FIBER IDENTIFICATION AND LENGTH DISTRIBUTION FOR AIRBORNE ASBESTOS FIBERS IN AN INSULATION MANUFACTURING FACILITY

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Tyler, Texas

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BACKGROUND AND PURPOSE

During the National Institute for Occupational Safety and Health (NIOSH) industrywide study of the asbestos products industry, several facilities with excessive asbestos exposure levels were noted. One of the most dramatic of these was the Tyler, Texas facility of the Pittsburgh Corning Corporation. Thermal pipe insulation was manufactured at this facility using amosite asbestos. (The facility has since ceased operations.)

The inplant environmental surveys conducted by NIOSH at the subject Pittsburgh Corning facility took place in 1967, 1970 and 1971 and yielded very high fiber concentrations, many of which were higher than 200 fibers (greater than 5μm in length) per milliliter of air. In October 1971, a NIOSH medical survey team conducted examinations of 63 employees at this facility. Seven of 18 workers with greater than ten years employment were diagnosed as having asbestosis.

In addition to the inplant asbestos exposure problem at this facility, a community air pollution problem also existed, including (1) potential "stack" and "ground level" emissions from the facility, (2) asbestos waste material being deposited in open dumps, which could allow the asbestos to become airborne by the action of surface winds, and (3) the sale of burlap bags, in which the amosite asbestos was received at the facility, to nearby greenhouse operators to be used during the planting of roses. (An experiment conducted by NIOSH in January 1972 demonstrated that asbestos exposures resulted when these bags were shaken.)

The most serious consequences of the asbestos exposures resulting from this facility in Tyler, Texas may be many years in coming. The latency period for asbestos-induced lung carcinoma and mesothelioma is 20 to 30 years. Furthermore, the "quantity" and physical characteristics of asbestos needed to induce these cancers are not completely understood. It has been postulated and in some cases demonstrated that cancer can be induced after only a casual exposure. In addition to the well known high rates of human lung cancer and mesothelioma associated with asbestos exposure, mortality studies have hinted of increased cancer rates at other sites such as the gastro-intestinal tract.[1,2]

In parallel to the Tyler, Texas situation is the present problem in Duluth, Minnesota involving probable asbestos contamination of drinking water supplies and ambient air. The Reserve Mining Company is presently dumping taconite tailings from iron ore processing into Lake Superior. Laboratory analyses of these tailings and the contaminated water have demonstrated the presence of quantities of fibrous amphiboles (some of which may be amosite) in excess of what would normally be considered "background" concentrations. Sizing of these fibers has shown the majority to be less than 5μm in length. It has been argued that since these fibers are less than 5μm in length (i.e., those fibers counted[3] when determining compliance with the present Occupational Safety and Health Administration /OSHA/ standard[4]), no health consequences should result.

The purposes of this paper are:

1. To identify the inplant airborne fibers in the Tyler, Texas asbestos facility and those fibers found in open dumps near the facility.

2. To demonstrate that, in fact, a large portion of all inplant airborne asbestos fibers in the Tyler, Texas facility were less than 5μm in length.

3. To point out that the present optical asbestos counting method[3] of considering only 5μm or longer fibers is only an index of actual asbestos exposures.

SAMPLING AND ANALYTICAL METHODS

Sample Collection

Inplant air samples used for discussion in this paper were collected during the previously mentioned NIOSH asbestos study. Two personal samples were utilized and collected in the worker's breathing zone. The samples were as follows:

Sample No.	Job Type	Fiber Concentration, fibers/ml Total Fibers	>5μm in length
1	Lift Truck Operator	70.8	22.8
2	Pipe Insulation Builder	134.7	66.4

The above fiber counts were made previous to the date of this report using the present asbestos sampling technique[3] and counting total fibers as well as those longer than 5μm.

In addition to the inplant air samples, on August 16, 1973, Richard A. Lemen, Division of Field Studies and Clinical Investigations, NIOSH, collected a bulk sample from an open dump located near the Pittsburgh Corning facility. The major purpose for this sample was fiber identification.

Fiber Identification

Identification of the fibers present in both the bulk sample and the inplant air samples was accomplished by the dispersion staining technique described by McCrone and Delly[5]. The bulk and inplant air samples and an amosite asbestos standard were mounted in a Cargille liquid with an index of refraction of $N_o^{25} = 1.67$. A Leitz petrographic microscope equipped with a 10X McCrone[5] dispersion staining objective was used with polarized light. Fiber identification was accomplished by comparison of the dispersion staining colors with those of the known standard.

Fiber Size Distributions

Fiber length distributions were determined for both of the inplant air samples using optical and electron microscopy. Optical size distributions were made using oil immersion phase contrast microscopy at 1000X magnification.*

*The presently used optical asbestos counting method[3] does not use oil immersion and requires a magnification of approximately 400X. The 1000X magnification was used to take complete advantage of the capabilities of the optical microscope so that more of the small fibers could be seen.

A "Zeiss" phase contrast microscope fitted with a 100X acromat objective (N.A. = 1.30), 10X Huygenian eyepieces, a Zernike type condenser (N.A. = 0.90) and a high light intensity illuminator was used. Size distributions were determined by comparison with a calibrated "Porton" eyepiece reticle. At least 200 randomly selected fibers were sized for each sample.

For size distributions by transmission electron microscopy, the samples were mounted on Formvar coated grids with the filter substrate being dissolved away in an acetone bath[6]. Micrographs were taken on a transmission electron microscope at approximately 6400X magnification (including photographic enlargement) and at an accelerating voltage of 50kv. Fiber length distributions were determined for each sample using the micrographs and a Zeiss Particle Size Analyzer. 228 fibers in Sample 1 and 189 in Sample 2 were randomly selected for fiber length distribution.

RESULTS

Fiber Identification

The results of the fiber identifications show unambiguously that the fibers present in both the inplant air samples and in the bulk sample are amosite asbestos.

Fiber Size Distributions

Results of the optical and electron microscope fiber size distributions are shown in Figure 1 and 2, respectively. From Figure 1, it can be seen that even with the optical microscope and its limited resolving power, 45 percent (Sample 2) and 54 percent (Sample 1) of the inplant airborne fibers were shorter than 5μm in length. This fact is further brought out with the electron microscope (Figure 2) and its superior resolving power in that 48 percent of the fibers for both samples were shorter than 4μm in length. Those fibers shorter than 5μm in length could not be estimated in this analysis because the magnification that was used limited the size range on the size analyzer to only those fibers equal to or less than 4μm in length.

FIGURE 1 AIRBORNE FIBER SIZE DISTRIBUTION BY OPTICAL MICROSCOPY
PITTSBURGH CORNING, TYLER, TEXAS

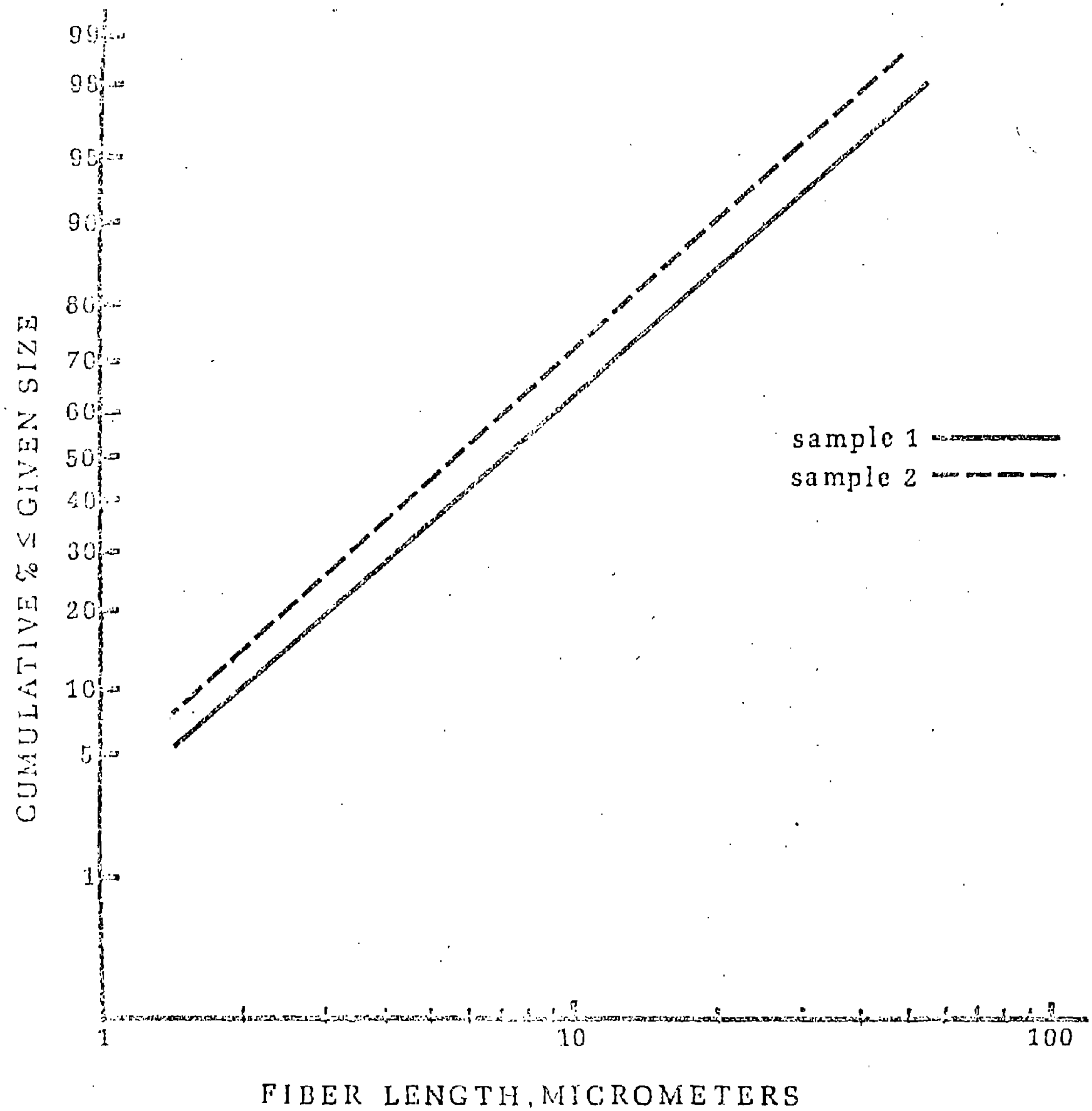
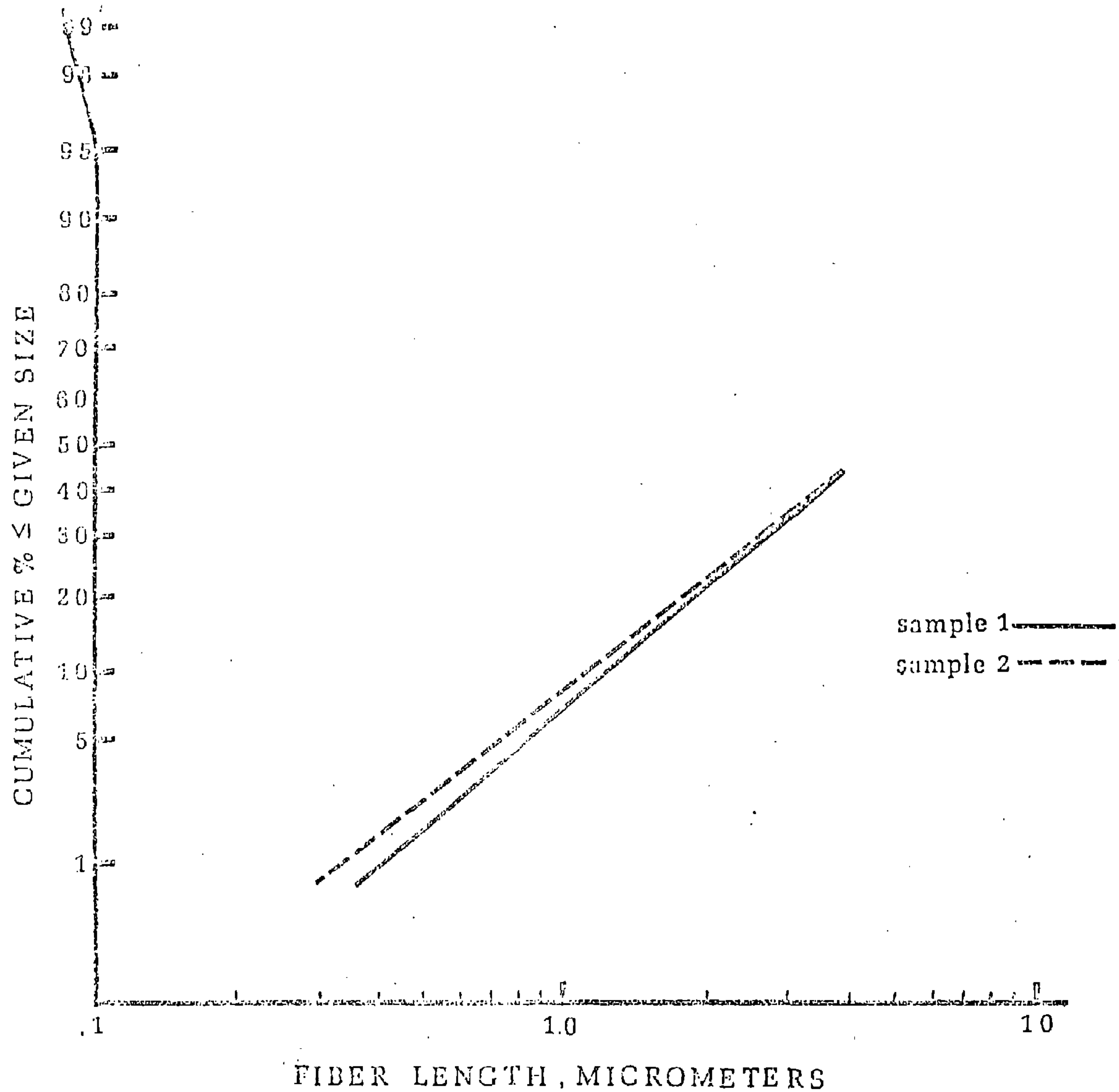


FIGURE 2 AIRBORNE FIBER SIZE DISTRIBUTION BY ELECTRON MICROSCOPY
PITTSBURGH CORNING, TYLER, TEXAS



However, this does not affect the results of the analysis, since even a greater percentage (than 48 percent) of the fibers would be shorter than 5μm in length, if the entire length distribution were identified. It should be noted that the greater resolving power of the electron microscope also is shown by the fact that fibers less than 1μm in length could be readily identified, which was not the case with the optical microscope.

DISCUSSION OF RESULTS

The analyses described have unambiguously identified the airborne fibers in the Tyler, Texas facility of Pittsburgh Corning and those fibers in the "open dump" near this facility as being amosite asbestos. In addition, the fiber size distributions for the two inplant air samples has shown that large quantities of airborne amosite fibers in this facility were shorter than 5μm in length.

A similar study to the one described herein was conducted by Lynch, et. al.[7] The results of their analysis are given in Table 1. These results also show that the majority of all airborne asbestos fibers in other asbestos operations are shorter than 5μm.

In summary, then, the fact is evident that when counting fibers in accordance with optical microscope techniques similar to those presently recommended by NIOSH[3] and included as part of the OSHA asbestos standard[4], a large portion of the fibers present (i.e., those less than 5μm in length) are not counted. These techniques, therefore, are merely an index of asbestos exposures and do not necessarily dictate particular health consequences*. This type of information is of considerable importance in regard to recent animal studies by Stanton[8] in which he has postulated that durable fibrous material acts as a carcinogen due to its

*These optical techniques and the use of the 5μm length cutoff were established because of instrument limitations.

Table 1

RESULTS OF FIBER SIZE DISTRUBTIONS BY ELECTRON MICROSCOPY*

Fiber Size Distribution
(5000X electron microscope)

Operation	Count Median Length (μ)	σg	% >5μ
Textile			
Fiber preparation & carding	1.4	2.0	4
Spinning, Twisting & weaving	1.0	2.0	2
Friction			
Mixing	0.9	2.2	2
Grinding, cutting & drilling	0.8	2.4	2
Pipe			
Mixing	0.9	2.3	2
Finishing	0.7	2.2	1

*Taken from Reference 7.

structural shape rather than its physiochemical properties. Also, recent animal experiments with chrysolite asbestos by Pott[9,10] have indicated that "...the carcinogenity of fibers <3μm (in length) may be <u>less but not unimportant</u> in comparison to the larger ones;..." and "...that a length of 2-3μm of the fibrous form of chrysotile is essential for the carcinogenic activity and not the chemical properties of asbestos."

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