Related reading


OSHA (1990) *Asbestos in air.* Salt Lake City, UT, Occupational Safety and Health Administration (OSHA Method ID-160).
Static monitoring is used for assessing the effectiveness of process-control techniques, detecting sources of contamination, determining background fibre concentration, etc. and does not yield a measurement representative of personal exposure. Samples collected at fixed locations—for example, outside asbestos stripping and encapsulating areas, inside decontamination rooms, for clearance monitoring after asbestos stripping and encapsulating and inside buildings or ships that contain asbestos—are called static samples and form the basis of static monitoring. This type of sampling is often conducted where there is a high proportion of fibres other than the one of principal interest, or particles that conform to the definition of a fibre given in section 3.2.3. Such interferences can cause problems in the interpretation of the results obtained by this method, which can be resolved only by obtaining information on fibre composition using other methods (e.g. electron microscopy).

The parameters and methodology specified for personal sampling generally apply to static monitoring. The main differences are indicated in the following discussion.

**Sampling**

Samples are taken at fixed locations. The sampling head should be mounted on a stand, usually 1–2 metres above floor level, with the cowl facing downwards, allowing free air circulation around the entry. It should be positioned with regard to local sources of dust or clean air. Cross-draughts of more than 1 m·s⁻¹ may reduce fibre collection.
Flow rate

*The sampling flow rate should be in the range* 0.5–16 litres·min⁻¹

Flow rates are usually higher for static sampling than for personal sampling. Over the range specified above, sampling efficiency (for chrysotile) has been found to be independent of flow rate.

Stop-counting rule

*One hundred fibres should be counted, or 200 graticule areas inspected, whichever comes first. Fibres should, however, be counted in at least 20 graticule areas.*

In many static monitoring situations, it is necessary to inspect 200 graticule areas.

If static monitoring is used in making measurements of airborne asbestos for the purposes of asbestos abatement, for example, and therefore comparisons are made with a clearance indicator, it may be unnecessary to evaluate 200 graticule areas or count 100 fibres. For instance, if 30 fibres in 200 fields would indicate a concentration of 0.015 fibres·ml⁻¹ (and the clearance indicator is 0.010 fibres·ml⁻¹), it would be possible to report an enclosure as unsatisfactory as soon as a count of 30 fibres is obtained, even if only a few fields have been examined.

The stop-counting rule and minimum total sample volume are usually such that the number of fibres counted in the neighbourhood of typical clearance indicators is below the lower limit of the recommended density range for optimal accuracy and precision, or even below the detection limit of the method. Therefore, concentration estimates can often be only approximate. The detection limit depends on the sample volume and should be reported by the laboratory with its results. For example, the limit of detection, assuming a 480-litre sample, an effective filter area of 380mm² and 200 graticule areas examined, is 0.010 fibres·ml⁻¹. A counting result falling below this limit should not be reported literally, but simply as <0.010 fibres·ml⁻¹.
Annex 2

Characterization of fibres

This publication describes a method for counting fibres that does not differentiate between fibre types. Although knowledge of the type of fibre produced by the bulk material provides a guide to what to look for in airborne samples, the only techniques that permit a scientific determination of the type of fibre present in a sample are based on different forms of microscopy. In choosing an analytical method and a laboratory, several factors need to be considered. The technique should be capable of discriminating between the fibre types in the sample and should be conducted by experienced analysts. The analyst should preferably be a graduate in geology, chemistry, materials science or a similar discipline, with at least 2 years' experience in the appropriate methods of fibre analysis. It is important to assess the laboratory's quality assurance protocol, which should include, wherever possible, participation in an external proficiency testing programme.

The methods listed below were developed for asbestos and other mineral or inorganic vitreous fibres. The cheapest and most readily available technique for fibre characterization is polarized light microscopy (PLM), which can be used to identify many fibre types so long as the fibres are greater than about 1 \( \mu \text{m} \) in width. Electron microscopy techniques are more expensive and can be used to provide additional information as needed. Scanning electron microscopy (SEM), in conjunction with energy dispersive X-ray analysis (EDXA), can generally be used to determine the elemental composition of fibres greater than 0.2 \( \mu \text{m} \) in width. The most expensive method, analytical transmission electron microscopy (TEM), is generally acknowledged as the most accurate technique for characterizing crystalline inorganic fibres and can be used to provide chemical and structural information for fibres down to about 0.01 \( \mu \text{m} \) in width. The costs of TEM analysis are approximately an order of magnitude greater than those of PLM or PCOM; with SEM, costs fall between the two.
Methods applicable to airborne fibres

Polarized light microscopy

For fibres greater than about 1µm in width, PLM techniques can be used to evaluate the optical properties of individual fibres.

Published methods of fibre characterization by PLM include:


Scanning electron microscopy

For routine analysis, SEM allows for good visualization of fibre morphology down to widths of about 0.05µm, depending on the method used. In addition, an energy dispersive X-ray analyser can be used to determine the elemental composition of fibres with widths greater than about 0.2µm. Sodium and lighter elements cannot generally be observed by SEM/EDXA. Detailed analysis of samples collected on membrane filters is not possible because of the instability of the filter medium; more stable filter media, e.g. polycarbonate filters, should therefore be used if SEM testing is envisaged.

Published methods of fibre characterization by SEM include:

WHO Regional Office for Europe, Scherfigsvej 8, DK-2100 Copenhagen Ø, Denmark).

- **Method RTM2.** Paris, Asbestos International Association (available from AIA, 10 rue de la Pepinière, 75008 Paris, France).
- **Method for the separate determination of asbestos and other inorganic fibres:** raster electron microscopic method (ZHI/120/46). Sankt Augustin, Germany, Federation of Industrial Injuries Insurance Institutions, 1991 (available from Federation of Industrial Injuries Insurance Institutions, Alte Heerstrasse 111, 53757 Sankt Augustin, Germany).

Transmission electron microscopy

The use of TEM allows characterization of individual fibres as small as 0.01 μm in width. Two powerful qualitative techniques are also available: electron diffraction (ED), which allows the determination of particle crystal structure, and (as with SEM) EDXA, which allows determination of the elemental composition of individual fibres. Combined with ED and EDXA, TEM is particularly useful for identifying inorganic crystalline fibres and generally provides the most definitive identification available. For non-crystalline inorganic materials it is similar to SEM in sensitivity. For qualitative analysis of organic materials, TEM is generally not useful. Sample preparation for TEM is more complex than for SEM.

Published methods of fibre characterization by TEM include:


DETERMINATION OF AIRBORNE FIBRE NUMBER CONCENTRATIONS

763, Appendix A to subpart E; available from EPA, 401 M Street SW, Washington, DC 20460, USA).

Methods applicable to bulk materials

X-ray diffraction (XRD)

In XRD analysis, a bulk sample of material is subjected to X-ray bombardment and the angle of the diffracted radiation is measured. This technique allows determination of the crystal structure of mineral compounds.

Published methods of fibre characterization by XRD include:

- **Method 9000. Asbestos (chrysotile): by X-ray diffraction.** Cincinnati, OH, National Institute for Occupational Safety and Health, 1994 (available from NIOSH, 4676 Columbia Parkway, Cincinnati, OH 45226, USA).


Chemical analysis

Some chemical analyses have been used to indicate the presence of certain elements or functional groups in a bulk sample, but these methods do not distinguish between fibres and other material with the same chemical properties. Commercially available analytical kits are able to detect the presence of magnesium (in chrysotile) and iron (in amphibole asbestos). Other tests may be used for the detection of man-made organic fibres.

A published method of fibre characterization by chemical analysis is:

- **Test for screening asbestos.** Cincinnati, OH, National Institute for Occupational Safety and Health, 1979 (Publication No. 80-110; available from NIOSH, 4676 Columbia Parkway, Cincinnati, OH, 45226, USA).
Infrared (IR) absorption

This technique indicates only the possible presence of certain functional groups in the components analysed and cannot distinguish between fibres and other material with the same chemical properties. The resonant absorption of IR radiation is measured for peaks indicative of various functional groups. The technique may be useful in identifying certain organic fibres.

A published method of fibre characterization by IR absorption is:

- *Method for the determination of chrysotile and amphibole forms of asbestos (ZHI/120/30)*. Sankt Augustin, Germany, Federation of Industrial Injuries Insurance Institutions, 1985 (available from Federation of Industrial Injuries Insurance Institutions, Alte Heerstrasse 111, 53757 Sankt Augustin, Germany).
Annex 3

List of participants at the final meeting

Geneva, 31 January–2 February 1994

Dr M. C. Arroyo, National Institute of Occupational Health and Safety, Baracaldo, Spain

Dr P. Baron, National Institute for Occupational Safety and Health, Cincinnati, OH, USA (Co-rapporteur)

Mr P. Buchanan, Luxembourg (representing the European Commission)

Mr P. Class, Rueil-Malmaison, France (representing the European Ceramic Fibres Industry Association)

Ms R. Cosca-Sliney, University Institute of Medicine and Occupational Hygiene, Lausanne, Switzerland

Dr N. P. Crawford, Institute of Occupational Medicine, Edinburgh, Scotland (Rapporteur)

Dr G. W. Gibbs, Winterburn, Alberta, Canada (representing the International Commission on Occupational Health)

Mrs B. Goelzer, Occupational Health, World Health Organization, Geneva, Switzerland (Secretary)

Mr F. I. Grunder, American Industrial Hygiene Association, Fairfax, VA, USA

Mr S. Houston, International Fibre Safety Group, Montreal, Canada

Dr E. Kauffer, National Institute of Research and Safety, Vandoeuvre, France

Professor S. Krantz, National Institute of Occupational Health, Solna, Sweden
ANNEX 3. LIST OF PARTICIPANTS AT THE FINAL MEETING

Professor Y. Kusaka, Department of Environmental Health, Fukui Medical School, Fukui, Japan

Dr J. LeBel, Asbestos Institute, Sherbrooke, Quebec, Canada

Dr M. Lesage, International Labour Office, Geneva, Switzerland

Professor M. Lippman, Department of Environmental Medicine, New York University, Tuxedo, NY, USA

Dr A. Marconi, Istituto Superiore di Sanità, Rome, Italy

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

Dr T. K.-W. Ng, Occupational Health, World Health Organization, Geneva, Switzerland

Mr G. Perrault, Quebec Research Institute for Health and Occupational Safety, Montreal, Canada

Mr A. L. Rickards, Rugby, England (representing Asbestos International Association)

Dr G. Riediger, Sankt Augustin, Germany (representing the European Committee for Standardization)

Dr H. U. Sabir, Occupational Health and Safety Institute, Ankara, Turkey

Mrs M. M. Teixeira Lima, Brasilia, Brazil (representing the National Foundation for Occupational Health (Fundacentro))

Professor F. Valic, Zagreb, Croatia (representing the International Programme on Chemical Safety)

Mr R. A. Versen, Littleton, CO, USA (representing the Thermal Insulation Manufacturers Association)

Dr N. G. West, Health and Safety Executive, Sheffield, England (Chairman)