SLOVENSKI STANDARD
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Izpostavljenost na delovnem mestu - Vodilo za uporabo instrumentov z neposrednim odčitavanjem za monitoring aerosolov - 1. del: Izbira instrumenta za specifične uporabe

Workplace exposure - Guide for the use of direct-reading instruments for aerosol monitoring - Part 1: Choice of monitor for specific applications

Exposition am Arbeitsplatz - Leitfaden für die Anwendung direkt anzeigender Geräte zur Überwachung von Aerosolen - Teil 1: Auswahl des Monitors für besondere Anwendungsfälle

Exposition au poste de travail - Guide d'utilisation des instruments à lecture directe pour la surveillance des aérosols - Partie 1: Choix du moniteur pour des applications spécifiques

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Foreword

This document (CEN/TR 16013-1:2010) has been prepared by Technical Committee CEN/TC 137 "Assessment of workplace exposure to chemical and biological agents", the secretariat of which is held by DIN.

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CEN/TR 16013, *Workplace exposure — Guide for the use of direct-reading instruments for aerosol monitoring*, consists of the following parts:

— *Part 1: Choice of monitor for specific applications*

— *Part 2: Evaluation of airborne particle concentrations using Optical Particle Counters*

— *Part 3: Evaluation of airborne particle concentrations using photometers* (in preparation)

Introduction

The assessment of aerosols in the workplace can have several aims, including:

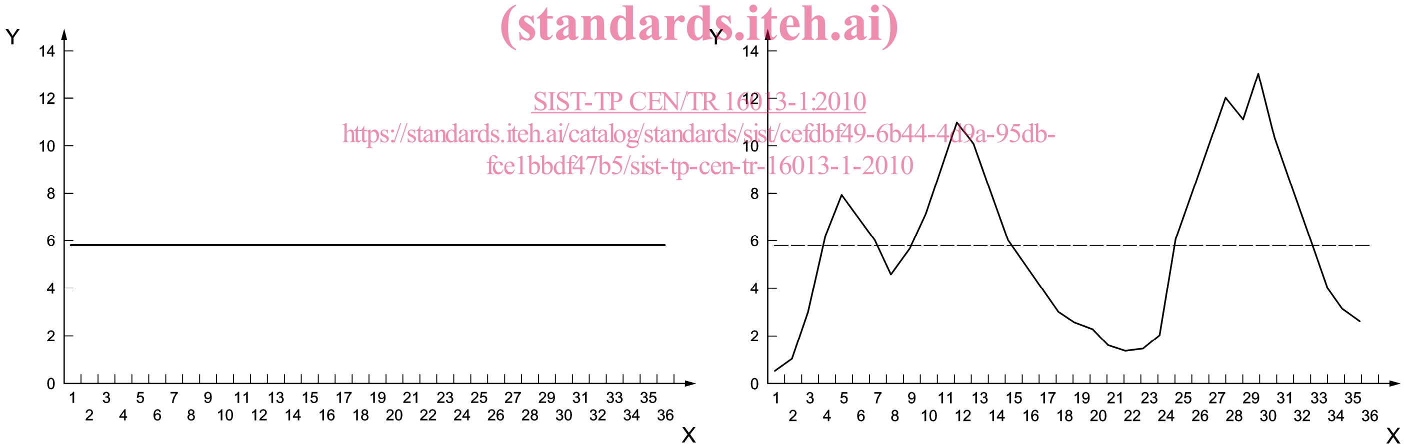
a) estimation of the mean concentration of health-related aerosol particles (see EN 481) during a working shift period (workplace characteristics or personal exposure by static or personal sampling);

b) sampling to provide a sample of airborne particles for later analysis (gravimetric, morphological, chemical, physical, mineralogical, etc., see EN 482);

c) evaluation of almost instantaneous concentrations produced by various work activities using automatic instruments (photometers, β-attenuation instruments, vibrational mass balance instruments);

d) evaluation of almost instantaneous concentrations and particle size distributions (optical particle counters – OPC).

This Technical Report concerns items c) and d), gives the principles, and details the general conditions to be satisfied. In occupational hygiene, no measurement procedure recommends exposure monitoring using direct-reading aerosol monitors. These instruments should instead be considered as permitting a complementary approach to the conventional filter-based gravimetric method. The different types of information obtained are explained in Figure 1.



a) b)

Key

X sample number (time) Y concentration (arb units)

Figure 1 — Information from integrated filter sampling vs. continuous monitoring

There is a wide range of portable and personal direct-reading aerosol monitors available.

Recent advances in modern electronics and battery technology means direct-reading dust monitors are becoming smaller and lighter and of relatively low price. In addition to reliance on compliance with Occupational Exposure Limits, emphasis is now also being placed on control banding and advice on suitable control systems. This has led to new roles being identified for direct-reading aerosol monitors in ensuring that systems deployed to control exposure to airborne dusts actually work. Some types of direct-reading aerosol monitors appear to be well suited to evaluate prevention action efficiency and to space- and time-related monitoring of concentration.

All instruments mentioned in this document (see, in particular, Tables 2, 4, 6, 8 and 10) are examples of suitable products available commercially. This information is given for the convenience of users of this Technical Report only and does not constitute an endorsement by CEN of these products.

1 Scope

This Technical Report describes the principles underlying the evaluation of one or more aerosol fractions using direct-reading aerosol monitors. The currently available methods for monitoring levels of aerosols in workplaces for a range of different purposes are described and details are given of their limits and possibilities in the field of occupational hygiene.

The document does not cover the sampling of aerosols for compliance with occupational exposure limits or the collection of aerosol particles for subsequent analysis.

2 Abbreviations

For the purposes of this document, the following abbreviations apply.

DRAM direct-reading aerosol monitor

LOD limit of detection

OEL occupational exposure limit

OPC optical particle counter

PM particulate matter

TEOM tapered element oscillating microbalance

TSP total suspended particulate

3 Principles of direct-reading aerosol monitoring methods

3.1 General

There are many methods, based on different physical principles, for the instantaneous measurement of aerosols. Instruments used are generally called direct-reading or continuous monitoring instruments. Depending on their design, they can give the instantaneous or sequential concentration and can sometimes even measure particle size distribution.

Instantaneous measurement has several advantages:

a) immediate knowledge of the result without going through the laboratory, whence the possibility of rapid intervention (e.g. implementation of a ventilation system);

b) continuous measurement, long-distance surveillance, concentration record over time, mean concentration integration and calculation in selected periods, maxima and minima determination, source location, etc.;

c) measurement of concentration for particles of unstable composition (e.g. volatile substances);

d) monitoring and control of aerosol concentration.

Depending on the principles used, automatic methods can be classed into the following three main groups:

— vibrational mass method (see 3.2);

— beta attenuation method (see 3.3);

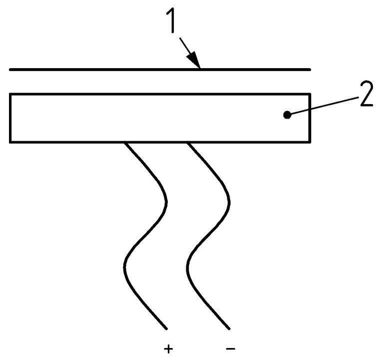
— optical methods (see 3.4).

3.2 Vibrational mass methods

3.2.1 Piezoelectric mass monitors

3.2.1.1 Operating principle

Particles drawn into the instrument are collected on the surface of a piezoelectric crystal, forming part of a quartz crystal-based oscillating circuit (see Figure 2).



Key

1 piezoelectric crystal

2 frequency

Figure 2 — Schematic of piezoelectric mass monitor

The mass of deposited particles causes a reduction in the oscillation frequency f. The changed frequency is compared with the previous recorded initial frequency or a control circuit frequency. The frequency reduction is directly proportional to the particle mass (see [8]). The proportionality factor k_f expresses the crystal sensitivity with respect to the deposited weight. It is constant for each crystal (see [7]) and its value varies, in most cases, by approximately 200 Hz/µg. If the frequency change during sampling, for a time t, is Δf, the weight of collected dust will be $\frac{\Delta f}{k_f}$ and the aerosol mean concentration can be calculated according to Equation (1):

$$C = \frac{\Delta f}{Q \times t_s \times k_f} \quad (1)$$

where

C is the aerosol mean concentration, in milligrams per cubic metre;

Δf is the change resonance frequency, in Hertz;

Q is the sampling flow rate, in litres per minute;

t_s is the sampling time, in minutes;

k_f is the crystal mass sensitivity, in Hertz per microgram

The method is very sensitive and allows low concentrations of the order of several tens of micrograms per cubic metre to be measured. However, it is limited to fine particles (usually smaller than 10 µm) because of the small mechanical force between the particle and the crystal surface: if its mass is high, the particle cannot follow the vibration frequency. This is also a problem for high loads when there is lack of coupling between the outermost layers of particles and the crystal. This requires the crystal to be regularly cleaned and may limit the monitoring duration.

3.2.1.2 Determination of mass concentration of health-related fractions

The change in frequency of crystal is directly proportional to the mass of particles deposited and is therefore largely independent of the physical and chemical properties of the particles. There is no need therefore to use on-site calibration factors, providing that the crystal is not overloaded. Because of particle size limitations on particle/sensor coupling (mentioned above) only the mass concentration of the respirable fraction is measurable. Respirable size selection can be achieved using any suitable size selector; one instrument uses a single stage impactor with the respirable particles deposited on the crystal by electrostatic precipitation. Another instrument uses multiple crystals as the collection substrate for size separated particles in a 10-stage cascade impactor.

3.2.1.3 Calibration of piezoelectric instruments

Each crystal sensor has its own frequency response and so the instrument incorporating the crystal will be calibrated in the factory to give the required mass response. Provided that the crystal is not damaged, no further calibration is required.

3.2.1.4 Advantages/disadvantages of piezoelectric instruments

Table 1 gives advantages and disadvantages of piezoelectric instruments.

Table 1 — Advantages/disadvantages of piezoelectric instruments

Advantages	Disadvantages
— direct measurement of dust mass	— usage limited by dust loading on crystal
— no on-site calibration required	— regular cleaning of crystal required
— response independent of chemical composition and particle size (below 10 µm)	— only suitable for respirable particles
— relatively easy to use	

3.2.1.5 Currently available piezobalance instruments

Table 2 gives an overview on currently available piezobalance instruments.

Table 2 — Currently available piezobalance instruments

Name [a]	Portable/ personal	Size mm	Weight kg	Size selection	Flow rate l/min	Response time s	Accuracy	Measure-ment range mg/m^3
Kanomax Piezo-balance dust monitor Model 3511®	portable	311 × 170 × 130	2	respirable fraction by impactor	1	from 0 mg/m^3 to 1 mg/m^3: 24 s from > 1 mg/m^3 to 10 mg/m^3: 120 s	± 10 % of reading	0,02 to 10
California Measure-ments Inc, PC-2HX QCM® real-time cascade impactor	portable, but mains-operated (battery-powered version by special order)	cascade impactor: 35 × 12,5 × 32 control unit: 18 × 43 × 32	5,4 10	10 stages (0,1 µm to 14 µm)	2	for average concentration 0,05 mg/m^3: 30 s	not given	0,005 to 1

NOTE "Accuracy" is defined by the manufacturers.

[a] Kanomax Piezo-balance dust monitor Model 3511® and California Measurements Inc, PC-2HX QCM® real-time cascade impactor are examples of suitable products available commercially. This information is given for the convenience of users of this Technical Report and does not constitute an endorsement by CEN of these products.

3.2.2 TEOM − Tapered Element Oscillating Microbalance

3.2.2.1 Operating principle

This device is similar in principal to the piezoelectric microbalance but the oscillating frequency is applied to a tapered glass tube equipped with sampling filter at its narrow end (see Figure 3).