ASBESTOS STUDY - PROCEDURES AND FINDINGS

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INTRODUCTION

In the early 1900's massive exposures in the dusty trades were common and the situation in American asbestos processing plants was no exception. The ability of asbestos dust to cause pneumoconiosis had been recognized for some years and a series of studies sought to define the dose-response relationship. In 1934 the Department of Labor and Industry of the State of Pennsylvania undertook an investigation of asbestos fabricating plants but was unable to establish the maximum safe concentration of asbestos dust in the air.(1) In 1938 the U. S. Public Health Service related dust concentrations to incidence of disease and recommended that 5 million particles per cubic foot, as measured by the impinger method, be regarded tentatively as the threshold value for asbestos dust until better data were available.(2) This "tentative" standard has been used for 28 years. These investigations were one-time studies of actively employed asbestos workers. However, due to the long period of time between exposure to asbestos dust and onset of disease, a prospective study which follows the workers for a period of years, during and after the exposure, is required to define adequately the safe level of exposure. In addition to this lack of sufficient information upon which to base a standard for the prevention of asbestosis, a number of investigators have reported an association between exposure to asbestos and the occurrence of certain malignancies. Consequently, the U. S. Public Health Service has undertaken an occupational health study of the asbestos products industry.

OBJECTIVES

The objectives of this present study are as follows:(3)

"1. To determine the health status of the asbestos workers in this industry with special attention to diseases of the respiratory tract.

2. To determine which environmental factors have an adverse effect upon the health of asbestos workers in the asbestos-products industry.

3. To determine the relationship between occupational exposure and cause of death of asbestos workers.

4. To develop medical and environmental criteria and procedures for the control of health risks identified by the studies."

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METHODS

The over-all study is divided into three semi-independent phases: biometric, medical and environmental. The biometric phase of the study uses data obtained from the Bureau of Old Age and Survivors Insurance (BOASI) to calculate the mortality among asbestos workers. These mortality rates are compared to those of similar unexposed occupational groups to indicate those diseases for which there appears to be an excess risk related to occupation. Later, as BOASI reports the filing of death claims on members of the groups of workers identified in the environmental phase, death certificates and autopsy data, when available, will be collected to determine the causes of deaths among these groups.

The medical phase of the study will consist of base line and routine follow-up examinations on a part of each group of workers included in the environmental phase. Appropriate tests and examination procedures are being devised.

In the environmental phase of the study the hazards to which the workers are exposed are measured by surveys of asbestos processing plants. Between January 1964 and April 1965, eight textile plants, three friction product plants, and one plant producing hydraulic packing were surveyed. Additional measurements will be made in these plants at intervals of a year or more as part of this prospective study. Detailed interviews are also being conducted to obtain identifying information, occupational histories and smoking histories on each worker included in the groups or "cohorts" of workers on whom exposure measurements have been collected.

A field team consisting of three industrial hygiene engineers and a dust counting technician, augmented by State industrial hygiene personnel when available, performs the environmental survey of each plant. After meeting with management and union representatives to explain details of the operation, the team collects samples throughout the plant following the production route. All of the impinger samples taken are counted within 36 hours at a field laboratory set up convenient to the plant. All other samples are returned to the Division of Occupational Health laboratories in Cincinnati for later counting or analysis. In addition to sampling, local and general exhaust ventilation systems are studied and certain other information, such as machine speed, is obtained.

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The types of samples collected can be divided into four categories.

I. Bulk samples. Several pounds each of the different types of crude fiber, bag house waste and treating and lubricating oils used are collected at each plant. These samples are subjected to such analyses as x-ray diffraction for minerals including free silica, mass spectroscopy for such metals as nickel and chromium and other analyses for polycyclic aromatic hydrocarbons and natural radioactivity.

II. Long period gravimetric samples. Several instruments for obtaining mass samples of total and respirable dust are run simultaneously in a representative area in the midst of each operation. These instruments include a high volume sampler, a Hexhlet modified to take a membrane filter, a conicycle, an electrostatic precipitator and a set of four membrane filter field monitors with and without 10 mm cyclone pre-samplers. An additional high volume sampler is set up outside the plant to sample the makeup air being used. Certain of these samples are analyzed for the same constituents as the bulk samples. Other methods of analyses are being developed to estimate the respirable mass of asbestos.

III. Simultaneous impinger-filter samples. Breathing zone samples taken with an impinger and a membrane filter simultaneously are used to obtain a comparison of these methods of dust enumeration. Other sets of impinger-filter simultaneous samples, with and without horizontal elutriator pre-samplers, are taken in the general room air near specific operations.

IV. Personal samples. Membrane filter field monitors connected to personal sampler pumps are worn by workers with the monitor attached to their collars. These samples are collected for one to two hours at a rate of 1.5 or 2.0 lpm. In the large plants personal samplers are worn by about half the workers while in the small plants almost all the workers wear them.

Impinger samples are counted in a Dunn cell using a 16 mm (10X) light field objective, 10X ocular with a Porton eyepiece reticle and Kohler illumination. Membrane filters are rendered transparent with a mixture of dimethyl phthalate and diethyl oxylate and counted with a 4 mm phase contrast objective and 10X ocular.

RESULTS

All of the data presented here represent optical dust counts on impinger and filter samples taken in asbestos textile plants. The average results for impingers (Figures 1 and 2) are presented by plant and operation so as to permit comparison of the effectiveness of dust controls.

Asbestos enters the textile mill in 100 lb. pneumatically packed bags of opened fiber. The first operation, fiber preparation, includes the "picking" of the fiber to loosen and further open the material, followed by blending. Usually cotton, rayon or other fibers are mixed with the new fiber and in some cases, bag house waste and rendered yarn are added. Each ingredient is weighed, mixed and sent by pneumatic conveyor to a "condenser" which separates the asbestos from the air. The dust concentrations for fiber preparation reflect the degree of enclosure used at the different plants. Plants 2 and 4 used almost totally enclosed systems such that the asbestos did not emerge until it dropped out of the condenser. In the other plants manual handling was involved in moving the fiber from one step to the next and dumping into hoppers.

The carts of blended fiber are moved into carding and the fiber is manually transferred to the card hoppers. The card combs the fibers into a web which is separated into strands to form a "roving" wound on spools at the end of the machine. All cards were enclosed since it would be impossible to operate a card without almost complete enclosure and stay under the TLV. The dust concentrations in carding were inversely related to the volume of air exhausted and the tightness of enclosure. All air volumes were above the 800 cfm per card recommended by the Committee on Industrial Ventilation of the American Conference of Governmental Industrial Hygienists[4] and some were over twice that figure. However, none were as high as the 2300 cfm per card used in one English asbestos textile mill.[5]

The spinning machine imparts a twist to the parallel fibers in the strand of roving to produce a yarn. Plant 3 had no exhaust on the spin frames and the exhaust in Plant 1 was ineffective due to a plugged duct. Plants 4 and 5 both had good down-draft local exhaust systems with baffles in front of the spools to limit the open area to the top where the roving entered. Plant 2 had no local exhaust but a very large general exhaust system removing 120,000 cfm from a room of approximately 450,000 cubic feet containing 60 spinning and twisting frames.

The yarn produced by the spinning frame is next plyed with some other yarn and possibly nylon, glass or metal threads on a twisting machine. None of these machines had any local exhaust ventilation. The higher concentrations were partly related to higher machine speeds, which ranged over 3000 RPM as opposed to less than 2000 RPM in spinning. Another contributing factor was the practice of unwinding a spool on the high speed shaft to locate a broken wire. This resulted in beating the twisted yarn against the frame and occasionally produced dust levels in excess of the TLV. The average concentration in twisting in Plant 3 exceeded the TLV and probably resulted from the use of dusty raw fiber, which created generally higher dust concentrations in this plant. Plant 4 used a "speeder" or "slubber" twister instead of a ring twister. This machine enclosed the yarn on its way to the spool and thus produced less dust.

The twisted asbestos yarn, synthetic fibers and wire are then woven into cloth or tape. Tape weaving was less dusty than cloth weaving. Plant 1, for example, wove only tape and had low concentrations at the weaving operation in spite of generally higher concentrations at other operations. Most plants wet either the warp or the filling or both to reduce the dust. This was very effective in Plant 4 where a water spray thoroughly doused the warp. Plant 3 also used wet control by submerging the filling in a bucket of water before loading into the shuttle. Apparently not enough water penetrated the tightly wound cop and considerable dust emanated from the unventilated machine. Plant 2 wove cloth entirely dry, due to customer requirements, but had a well designed canopy hood with side and partial front baffles which was successful in removing the dust. Apparently, either wet weaving or good local exhaust is effective in maintaining dust concentrations below the TLV.

These results showed that average dust concentrations in asbestos mills were generally below the threshold limit value and in some cases very much below this limit. Tremendous progress has been made over the past 30 years as can be seen from Table I. The 1934 Pennsylvania survey occurred at a time when controls were relatively unknown and dust exposures were massive. By 1938, when the Public Health Service studied plants in North Carolina, some controls were in use and concentrations were measured with and without controls. No control system had yet been devised for spinning and only one twisting machine had local exhaust. Average dust levels reported here are well below the previous levels but about 10 per cent of the individual measurements are still over 5 mppcf. Effective engineering dust control practices are available and application of these methods would eliminate the occasional high dust concentrations.

Dust concentrations on membrane filters counted with a 4 mm phase contrast objective cannot be evaluated by the same TLV established for impinger samples counted with a 16 mm light field objective. Comparison of fiber concentrations on filters with total particles by impinger do not yield a high correlation since the two methods are not measuring the same thing. However, an approximate equivalence has been derived by the methods described by Ayer, et al.(6) The number of fibers per cc equivalent to one million particles per cubic foot arrived at by these methods is: 10 total fibers or 6 fibers longer than 5 μ or 3 fibers longer than 10 μ.

The results of over 600 membrane filter samples are summarized in Figure 3. Each of the bars represents the average concentration of the samples taken in each operation in four plants. In order to compare impinger results, the average dust concentrations measured by impinger (see "1964" column, Table I) have been converted to equivalent total fiber concentrations using the above approximate relationship. These are shown as circles on Figure 3. If the ratio of total fiber concentration by membrane filter to dust concentration by impinger were the same for all operations, all the circles would be expected to lie at the ends of the total fiber bars. However, in some operations significant differences can be noted. Fiber preparation is relatively dustier as measured by impinger, while the later operations of carding, twisting and weaving have relatively higher fiber concentrations on membrane filters. It may be that the granular dust which contributes the bulk of the impinger count disperses from the asbestos early in processing while the fibers are dispersed more slowly. The ratios of concentrations of fibers of different lengths are not constant. For example, the total fiber concentration for spinning is much lower than that for twisting but the > 5 μ fiber concentration is higher for spinning. This illustrates the difficulties in attempting to characterize the exposure to all sizes of fibers by counting only fibers longer than a certain size. The total fibers show more variability from operation to operation indicating they may be a more sensitive measure of relative dustiness.

Some British asbestos textile mills use a concentration of 4 fibers per cc longer than 5 μ as a goal in dust control. This is shown on Figure 3 by vertical lines. It would appear from the results reported in this study that the British limits are exceeded, on the average, in all operations. However, their counts are made with vertical illumination on colored membrane filters while in this laboratory counts are made with transmitted light-phase contrast on cleared filters, and therefore the two standards may not be comparable. Further work is in progress to resolve this question.

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CONCLUSION

It should be emphasized that all of the data presented are preliminary and that the results of more extensive studies both in textile and other asbestos processing plants will be reported in the literature as the studies progress. In general, dust concentrations reported to date in this study are considerably below those found by previous investigators in 1934 and 1938. However, improvements in the dressing of crude asbestos may have increased the fiber to particle ratio so that fiber concentrations may not have decreased as much as particle concentrations. Additional data from many different types of plants will be required before the combination of epidemiological and dust concentration data may lead to a new standard of safe levels of exposure possibly based on a new method of evaluation.

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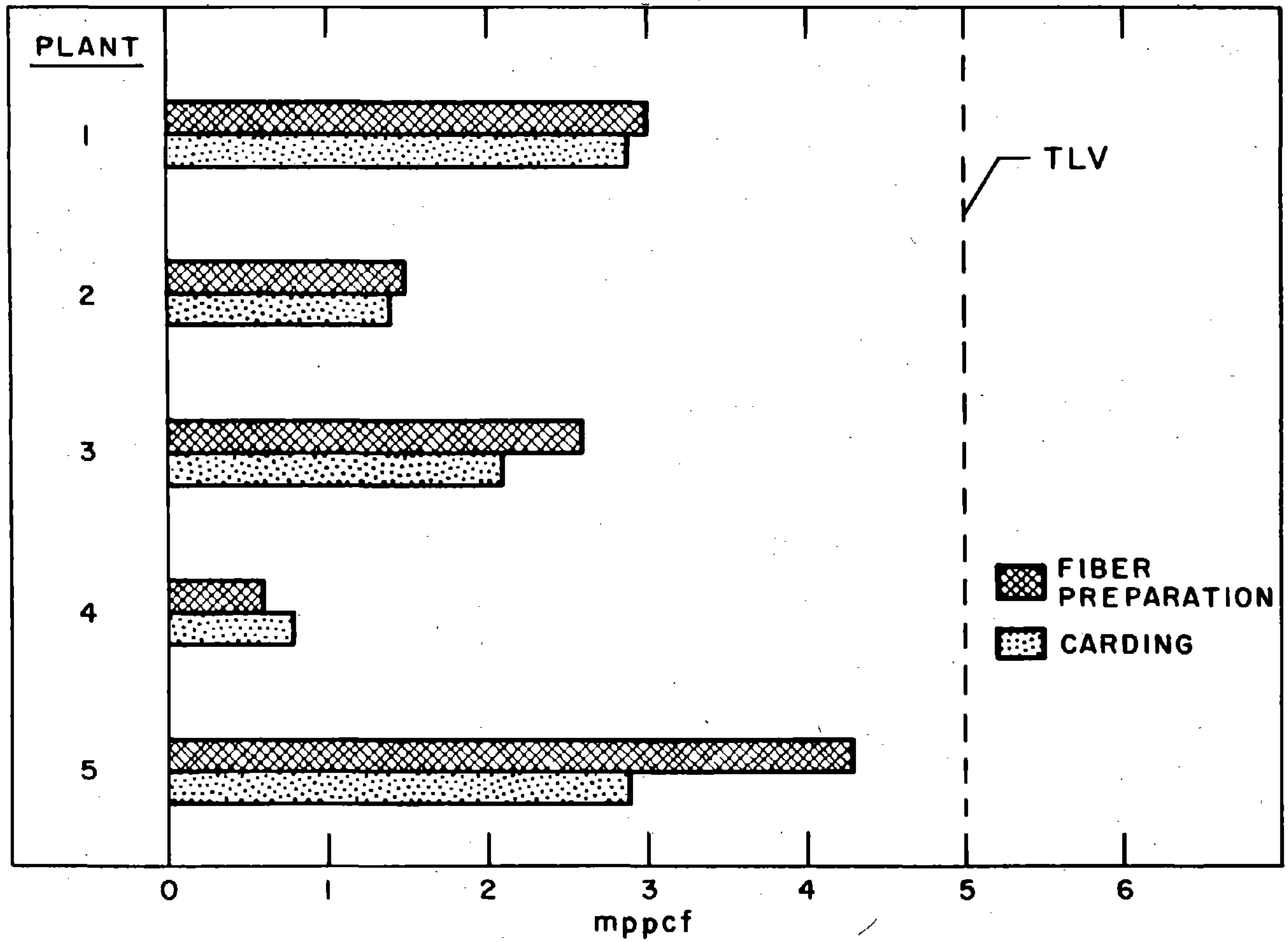
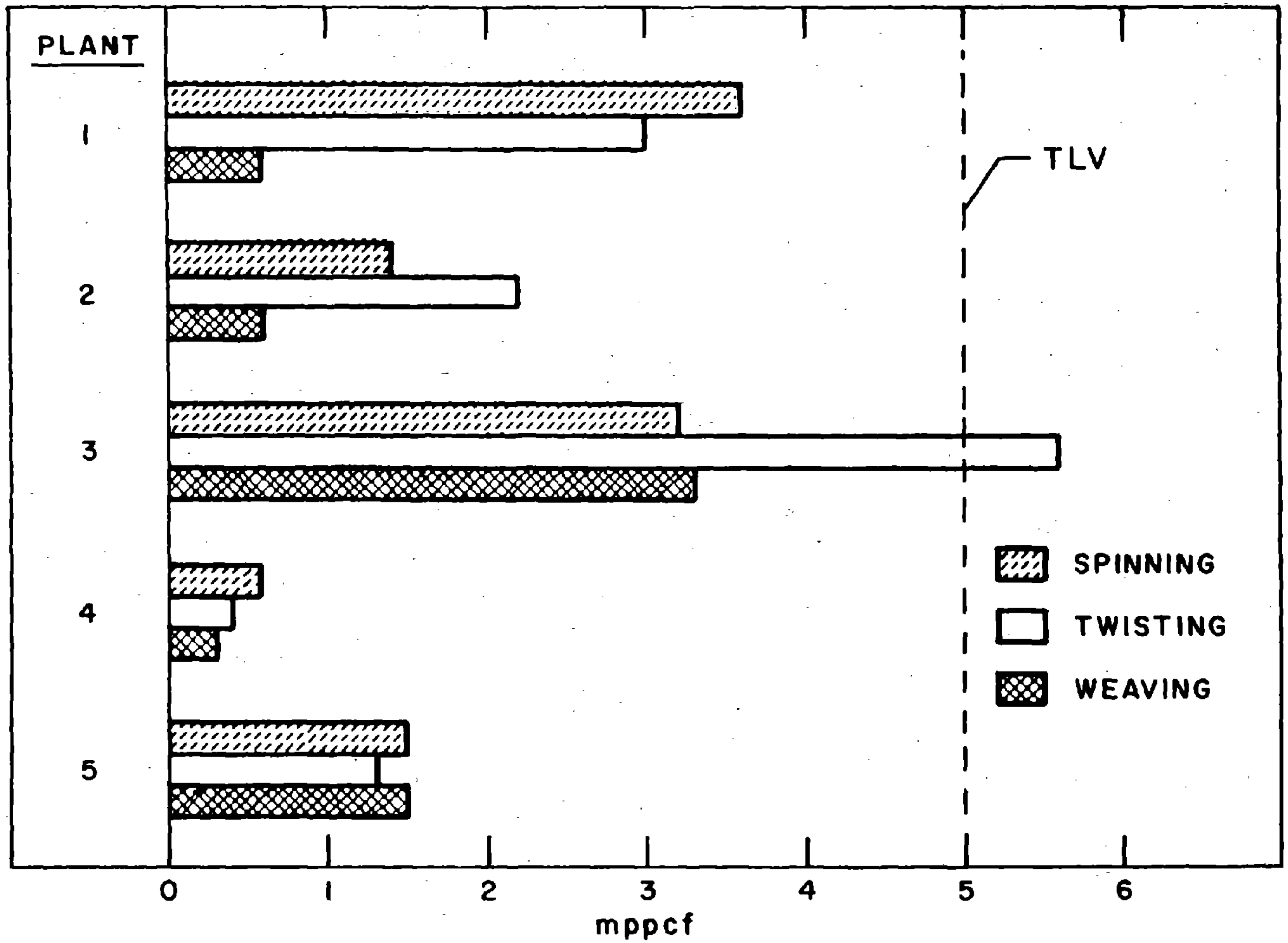
TABLE I

DUST CONCENTRATIONS - ASBESTOS TEXTILE SURVEYS

SURVEY / OPERATION	Penna. 1934	PHS 1938 without control	PHS 1938 with control	Public Health Service 1964
	Mean Concentration in mppcf			
Fiber Preparation	67.0	36.0	6.0	2.6
Carding	31.1	25.7	3.3	1.7
Spinning	16.2	7.1	---	1.2
Twisting	3.8	11.1	---	1.5
Weaving	19.8	14.0	2.1	1.2

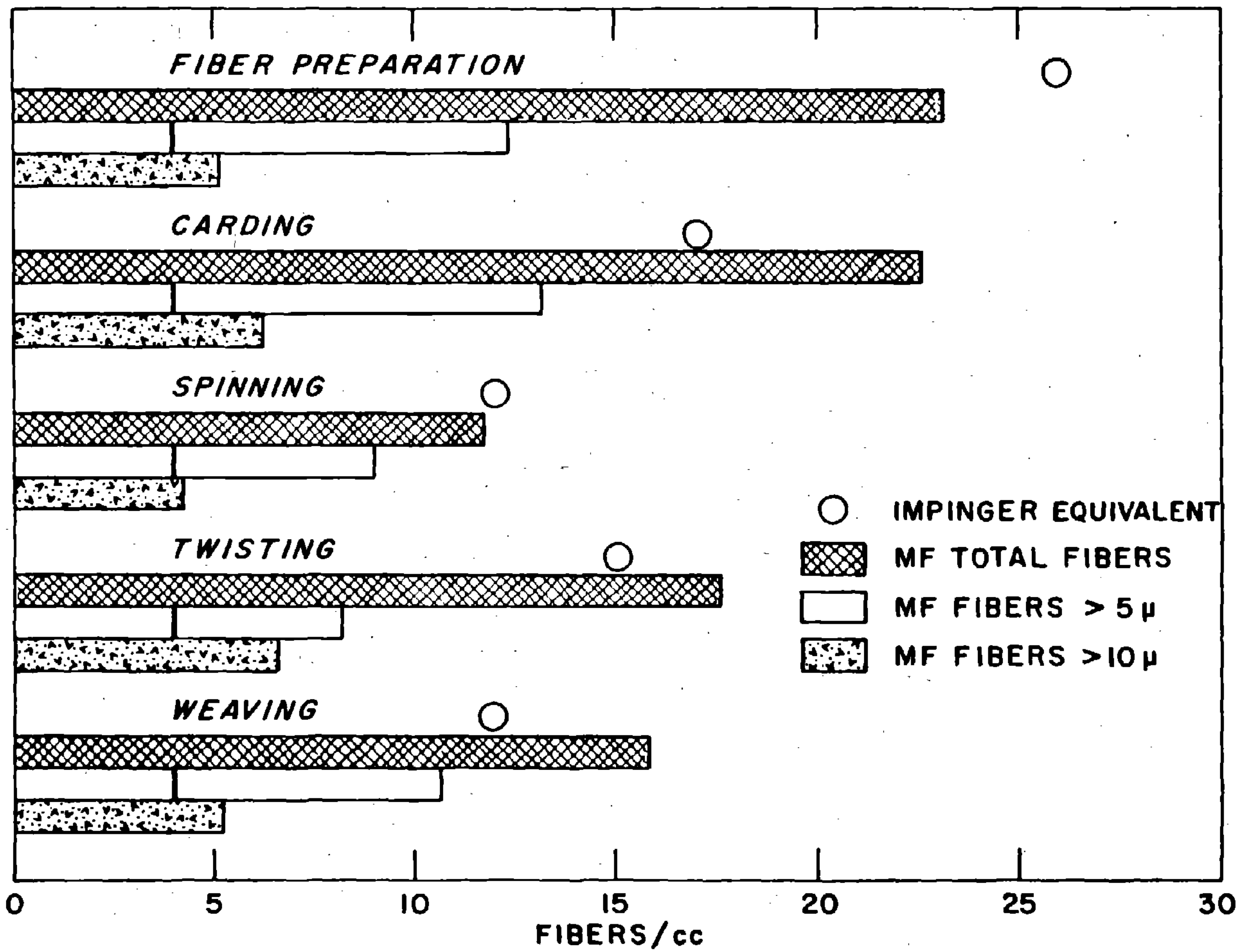


AVERAGE DUST CONCENTRATIONS BY PLANT AND OPERATION
IMPINGER SAMPLES COUNTED AT 100X
Figure 1



AVERAGE DUST CONCENTRATIONS BY PLANT AND OPERATION
IMPINGER SAMPLES COUNTED AT 100X

Figure 2



DUST CONCENTRATIONS BY OPERATION

MEMBRANE FILTERS COUNTED AT 430X PHASE CONTRAST

FIGURE 7

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

An industrial hygiene survey of asbestos (1332214) exposure in asbestos processing facilities (SIC-3292) was conducted. The survey was part of an ongoing United States Public Health Service (USPHS) occupational health study of the asbestos products industry. Eight textile manufacturers, three friction products facilities, and one factory producing hydraulic packing were surveyed. Bulk, gravimetric, personal, and simultaneous impinger or filter samples were obtained and analyzed for asbestos. Average asbestos concentrations obtained from impinger samples in various operations at the textile facilities expressed in millions of particles per cubic feet were: fiber preparation, 2.6; carding, 1.7; spinning, 1.2; twisting, 1.5; and weaving, 1.2. The USPHS threshold limit value (TLV) for asbestos is 5. At five textile factories, all impinger asbestos dust concentrations in fiber preparation, carding, spinning, and weaving operations were below the TLV. Asbestos dust concentrations at four of the five facilities were below the TLV. Total asbestos dust concentrations determined from filter samples at the textile facilities ranged from approximately 12 to 22 fibers per cubic centimeter. The author notes that the TLV value for impinger samples is not applicable to filter samples. Asbestos concentrations reported in the present survey seem to be below those found in previous surveys.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

Asbestos-dusts, Workers, Epidemiology, Dust-control, Textiles, Textiles-industry, Work-practices, Testing-equipment, Workplace-studies, Polycyclic-aromatic-hydrocarbons, Asbestos-fibers

c. COSATI Field/Group

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