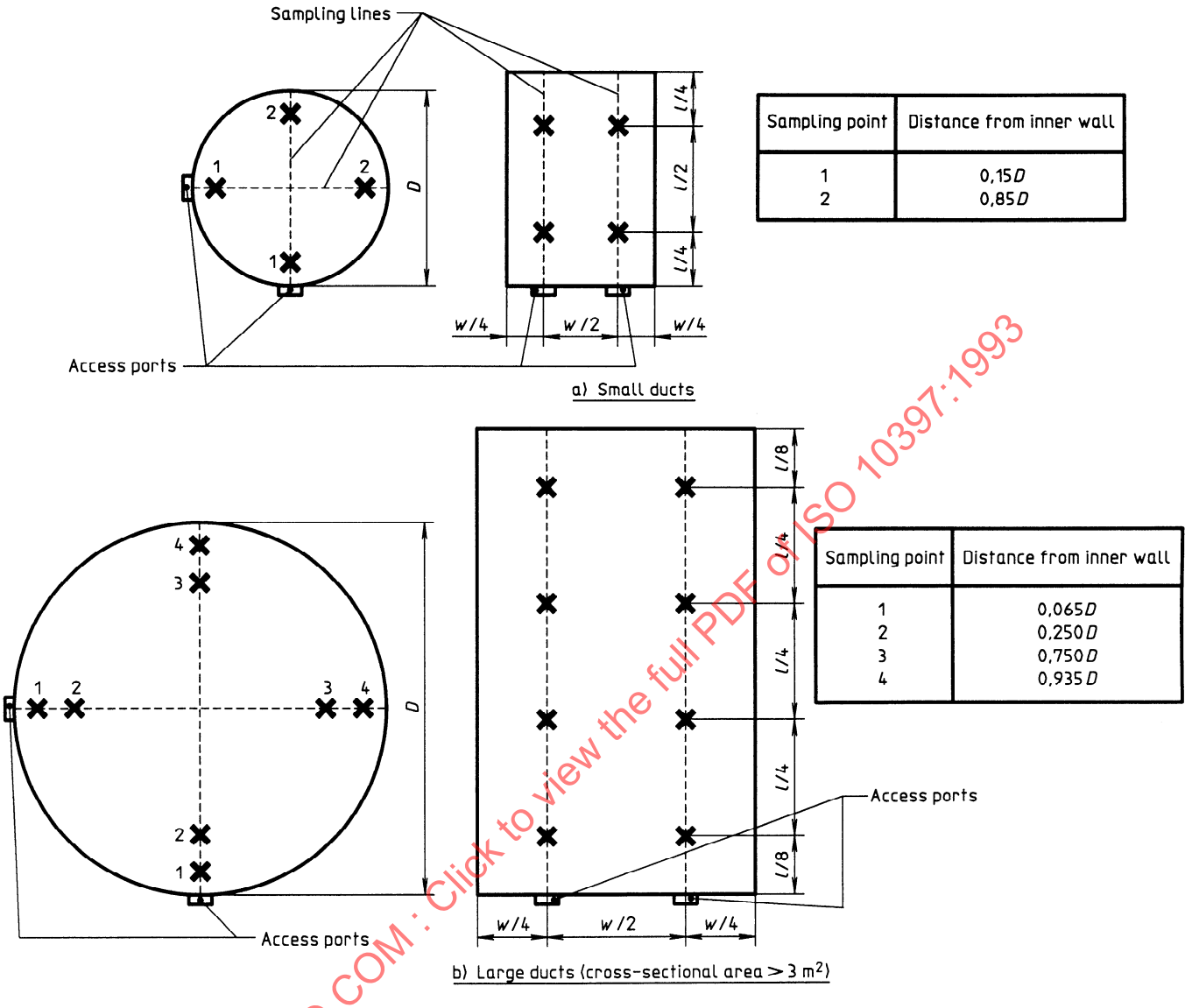

Sampling point	Distance from inner wall
1	0,15*D*
2	0,85*D*

Sampling point	Distance from inner wall
1	0,065*D*
2	0,250*D*
3	0,750*D*
4	0,935*D*

D Diameter of the duct

l Length of the duct

w Width of the duct

Figure 5 — Position of sampling points

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9 Site work prior to sampling

9.1 General

Before carrying out any measurements, make a full record of all relevant data about the asbestos processes involved and their operation, to ensure that they will be operating while sampling. Typical data sheets for site work are shown in annex C. Because of the potentially hazardous nature of asbestos, take all suitable safety precautions (see page 1).

Mount membrane filters in the filter holders in a clean fibre-free atmosphere.

Assemble the sampling apparatus for use (use any appropriate nozzle), and check it for leaks as follows. Plug the nozzle inlet with a rubber bung, apply a 50 kPa vacuum to the sampling train and seal it. If the dry gasmeter reading moves, the maximum acceptable leakage rate 0,5 l/min.

9.2 Duct cross-sectional area at the sampling plane

Measure the internal dimensions of the duct or chimney and calculate the cross-sectional area available for flow.

NOTE 14 Neither the gas velocity measuring equipment nor the probe with nozzle should be used for this purpose.

If the cross-sectional area is derived from drawings, check to see if the drawings are in agreement with the duct in question. Otherwise, rely on duct measurements.

9.3 Velocity and temperature survey

Take velocity and temperature measurements along each sampling line as described in 8.2, but including the centre of one of the sampling lines, and record them for use in 9.5 and 10.2. The atmospheric pressure (at the same height as the sampling location) shall be taken and recorded using a barometer.

9.4 The number and position of sampling points

Isokinetic samples shall be taken (see clause 10) from four or eight sampling points, depending on the size of the duct. These sampling points shall be situated at the centre of four or eight equal areas within the duct. If the cross-sectional area of the duct exceeds 3 m^2 at the sampling plane, or if the ratio of the highest to lowest pitot-static readings exceeds 4:1 (i.e. the ratio of gas velocities exceeds 2:1), then eight sampling points shall be used. Take the sample, if possible, cumulatively to satisfy the sample flow rate, the sample volume and the fibre loading on the filter. Depending on the shape and size of the duct and after consulting figure 5, determine the number and position of the sampling points.

9.5 Preliminary sample

9.5.1 To ensure that the correct sampling regime is employed when taking the two definitive samples, take a preliminary sample from the centre of the duct, as follows.

Using the reading recorded in 9.3, calculate the velocity of the gases at the centre of the duct (see clause 12). Then refer to the setting chart for velocity/sampling rate/nozzle diameter (see figure 6), to determine the largest nozzle diameter and the isokinetic sampling rate.

NOTE 15 The reason for choosing a large nozzle is to ensure that the duration of sampling is as short as possible.

Having chosen the nozzle, estimate the sampling duration Θ, in minutes, required by using equation (1), making assumptions that the fibre concentration in the duct might be about 2 fibres/cm^3 and that the optimum loading on the filter will be 300 fibres/mm^2:

$$\Theta = \frac{300}{2} \times \frac{A_F}{R} \times 10^{-6} \qquad \ldots (1)$$

$$\Theta = 15 \times 10^{-5} \times \frac{A_F}{R}$$

where

A_F is the effective filtering area, in square millimetres, of the membrane filter;

R is the sampling rate, in cubic metres per minute.

EXAMPLE

If $A_F = 300$ mm^2 and $R = 0{,}01$ m^3/min

then the sampling duration $\Theta = 15 \times 10^{-5} \times \frac{300}{0{,}01}$ = 4,5 min.

Alternatively, estimate the sampling rate and duration of sampling by reference to a chart such as that shown in figure 7.

NOTE 16 The optimum sampling duration is likely to be between 2 min and 10 min.

9.5.2 Attach the chosen nozzle (see 9.5.1) to the sampling apparatus and ensure that the control valve is closed. Then insert the probe through one of the access ports and position the nozzle at the centre of the sampling line. Ensure that the nozzle is facing at right angles to the gas flow, but not upwards, so as to prevent particles or fibres being collected inadvertently in the apparatus.

Allow the apparatus within the duct to attain the temperature of the duct gas, to avoid condensation in the apparatus.

Simultaneously start the pump, turn the probe until it faces directly upstream (to within 10°), start the timing device and open the control valve. Adjust the control valve to obtain the required isokinetic sampling rate (see 9.5.1) on the flowmeter.

Throughout the sampling period adjust the control valve as necessary to maintain the isokinetic sampling rate. The velocity of the gas to be drawn through the entry nozzle shall be within an error of ± 10 %, relative to the velocity of the duct gas at the sampling point.

9.6 Sample transfer and assessment

Once the calculated duration (see 9.5.1) of the sampling period has elapsed, simultaneously close the control valve, rotate the nozzle through 90° (but not upwards) and stop the pump. Then remove the probe carefully from the duct, and also remove the nozzle/filter assembly and place it in a clean container or bag. Seal the container/bag and take it to the laboratory for analysis.

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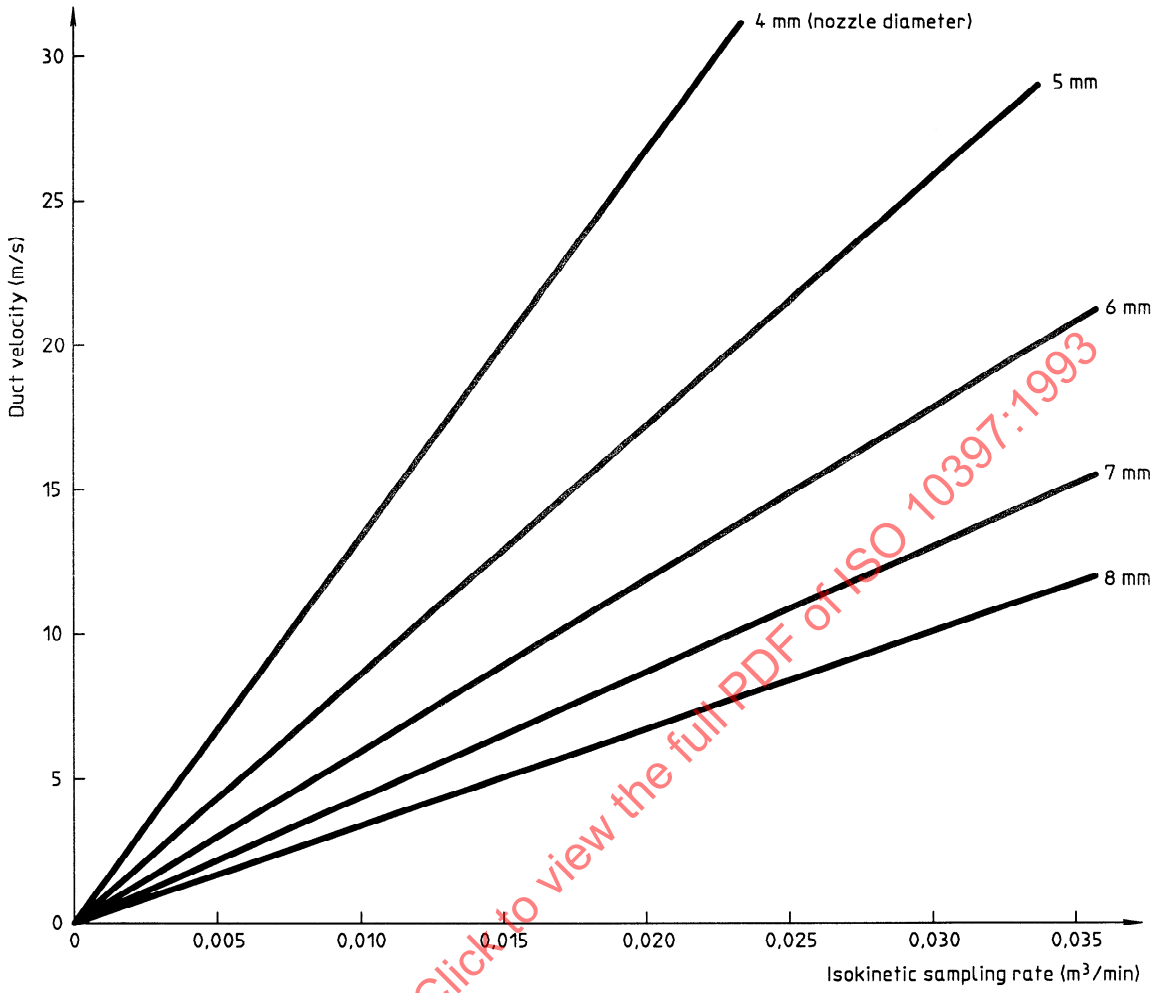

Figure 6 — Typical setting chart for velocity/sampling rate/nozzle diameter

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As soon as possible, follow the instructions given in clause 11 so that definitive sampling can begin.

10 Sampling procedure

10.1 General

Assess the analytical results from 9.6. If the fibres loading of the preliminary sample is within the 100 fibres/mm^2 to 600 fibres/mm^2 range, consider the sample duration to be satisfactory. If the loading is higher or lower than this range, the sampling duration will have to be shortened or extended respectively.

NOTE 17 It is necessary to know the velocity of the gases in the duct at the sampling points, before sampling can begin (see 10.2 and 12.1).

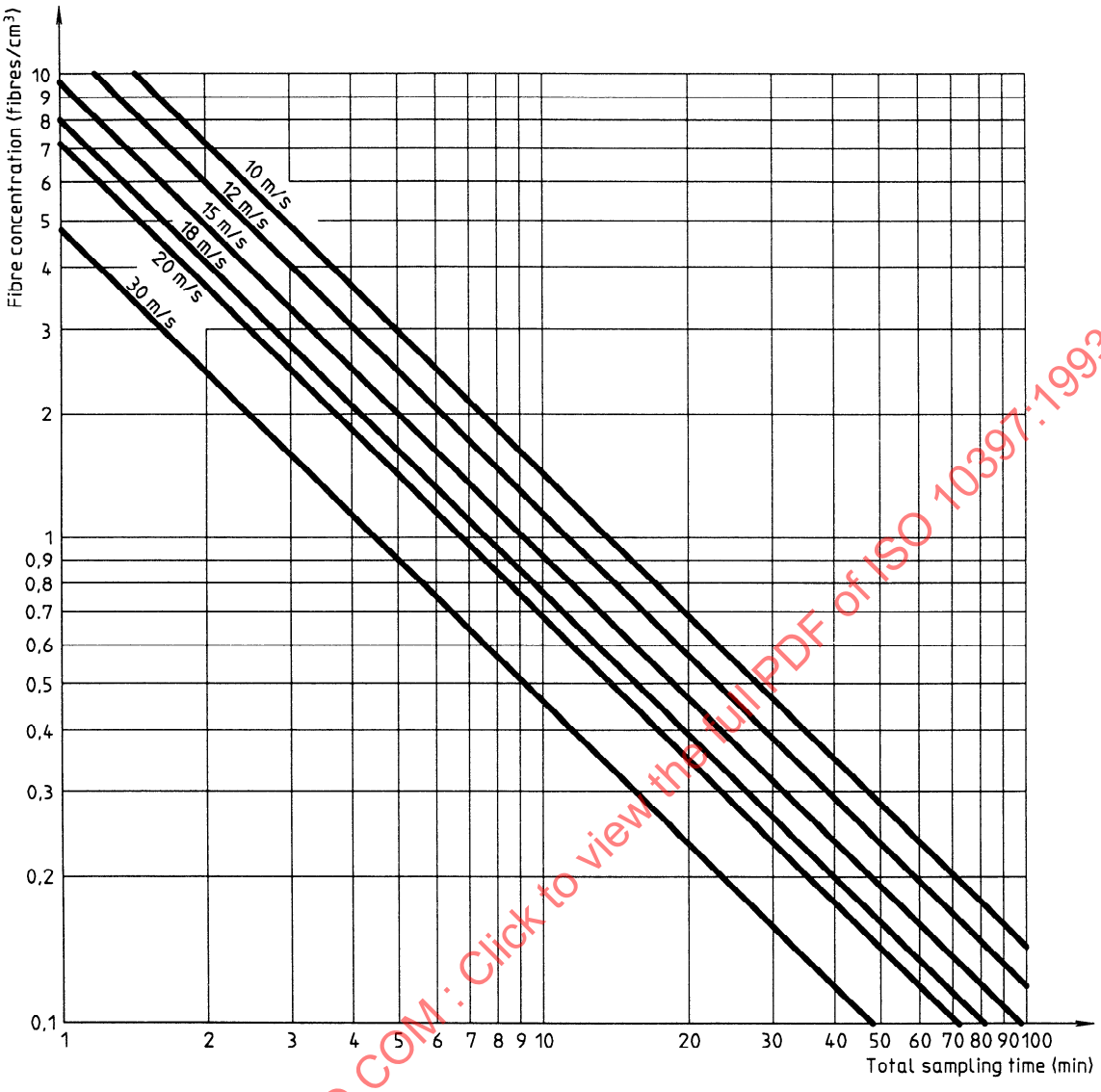
Because of the sensitive nature of the test method, make an accurate and full record of all the operating plant parameters (see clause 13).

10.2 Nozzle diameter, sampling rate and duration

The velocity and temperature of the gases in the duct at the sampling points have been taken and recorded (see 9.3). Using these readings, consult the velocity/sampling rate/nozzle diameter setting chart (see figure 6) to select the nozzle sizes that could be used. Then, considering the information determined in 10.1, choose the most suitable nozzle diameter, together with sampling rate and duration, that will give the optimum loading (300 fibres/mm^2) on the filter. Fit the nozzle on the sampling apparatus.

Since the sampling duration determined in 9.5 is for a single sample, where four or eight sampling points are required, it will be necessary to divide the total duration time by four or eight respectively.

The minimum time per sampling point for multipoint sampling shall be 3 min, and for single point sampling, 10 min.



NOTE — Assumes the use of a 25 mm membrane filter with an exposed area of 368 mm^2 and a loading of 300 fibres/mm^2.

Figure 7 — Typical sampling time graph (4 mm diameter nozzle)

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10.3 Definitive sampling

10.3.1 General

It is now necessary to take two definitive samples to assess the emission by a cumulative sampling technique (10.3.2), which means that each definitive sample is taken on only one membrane filter. However, where this technique may overload the filter, or where more detailed information on concentrations present in the duct is required, it is permissible to take individual samples at each sampling point. However, averaging of these samples should not be attempted as they could give misleading results.

With the correct nozzle fitted and using the information from 9.3, follow the procedure described in 9.5.2, but position the nozzle at one of the sampling points, excluding the centre-point.

Adjust the control valve, as necessary, throughout the sampling period, to maintain the sampling rate (see 10.2). The velocity of the gas to be drawn through the entry nozzle shall be within an error of ± 10 %, relative to the velocity of the duct gas at the sampling point.

10.3.2 Cumulative sampling (see 3.3)

After the first sample has been collected on the filter, without using a new filter, quickly adjust the probe tube to reposition the nozzle at the second sampling point. Immediately adjust the control valve to the flow reading required at the second sampling point (see 10.2). Then continue sampling as described in 9.5.2

and repeat the procedures, if necessary, until samples have been taken at all the points of the first sampling line (see figure 5). Close the control valve and stop the timing device. Remove the probe tube from the access port, reposition it on the next sampling line, and repeat these procedures until a cumulative sample from all the points has been collected. The filter now contains the first definitive sample.

10.3.3 Sample transfer

Repeat the procedure described in 9.6.

10.3.4 Velocity and temperature readings

Repeat the readings of gas velocity and temperature at each sampling point as soon as the sampling at all the sampling points has been completed. If the sum of the Pitot tube readings differs by more than ± 10 % (or the sum of the gas velocity readings by more than ± 5 %) from the original readings of 10.2, consider that the test results do not have the required accuracy.

NOTE 18 If this occurs, the reasons for the discrepancies should be found before attempting to repeat the procedure.

Check whether isokinetic conditions have been fulfilled (to within ± 10 %), by comparing the calculated flow rate that should have been extracted with the measured sample flow rate converted to actual duct conditions (see clause 12).

If it turns out that isokinetic conditions have not been achieved, disregard the measurements, investigate the causes and repeat the measurement.

10.4 Second definitive sample

Repeat the procedure described in 10.3 under comparable plant conditions and as soon as it is practicable.

NOTE 19 If this second sample is taken immediately after the first, the gas velocity and temperature readings recorded at the end of 10.3 may be used as the initial readings for the second set of samples.

11 Analytical procedures

11.1 Return of the filter(s)

Once the nozzle/filter assembly is safely back in the laboratory, dismantle the filter holder and carefully remove the filter with tweezers, so as not to dislodge any deposited fibres, and place it on a clean glass microscope. (See ISO 8672 for details on cleanliness.)

11.2 Filter clearing in preparation for fibre counting

Use the acetone/triacetin method for clearing and mounting slides described in ISO 8672:1993, annex A.

NOTE 20 The principle is that a liquid solvent mixture is used to collapse the pores of the filter, causing it to adhere to the glass slide, and turning it into a solid, transparent, and (ideally) uniform plastics film, with the fibres in the upper surface. The membrane filter is placed, face-up, on a glass slide. A few drops of liquid triacetin are placed on the surface, to provide the desired contrast with the fibres and to provide optical contact. Then a cover slip is placed on top (see figure 4b). Samples prepared in this way only deteriorate very slowly. Before a real sample is used, this delicate sample preparation technique should be practised on blank filters to acquire the necessary competence.

11.3 Fibre counting

Count the fibres on the slide as described in ISO 8672.

12 Method of calculation

12.1 Calculation of gas velocity

Calculate the gas velocity v, in metres per second, at the sampling point from the Pitot-static tube readings and the temperature and density of the duct gases, using the equation

$$v = K \sqrt{2 \times \frac{\delta p}{\rho} \times \frac{(273 + t)}{273}} \qquad \ldots (2)$$

where

δp is the differential pressure, in pascals;

ρ is the density, in kilograms per cubic metre, of the duct gases;

t is the temperature, in degrees Celsius, of the duct gases;

K is the calibration factor for the Pitot-static tube.

NOTES

21 The factor K will vary according to the type of Pitot-static tube used. For Prandtl tubes $K = 1$.

22 In practice, the density of the duct gas can be assumed to be the same as that of air. Also, the temperature of extracted gases from many asbestos processes is unlikely to be above ambient temperature and therefore, if it is assumed that the duct temperature is 15 °C, equation (2) could be simplified to

$$v = k \sqrt{\delta p} \qquad \ldots (3)$$

where k is the simplified calibration factor for the Pitot-static tube.

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12.2 Volume of air sampled

If the velocity at each sampling point is expressed as v_1, v_2, v_3 etc., the nozzle diameters are d_1, d_2, d_3 etc. and the sampling duration is Θ_1, Θ_2, Θ_3 etc. respectively, calculate the volume of the sampled gas V_T, in cubic metres, as follows:

$$V_T = \frac{\pi d_1^2}{4} \times v_1 \times \Theta_1 + \frac{\pi d_2^2}{4} \times v_2 \times \Theta_2 + \text{etc.} \quad \ldots (4)$$

However, where the nozzle diameters, d, and the sampling duration, Θ, for each sampling point are the same, equation (4) can be simplified to

$$V_T = \frac{\pi d^2}{4} \times \Theta(V_1 + V_2 + V_3 + \text{ etc.}) \quad \ldots (5)$$

Correcting to standard conditions this becomes

$$V_S = V_T \times \frac{p}{p_T} \times \frac{T_S}{T} \quad \ldots (6)$$

12.3 Validation of isokinetic sampling

Isokinetic sampling shall be deemed to have taken place if the volume sampled, V_S, corresponds within $\pm$ 10 % of the measured sample volume V_I, as shown by the following limits:

$$0{,}9\ V_S < V_I < 1{,}1\ V_S \quad \ldots (7)$$

NOTE 23 The measured sample volume, V_I, is that recorded on the integrating meter, corrected to standard conditions.

12.4 Fibre concentration

Calculate the concentration of fibres C, in fibres per cubic centimetre, in the stack gas using the equation

$$C = \frac{N}{nV_I}\left(\frac{D_F}{D_G}\right)^2 \quad \ldots (8)$$

where

N is the total number of fibres counted (from 11.3);

n is the number of graticule areas examined (see 11.3);

V_I is the volume, in cubic metres, of air sampled (see 12.3);

D_F is the diameter, in millimetres, of the exposed area of the filter (see 11.3);

D_G is the diameter, in micrometres, of the Walton-Beckett graticule, measured with a stage micrometer (see 11.3).

Equation (8) applies to one individual filter (see 13.2).

13 Presentation and interpretation of results

13.1 Presentation

Present the measured parameters, sampling and processing data and analytical results in tabular form. The range of typical data is shown in annex D. Record all raw data and show them on a data sheet for site work (a typical sheet is shown in annex C).

Where non-ideal conditions are encountered, these shall be stated. Guidance is given in annex A.

13.2 Interpretation of results

The method is based on taking a calculated volume of fibre-laden gases, on the assumption that the concentration of fibres in the duct will be 2 fibres/cm^3 and that the loading of fibres collected on the sample filter will be 300 fibres/mm^2. These assumptions are first checked by taking a preliminary sample. By visual inspection of the membrane filter, examination of the dust collection equipment and/or fibre counting of the filter, it should be possible to deduce whether the correct sampling duration has been chosen. This should enable a more suitable sampling duration to be used for the two definitive samples.

If the fibres on the two filters (i.e. the two definitive samples) can be counted, the two samples should be averaged. Where the average result is less than 2 fibres/cm^3, it can be assumed that the pollution control equipment is working satisfactorily. However, where the two results straddle 2 fibres/cm^3, such averaging is not appropriate. Instead, record each result and take two further samples.

NOTES

24 Where counting problems are found, it may still be possible to make the following general assumptions.

a) If the concentration of fibres is over 2 fibres/cm^3 or cannot be counted because there are too many fibres in the sample filter, the pollution control equipment is in need of inspection and/or repair.

b) If an insufficient number of fibres is counted according to the counting rules, or the concentration is at or under 2 fibres/cm^3, the equipment is probably operating satisfactorily.

c) Where several samples are taken that straddle 2 fibres/cm^3, it is not easy to interpret the results. However, this may suggest that the pollution control equipment should be inspected.

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Annex A
(informative)

Non-ideal circumstances

Where it is not possible to meet the criteria laid down in this International Standard, alternative criteria may be used as specified in this annex, but it should be appreciated that these may give less accurate results.

A.1 Less suitable sampling locations

If the criteria stipulated in 8.2 cannot be met, compromises may have to be made to allow sampling to be undertaken. However, much experience has been acquired with many process installations, in which sampling planes have been used in short straight duct lengths. Using this experience, it is recommended that sampling planes shall be selected at least a certain distance, expressed in hydraulic diameters, downstream from an obstacle in the duct system (see table A.1).

Table A.1 — Sampling location distances from obstacles

Obstacle	**Distance** (hydraulic diameters)
Duct bend	1
Junction of two ducts	1
Partly closed louvres	3
Discharge side of fan	4
Duct outlet	4

Consideration should also be given to enhancing the flow development upstream of the sampling plane by, for example, narrowing the duct or installing flow straighteners. When designing a new plant, it is recommended that allowance be made for a straight duct section and facilities for sampling in accordance with this International Standard.

To achieve maximum accuracy of the method, it is important that the isokinetic requirement should be followed closely and the duct cross-section and the effective nozzle diameter should be determined exactly.

A.2 Position of sampling point

In ducts with very small diameters, it may be more practicable to sample only at the centre of the duct. Also, where access is limited and flow in the duct is known to be homogenous, sampling may be conducted along a single line.

A.3 Analytical procedures

In normal practice, positive phase contrast microscopy is used. The use of negative phase contrast microscopy is also possible, but may not provide such good definition of fibres.

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Annex B
(informative)

Care of apparatus

B.1 Pitot-static tubes

This equipment is generally not very robust and must be handled with care if accurate measurements are to be made. Orifices and tubing must be regularly checked for cleanliness. Also, where manometer fluids are used these should be topped up or replaced regularly. More detailed guidance is given in ISO 9096.

B.2 Sample nozzles

Because the best nozzles for taking samples isokinetically are sharp edged nozzles, it is important that they be treated with extreme care. The slightest knock or dent in the sample nozzle will affect the accuracy of measurements. Dented nozzles should not be used.

B.3 Integrating meters

Integrating meters play an important part in the flow measurement and should therefore be calibrated regularly. Also, where there is a possibility that they may be used in moist or corrosive gases, they should be examined for corrosion and maintained regularly.

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