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Evaluation of Asbestos Exposures in the Working Environment

The extensive use of asbestos in industrial and consumer products and the related occurrence of occupational diseases, especially asbestosis and neoplasms, associated with excessive exposure to the airborne asbestos fibers have stimulated much research over the past decade in many countries on exposure to asbestos as related to health, establishment of standards, and monitoring of the environment. The procedures used in the various countries for enumerating and characterizing exposures to respirable asbestos fibers differ considerably, making it extremely difficult, or impossible, to compare and interchange seemingly similar data between countries. The impact of the worldwide research on asbestos would be much greater if uniform procedures were used to collect, enumerate, and characterize exposures to respirable asbestos fibers. This would permit the data from different countries to be interrelated and included in a collective data bank, thus increasing the scope, reliability, and usefulness of the data.

The Sub-Committee on Asbestosis of the Permanent Commission and International Association on Occupational Health recommends the following procedures for collecting, enumerating, and characterizing respirable asbestos fibers in the working environment:

A. Fiber Exposure Evaluation Procedures

1. Collection of Airborne Sample

The membrane filter technique should be used for collecting airborne asbestos fibers. The respirable fraction should be used in making measurements for relating levels of exposure to health effects and for determining compliance of standards.

Specific procedures recommended for collecting membrane filter airborne samples of asbestos fibers including equipment, sampling rate and type of filter have been developed for the Asbestosis Research Council, England, and the National Institute for Occupational Safety and Health, United States. These procedures are described in "The Measurement of Airborne Asbestos Dust by the Membrane Filter Method"[1] and "The Method Used by the U.S. Public Health Service for Enumeration of Asbestos on Membrane Filters."[2] Each of the methods described gives comparable results.

2. Sampling Location

The purpose for which the sample is to be used will determine not only the type of sample to be obtained but also the location where it should be taken. Airborne samples collected at the breathing zone of the workers should be used in obtaining exposure data for application in studies on health effects and in evaluations for compliance of standards. These samples may be taken with personal samplers located on the workers[2] or by an operator holding the sampling equipment near the breathing zone of the workers. Stationary (fixed site) airborne samples may be collected for obtaining data to assure that dust control equipment and procedures at specific operations are functioning properly and efficiently.

3. Sampling Time

In collecting a sample of airborne asbestos dust, the length of time needed for collecting the sample will depend on the sampling rate of the instrument, the relative concentration of dust in the air, and the purpose for which the sample is collected. A relatively short sampling time but frequent sample taking should be utilized in determining maximal levels of exposure and their intermittency. In contrast, longer time samples should be taken for determining weighted exposures. Most sampling regimens, both for obtaining exposure data for correlation with health effects and for compliance with standards, will require both short- and long-term sampling times. In some instances, the regulations will specify both the sampling instruments and the sampling times to be used.[3] Both the sampling time and number of samples taken at any given operation should be so related as to give reliable data to fulfill the purpose for which the samples were taken.

4. Fiber Enumeration

Although the specific etiologic agents responsible for the health effects from excessive exposure to asbestos dust are not known, the accepted best index of exposure is the quantity of respirable fibers in the worker's breathing zone. It would be impossible to count all of the respirable fibers, since many of these are sub-micron in size and would require the use of the electron microscope for quantitation. The latter would be too time consuming and costly to use as a routine counting procedure. Consequently, at present it is feasible to count and use as an index of the overall spectrum of exposure only the respirable fibers that can be detected using specific optical microscopic equipment and procedures.

For differential purposes and based on past usage, a fiber is arbitrarily defined as a particulate in which the ratio of the length to the diameter is equal to or greater than 3 to 1. Fiber counts should be expressed in number of fibers per cubic centimeter (or milliliters) greater than 5.0 microns (or micrometers) in length. Fibers greater than 5.0 microns in diameter should be excluded since they are predominantly non-respirable. Asbestos fibers should be counted using phase contrast microscopy at around 400-500 x magnification. The treatment of the membrane filter on which the asbestos fibers are deposited and the microscopic counting technique involved are described in "The Measurement of Airborne Asbestos Dust by the Membrane Filter Method"[1] and "The Method Used by the U.S. Public Health Service for Enumeration of Asbestos Membrane Filters."[2] Each of the procedures gives comparable data.

In addition, for research purposes, limited measurements of the respirable fibers on the membrane filter samples should be made by means of both optical and electron microscopy to establish the ratio of fibers under 5.0 microns in length to fibers greater than 5.0 microns in length, as well as their respective distribution based on diameter. These measurements are needed since the biologic importance of sub-micron asbestos fibers is largely unknown and the fibers equal to or greater than 5.0 microns in length may not always be a valid index of exposure expressing the relation and significance of the spectral distribution of the respirable fibers present.

For hazard evaluation and compliance of standards as well as research purposes, it is recommended that the ratio of respirable asbestos fibers to total respirable particulates be determined. This is especially important in instances where the other respirable particulates may be biologically reactive per se or additive to the effects of the asbestos and where fiber counts may be relatively low so that the standard for other respirable materials present may become the most relevant factor.

B. Chemical Characterization of Fibers

1. Type of Fibers

Different types of asbestos fibers may evoke different biological responses depending on their chemical and physical characteristics. The type of asbestos present in the respirable fibers, e.g., chrysotile, amosite, crocidolite, etc., should be identified and this information given as a part of the exposure data. This identification may be relatively easy if the source and nature of the parent bulk asbestos is known. In some instances, however, a natural mineral such as talc may contain a mixture of fibers. Also, the source and nature of the asbestos represented in the respirable sample may be unknown. In such instances, polarizing microscopy, X-ray diffraction, electron microscopy, electron microprobe, electron diffraction, and other special techniques may be needed to identify the nature of the fibers.

2. Metals

Asbestos fibers sometimes have associated with them a number of metals which may be biologically active. Those metals may arise out of the mineralogy involved in the formation of the fibers or from the abrasive action of the fibers on the alloy metals in which they are processed. The quantity of the specific metals present in a respirable sample may differ markedly from that of bulk or settled dust samples. For research purposes, representative airborne samples of respirable asbestos dust collected at strategic operations should be analyzed for biologically active metals, e.g., nickel, chromium, cobalt, manganese, iron, etc. Sufficiently sensitive methods should be used to express concentrations accurately within the lower range of micrograms per cubic meter of air.

3. Free Silica

Some types of asbestos fibers may contain appreciable amounts of free silica. At times, silica may be added in the preparation of an asbestos product such as in shingles, sidings, and pipes. In evaluating the exposure of the asbestos worker, measurements should be made of free silica concentrations at strategic operations where it may be present in the air in amounts approaching the standard[4] for exposure to silica.

4. Organic Contaminants

Respirable asbestos dust samples may contain varying amounts of polycyclic aromatic hydrocarbons, depending on the nature and source of the asbestos fiber, the processing and packaging involved, and the absorption of organic compounds from the ambient air on to the fibers. For research purposes, concentrations of cyclohexane extractable materials should be determined in airborne samples of respirable asbestos dust collected on glass fiber filters in various working environments. High volume samplers should be used where possible to estimate the amounts of common polycyclic aromatic hydrocarbons in the samples.

C. Physical Characterization of Fibers

Under the microscope, respirable asbestos fibers may at times show physical appearances that are different from those usually observed, e.g., curling of fibers, excessive spreading within the fiber bundle, etc. For research purposes, these patterns, along with their frequency of occurrence, should be noted and reported.

D. Alternative Exposure Evaluation Procedures

1. Counting and Enumeration

Many countries have had long years of experience in using specific procedures, such as the konimeter, bright field projection microscopy, etc., for collecting and counting asbestos dust in determining exposure levels and have developed extensive knowledge by correlating the data with health effects. It is important that such knowledge not be lost and that an accurate bridge of relation be established between these data and similar data obtained with the use of the uniform procedures recommended by the Sub-Committee on Asbestosis. Thus, it is strongly recommended that countries not using the recommended uniform procedures routinely be urged to use these procedures concurrently with their usual collecting and counting procedures so that comparative data can be made available.

2. Other Procedures

Other procedures being selectively used to measure and characterize the respirable dust associated with asbestos exposures utilize direct and indirect reading dust counters, mass measurements, surface area measure-

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ments, and the like. The application of these methods of counting and characterization should be encouraged and may give new knowledge on the biological response to fibers. It is urged, however, that concurrent data also be obtained with the procedures recommended by the Sub-Committee on Asbestosis.

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