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Workplace exposure - Guide for the use of direct-reading instruments for aerosol monitoring - Part 3: Evaluation of airborne particle concentrations using photometers

Exposition au poste de travail - Guide d'utilisation des instruments à lecture directe pour la surveillance des aérosols - Partie 3 : Évaluation des concentrations de particules en suspension dans l'air à l'aide de photomètres

Exposition am Arbeitsplatz - Leitfaden für die Anwendung direkt anzeigender Geräte zur Überwachung von Aerosolen - Teil 3: Bewertung der Konzentration luftgetragener Partikel mit Photometern

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Foreword

This document (CEN/TR 16013-3:2012) 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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

— *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*.

Introduction

All photometer-based direct-reading aerosol monitors use the principle of light scattering to determine airborne particle concentration. Here, a light source (usually produced by a laser or diode) is collimated and illuminates airborne particles entering a sensing volume. The instrument optics are usually designed such that the intensity of the light scattered at a particular angle is proportional principally to the respirable fraction of the airborne particle concentration. Other physical properties of the aerosol such as particle size, refractive index and particle shape, will affect their response by varying degrees (see [7]) although this can be minimised by careful design of the photometer. Therefore, photometer-based direct-reading aerosol monitors are not ideal for the measurement of worker exposure or to check whether threshold limit values of industrial dust concentrations are exceeded. Their main advantage is that they give an almost instantaneous measure of airborne particle concentration, thereby reducing considerably the time and effort associated with standard gravimetric methods. They are also better at measuring aerosols with high vapour pressures that would normally evaporate during standard gravimetric analysis. Some instruments include a pre-classifier on the inlet (cyclone or impactor) to make the overall response closer to the respirable dust definition.

Photometers are therefore best suited to assess variations of airborne particle concentration in time or space and to check for any sudden change of concentration. Typical applications are:

- walk-through surveys;
- background sampling to assess concentration variations and mean concentration during a working shift period;
- assessment of the effectiveness of dust control systems;
- measurement of indoor air quality;
- as part of exposure video visualization systems.

For measurement of personal exposure they should be considered as complementary to conventional filter-based gravimetric methods (see [2]), although with careful calibration, they can also give an accurate measure of respirable dust exposure, i.e. that which enters the mouth and nose and passes to the lower regions of the respiratory system (see EN 481).

1 Scope

This Technical Report describes the use of photometers for the determination of airborne particles belonging to the respirable fraction and gives details on their limitations and possible uses in the field of occupational hygiene.

NOTE Photometers can also be used to detect other size fractions of airborne particles after aerodynamic pre-separation, but these are not the focus of this Technical Report.

The method complements existing conventional long-term aerosol particle sampling and can be used for:

- instantaneous (direct-reading) measurement,
- time-related monitoring,
- investigation of space-related aerosol evolution (mapping), and
- exposure visualization.

The method enables e.g.:

- detection and relative quantification of concentration peaks due to specific operations (bagging, sanding, etc.);
- identification of most exposed workers with a view to more detailed studies of risks and prevention measures to be applied; and
- detection of dust emission sources and their relative magnitudes.

2 Operating Principle

2.1 General

A laser or light emitting diode is used to produce a high intensity source of light, which is usually in the visible near-infrared spectrum. This is collimated and illuminates airborne particles entering the sensing volume of the instrument. The optical sensing volume is created by intersection of illuminating and detecting light beams as shown in Figure 1. The intensity of the light scattered at a particular angle is proportional to the airborne particle concentration and is detected using sensitive photomultipliers or photodiodes with response spectra covering approximately the source emission spectra.

2.2 Light scattering

Interaction of a light beam with an airborne particle in suspension can cause several effects: absorption of part of the light, reflection, refraction or diffraction of the beam. These combined effects result in scattering of the incident light in every direction. The illumination and collection optics are arranged inside a photometer so that light scattered at a fixed range of angles reaches the detector (see Figure 1). Depending on the design, these instruments can measure the scattered light in the region of $\theta = 90^\circ$, 45° or less than 30°. Choice of observation angle plays a prominent part in detection. Front scattering is relatively insensitive to changing airborne particle refractive index and so forward-scattering photometers with scattering angles $< 30^\circ$ are less sensitive to the refractive index of the aerosol than instruments with a 90° scattering angle. However, at small scattering angles, photometers overestimate particles smaller than 1,5 µm.