Determination of airborne fibre number concentrations

A recommended method, by phase-contrast optical microscopy (membrane filter method)

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Preface

The inhalation of airborne fibres in the workplace can cause a variety of occupational respiratory diseases, which contribute appreciably to morbidity and mortality among workers in both developing and developed countries. Monitoring airborne fibre concentrations is an important tool for occupational health professionals for assessing exposure and establishing the need to control it, evaluating the efficiency of control systems, and characterizing exposure in epidemiological studies. However, a proliferation of methods has hitherto hindered the comparability of results, as well as the possibility of having worldwide proficiency testing to ensure the reliability of obtained data.

A methodological framework that allows for meaningful comparisons between results obtained by different researchers and laboratories is of immense benefit for all aspects of occupational hygiene, but particularly for exposure assessment and environmental monitoring. In addition to proficiency testing, quality assurance schemes, comparisons and exchanges of data and international collaborative studies depend on the use of compatible methodologies. Furthermore, to ensure that preventive control systems in the workplace are adequate and effective, the reliability and comparability of monitoring and exposure data are essential. Occupational health surveillance and the ability to establish correlations between epidemiological and environmental indicators also depend on the ability to compare data from diverse sources.

A project aiming to establish a unified methodology for the evaluation of airborne fibres in the work environment was therefore carried out by the World Health Organization (WHO). A draft text of the present method specification was initially prepared by Dr N. P. Crawford, Institute for Occupational Medicine, Edinburgh, Scotland. During the course of four meetings of an international working group of experts (see Annex 3 for a list of participants at the final meeting),

current evaluation methods were compared and their differences identified and analysed, with a view to understanding the effect of these differences on the results of counting airborne fibres. Consensus was reached by the working group on a recommended method for the determination of airborne fibre number concentrations by phase-contrast optical microscopy. Dr Crawford's role as rapporteur at the final meeting and his work in revising the draft manuscript are gratefully acknowledged.

Collaboration from the International Labour Office (ILO), the European Commission (EC), the International Organization for Standardization (ISO), the European Committee for Standardization (CEN), the International Fibre Safety Group (IFSG), as well as national agencies, particularly the Health and Safety Executive (HSE), United Kingdom, and the National Institute for Occupational Safety and Health (NIOSH), USA, has been fundamental to this project and is also gratefully acknowledged. Special thanks are offered for the financial support provided by the EC and the IFSG.

Particular acknowledgement should also be made of the valuable personal contribution of several members of the working group, particularly Dr N. G. West (HSE), Dr P. Baron (NIOSH), and Mr S. Houston (IFSG), as well as Mrs B. Goelzer, Occupational Health, WHO.

In its first phase, this project has focused on methodology, so that authoritative scientific knowledge can be utilized to ensure accurate and precise measurements of airborne fibre number concentrations. In its second phase, the project will consider worldwide efforts for proficiency testing, quality assurance, and technical cooperation, including training and education.

Dr M. I. Mikheev
Chief, Occupational Health
World Health Organization

Outline of the method specification

Principle of the method

A sample is collected by drawing a known volume of air through a membrane filter by means of a sampling pump. The filter is rendered transparent ("cleared") and mounted on a microscope slide. Fibres on a measured area of the filter are counted visually using phase-contrast optical microscopy (PCOM), and the number concentration of fibres in the volume of air is calculated.

Sampling

Filter:	Membrane of mixed esters of cellulose or cellulose nitrate, 0.8–1.2 μm pore size, 25 mm diameter.
Filter holder:	Fitted with an electrically conducting cowl.
Transport:	In closed holders.
Flow rate:	0.5–16 litres · min^{-1}. Adjust to give 100–650 fibres · mm^{-2}.
Blanks:	Sampling media, 4% of filters. Field, ≥2% of samples. Laboratory, optional.

Sample preparation

Acetone–triacetin for fibres with a refractive index >1.51; stable for ≥1 year.

Acetone/etch/water for fibres with a refractive index ≤1.51; unstable.

Sample evaluation

Technique:	Phase-contrast optical microscopy.
Microscope:	Positive phase contrast, ×40 objective, ×400–600 magnification.

	Walton–Beckett graticule, type G-22 (100 ± 2 μm diameter).
	HSE/NPL Mark II test slide.
	Stage micrometers (1 mm long, 2-μm divisions).
Calibration:	To meet visibility requirements of the test slide.
Analyte:	Fibres (visual count).
Counting rules:	Select counting fields at random, subject to defined criteria.
	A countable fibre is >5 μm long, <3 μm wide and with a length:width ratio >3:1, subject to defined rules when it overlaps the graticule perimeter and when it touches other fibres or particles.
Lower limit of measurement:	10 fibres per 100 graticule fields.
Bias and reproducibility:	See sections 4 and 5.