United States
Environmental Protection
Agency

Environmental Monitoring Systems
Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S4-83-033 Aug. 1983

EPA

Project Summary

Computer Simulation of the EPA Provisional Method for Measuring Airborne Asbestos

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A computer simulation program was developed to reproduce manual counting methods and calculate their accuracy in estimating the number of asbestos fibers on a filter surface. A model arrangement of asbestos fibers on a filter was generated for a predetermined number of fibers with lengths and widths according to lognormal distribution and uniformly random placement. These hypothetical fibers were next counted by computer in a program simulating manual microscopy estimating procedures. The protocols proved to have a quantifiable error factor when the computer counting results were compared with the predetermined, original total of model fibers. The bias resulted because, in the counting protocol, fibers on the sample grid having an aspect ratio less than 3 were not included. The mass estimates proved correct at light loadings but were biased low at heavy loadings. It is suggested that most of the mass is concentrated in the large fibers; thus, at light loadings these fibers are well sampled due to their size. At heavier loadings they are more likely to extend past the field of view and their size is more likely to be underestimated.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report describes a computer simulation of the EPA provisional method for measuring airborne asbestos.

The unique physical properties of asbestos have encouraged widespread use of this mineral for centuries in a variety of applications. A large industry has developed around usage of asbestos as a result. Unfortunately, exposure to airborne asbestos fibers adversely affects the respiratory system by reducing lung capacity, and recent studies have related various forms of lung cancer to asbestos exposure. The Environmental Protection Agency (EPA) and the scientific community believe that any level of exposure to asbestos involves some health risk, although the exact degree of risk cannot be reliably estimated. EPA has moved to control emissions of asbestos because of its widespread use and hazardous nature.[1] Because of the difficulty in controlling all sources of emissions, the need exists to monitor airborne asbestos.

Airborne asbestos fibers range in length from a few micrometers down to submicron sizes. Median airborne fiber lengths reported in the literature range from about .5 μm to as much as 5.0 μm[2,3] and are best measured using electron microscopy. Asbestos fibers are identified by morphology, chemical composition, and crystal structure. Morphology is determined by direct observation under the microscope. Chemical composition is determined by x-ray fluorescence. Crystal structure is determined by selected area electron diffraction.

The EPA provisional methodology for measurement of airborne asbestos employs samplers ranging from high volume using 8" x 10" filters to personal samplers containing circular filters 37 mm in diameter. Transmission electron microscopy (TEM) is used to identify and measure airborne fibers. Because several charac-

teristics of fibers are considered in health studies, fiber count, length, width, and mass are reported. Collecting fibers on filters presents the fewest problems in the measurement process described in the provisional method; however, microscopic analysis of the filters presents many problems. The method is an uneasy compromise between statistical sampling and TEM microscopy. The statistician worries about analyzing a large enough portion of the filter to make meaningful estimates, while the microscopist worries about analyzing a sample that is small enough to complete the job under time and budget constraints.

Following collection of fibers, a circular section 3 mm in diameter is removed from the filter for TEM analysis. The section is placed on a TEM grid to identify positions in the sample, where up to 10 grid openings (75 to 100-μm squares) are examined according to a strict counting protocol. Fiber counts on the filter are estimated from fiber counts in the sample section multiplied by the ratio of filter area sampled to total filter area. This ratio is usually in the neighborhood of 10,000. The importance of a well conceived counting protocol is obvious.

Testing the counting protocol has been accomplished by repeated experimental observations by TEM which are tedious, time consuming, and expensive. This report describes a computer simulation of the counting protocol. The program was developed on the UNIVAC at the EPA National Computer Center. The program used IMSL[4] and TEKTRONIX software and hardware.

Results

The computer simulation of human estimation methods for asbestos fibers on a filter produced a total of 1,161,023.4, as opposed to the true predetermined fiber count of 1,570,779 programmed for the research. The estimated mass on the filter was 0.002123, as opposed to an actual figure of 0.00235320815. The simulation identified error factors in human counting methods that were 26% low for total number and 16% low for mass.

Conclusions and Recommendations

If the model is a reasonable representation of the interaction between the provisional method and airborne asbestos, then the model indicates that the method provides fiber count data that are biased low. The most plausible reason for this is that the method calls all objects with a ratio of length to width (aspect ratio) less than 3 to be deleted from further consideration. The simulation model recognizes the existence of asbestos fibers with aspect ratios less than 3. It is uncertain whether or not objects with aspect ratios below 3 can really be considered asbestos; and even if they are asbestos, there is uncertainty as to health effects due to such short fibers.

Mass estimation is also biased low under higher loadings. A probable cause for this is that mass is concentrated in larger fibers. Under the provisional method, large fibers are not fully measured when filters are heavily loaded with fibers. This truncation may result in biased mass estimates. When there is a lighter loading, the entire fiber is measured, thus negating this bias.

Assumptions in the simulation model targeted for refinement are (1) fibers do not bend, (2) all objects below an aspect ratio of 3 are still fibers, and (3) there are no operator errors in following the protocol in measurement and identification.

References

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The complete report, entitled "Computer Simulation of the EPA Provisional Method for Measuring Airborne Asbestos," (Order No. PB 83-231 852; Cost: $7.00, subject to change) will be available only from:

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1983—659-017/7154