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Technological Feasibility of the 2 Fibers/cc Asbestos Standard in Asbestos Textile Facilities

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The technical feasibility of developing dust control practice which would bring the asbestos industry into compliance with the OSHA 2 fibers/cc standard, scheduled to become effective July 1, 1976, has been questioned since its promulgation. This paper presents the results of industrial hygiene surveys, including the results of 243 asbestos air samples, conducted at two asbestos textile production facilities which have achieved the 2 fibers/cc standard. Both facilities use nonconventional production techniques. Conclusions drawn from the investigations express the need for: (1) a study of new products; (2) a tool to motivate consumers to switch to the new products when appropriate; and (3) legislation which will protect all domestic producers of asbestos textiles from certain producers who do not have to absorb the added expense of meeting the OSHA standard.

Introduction

DUE TO THE OCCURRENCE OF ASBESTOSIS, mesothelioma, lung cancer, and other diseases associated with occupational asbestos dust exposures which were once considered safe, the National Institute for Occupational Safety and Health (NIOSH) issued an asbestos criteria document in January of 1972 dealing with occupational exposures to asbestos.[1] This document recommends that "no worker should be exposed to more than 2.0 asbestos fibers per cubic centimeter of air (fibers/cc) based on a count of fibers greater than five micrometers (5 μm) in length, determined as a time-weighted average (TWA) exposure for an eight-hour work day . . ." On July 7, 1972, the Occupational Safety and Health Administration (OSHA) issued regulations that required occupational asbestos dust exposures to be limited to 5 fibers/cc (TWA), effective immediately, and 2 fibers/cc (TWA), effective July 1, 1976.[2]

Compliance with the 1976 OSHA standard will require many facets of the asbestos industry to adopt extensive dust control practices. However, the technical feasibility of developing dust control practices which would bring the asbestos textile industry, in particular, into compliance with this standard has been questioned since its promulgation. The NIOSH asbestos criteria document presents data which show that none of seven asbestos textile plants surveyed was consistently meeting the two fibers/cc standard in any of the six standard textile manufacturing operations (*i.e.*, fiber preparation, carding, spinning, twisting, winding and weaving). The document concludes from its environmental data that the "present methods of control practices in the textile industry are not adequate for the (2 fibers/cc) standard proposed" but it also states the opinion that the standard "is felt to be feasible technologically for the control of the exposure to the worker." This opinion is not generally shared by representatives of the asbestos textile industry. They feel that the lowest asbestos dust levels for the as-

Mention of company or product names is not to be construed as an endorsement by the National Institute for Occupational Safety and Health.

asbestos textile operations, which are above the 2 fibers/cc level, presented in the criteria document are indicative of practical "state of the art" dust control practices.

Consideration of technical feasibility is included in the OSHA asbestos regulations. For example, the regulations allow the use of personal respirators or shift rotation of employees to bring a facility into compliance only after it is determined to be technically infeasible to reduce the airborne concentration of asbestos fibers below the limits of the standard by means of improved work practices and/or engineering controls. To asbestos textile manufacturers, the determination of technical feasibility can make the difference of spending very large amounts of overhead funds to design, develop and install sophisticated ventilation equipment, or the spending of negligible amounts to provide personal respirators to their employees. This difference may determine their continued existance in the asbestos textile industry.

As an initial step in resolving the question of technical feasibility, it was the objective of this study to identify and investigate asbestos textile plants which may have developed sufficient work practices and engineering controls to be in compliance with the 2 fibers/cc standard. The data collected during the study will be presented to OSHA for utilization in any future re-evaluation of the asbestos regulations.

Description of the Study

Selection of Plants Surveyed

Six manufacturers of asbestos textile products were contacted and asked if any of their plants had been relatively successful in reducing asbestos fiber exposures in the standard textile production operations. The desire to observe the "cleanest" plants was emphasized. All but two manufacturers felt that they had made enough progress in reducing their dust levels to merit a visit to at least one of their plants. Site visits were conducted at five "model" plants offered for inspection. Of these, only two had a possibility of achieving the 2 fibers/cc standard using their present production techniques, and those two were both limited production facilities. Detailed airborne asbestos dust sampling surveys were conducted at these plants which are described here as Plants A and B.

Survey Methods

The NIOSH method of collecting and evaluating asbestos dust samples, as described by Zumwalde, *et al.*,[3] was used in both plants A and B. Personal samples were collected on Millipore Type AA, 37 mm diameter membrane filters at a flow rate of 2.0 liters per minute provided by MSA Model G Personal Pumps. Cassettes holding the membrane filters were used open face during the sampling and were secured within the breathing zone of the worker. Sampling time was approximately two to four hours for each sample, depending upon the apparent dustiness of the location of the sample. Typically, a morning and an afternoon sample were collected on each worker for each of three days.

Fiber counts were conducted at 400X magnification, using phase contrast illumination, and with the sample mounted in a high-viscosity solution of membrane filter material. Only those fibers greater than 5 μm in length were counted, and all asbestos dust concentrations presented herein assume this restriction.

Ventilation measurements were taken with a hand-held, Alnor velometer.

Description of Conventional Processing Operations[4,5,6]

This description of conventional textile operations, accompanied with typical dust exposure levels for each operation, is presented as an aid in understanding the processing changes developed by Plant A and Plant B.

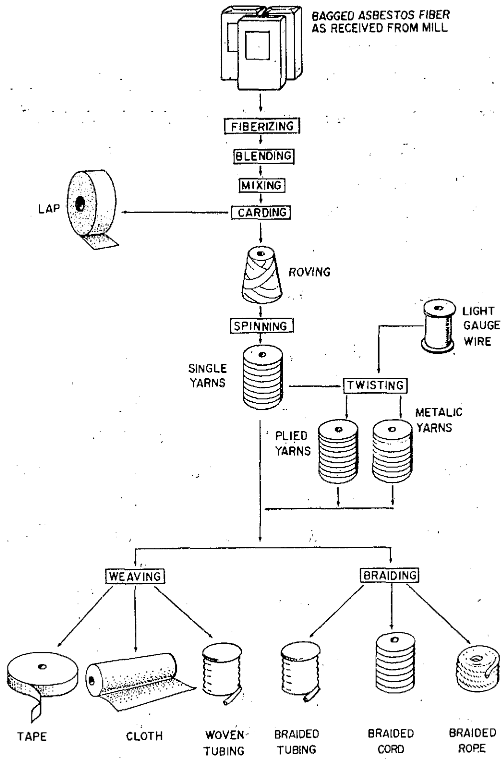

Figure 1. Flow diagram of conventional asbestos textile processing. (Courtesy of Asbestos Textile Institute)

Figure 1 is a block diagram which shows the processing flow of a typical asbestos textile production facility. Those familiar with the production of textiles from other materials will note the similarity. In fact, not much of the asbestos processing equipment is or has been designed for asbestos production. Practically all equipment in use is similar to that used for cotton and woolen goods production, with only slight or no modification.

The majority of asbestos textile plants receive bags of pre-milled asbestos fibers. The milling process provides preliminary opening and waste removal of the small bundles of unopened fibers received from the mines. This opening process is continued in the fiber preparation operation, which is often the dustiest area in an asbestos textile plant with airborne asbestos concentrations generally above 7 fibers/cc. Asbestos fibers must be mixed with longer, more flexible fibers of another material (usually cotton, rayon or some other synthetic fiber) before they can be spun and woven. This is due to the fact that the individual asbestos fibers resemble fine polished metal rods, free from any serrated surfaces. This characteristic makes it extremely difficult to spin a thread of pure asbestos. This problem is somewhat alleviated with the introduction of the "carrier" fibers which account for 5 to 20% of the weight of most asbestos textile products. The mixing of the carrier fibers with the asbestos fibers is performed in either the fiber preparation operation or the carding operation.

The blended fibers undergo a final opening and cleaning process by two carding machines, first a breaker card, and then a finishing card, which comb the fibers into a parallel arrangement to form a coherent mat of material. Strips, or slivers, are separated from the mat and mechanically compressed between oscillating surfaces into untwisted strands of asbestos roving. Vigorous manipulation of the asbestos fibers during the carding operation accounts for high dust concentrations (often more than 5 fibers/cc) in spite of extensive efforts to ventilate the carding machines.

Subsequent processing operations involve spinning, twisting and winding. The twisting and pulling operations performed by a spinning machine converts the relatively weak roving into a stronger structured yarn. The twisting operation involves the twisting of several single yarns to provide larger and stronger yarns. Strands made of other materials, such as nylon, fiberglass and wire, may be twisted with the asbestos yarns to meet specific product requirements. The only function of the winding operation is to wind the asbestos yarn into different size packages for marketing or to facilitate the loading of weaving looms or braiding machines.

Because of the nature of the design of standard spinning, twisting, and winding machines, the use of local exhaust in these operations is quite limited. Most facilities, however, have developed methods of applying moisture to the yarn as an aid in dust control. The moisture partially encapsulates the yarn and inhibits asbestos fibrils from breaking away from the yarn and becoming airborne. With the use of these "damp processing" methods, asbestos dust concentrations in the spinning, twisting, and winding operations are lowered to 2-5 fibers/cc. "Dry" spinning and twisting operations generally produce asbestos fiber counts in excess of the 5 fibers/cc OSHA standard.

In the weaving operation, asbestos yarn is woven into cloth on looms similar in principle to those used for weaving other types of fabrics. As in spinning and twisting, the weaving process may be performed with either damp or dry yarns. In damp weaving, moisture is applied to the yarn strands as they enter the loom by drawing the strands across wetting rolls. Asbestos dust concentrations in damp weaving areas generally range between one and 5 fibers/cc. Dry weaving operations must depend upon local exhaust for dust control and typically produce dust concentrations above 7 fibers/cc.

The final conventional asbestos textile operation is braiding. The braiding process is performed by a series of yarn-carrying spindles, half of which travel in one direction and half in the opposite direction. The interlocking action is similar to that in a maypole dance, the yarns being plaited together to form a braided product. Compared to the other operations, the braiding operation is relatively slow and mild in its manipulation of the asbestos yarns and creates less dust. Asbestos dust concentrations of 2 fibers/cc and less are frequently obtained in this operation.

Asbestos Textile Plant A

Description of Processes

Through modifications of the conventional processing methods, Plant A has been successful in achieving asbestos dust concentrations which are consistently less than 2 fibers/cc in all production areas. The most obvious difference between the asbestos textile operations found in Plant A and the conventional operations described earlier is the absence of a fiber preparation area and a spinning area in Plant A.

The elimination of separate fiber preparation is a result of alterations in the carding operation, which effectively eliminates two dust-control problem areas.

In the modified carding operation, the bags of pre-milled asbestos fibers are opened inside a partial enclosure under negative pressure and dumped onto a spiked apron which feeds the fibers directly into the breaker card. Rayon is used as a carrier fiber and is added to the asbestos fibers in the form of rolled lap at the breaker card. Both the breaker card and finishing

TABLE I
Local Exhaust Face Velocities (ft/min) at Plant A[a]

	Hood Size	Card Number						
Carding:		1	2	3	4	5	6	8
Breaker Card Feed Station	2 ft. x 4 ft.	50	150	75	50	110	110	160
Breaker Card Roll Out	4 ft. x 8 in.	250	150	200	175	150	225	175
Finishing Card Roll In	4 ft. x 2 in.	250	325	300	200	300	375	350
Finishing Card Take-Off	5 ft. x 2 in.	200	300	200	200	175	75	75
Weaving:								
Cloth Looms' Overhead Hood[b]	6 ft. x 10 in.		Loom 3 75-100			Loom 4 75-100		

[a]Local exhaust was not used at winding, twisting, and tape looms.
[b]Measurement taken at weaving surface 2 ft below the hood.

card have been enclosed and are kept under negative pressure (Table I), except for the camel-back conveyor between them. Each pair of cards has a cyclone type dust collector overhead. That fraction of dust which is not reintroduced into the carding machines is collected in a cloth bag type dust collector. Dust falling beneath the cards is continuously raked onto a side-conveyor, from which it is pneumatically conveyed back into the card for recycling.

A water solution is applied to the rovings as they come out of the finished card. The solution encapsulates the yarn so that dust levels are minimized in this, and subsequent, operations. The rovings also are spun at this point and then wound into packages of yarn. Spinning of the rovings at the finishing card is made possible with the addition of a polyvinyl acetate yarn insert which reinforces each roving, reducing the amount of yarn breaks occurring during processing.

This reduction of yarn breaks is particularly significant in the twisting operation, since it reduces the number of production delays and the number of broken thread ends that are whipped against the twisting frame, which can be a major source of dust emissions. The reinforced yarn also allows Plant A to apply increased amounts of moisture to the yarns being twisted and provides for a tighter twisting of the yarns which also inhibits dust emission.

There is no local exhaust in the twisting, winding, or braiding areas and only limited local exhaust in the weaving operation. The major method of dust control used in these operations is the application of the different wetting solutions to the yarns as dust suppressors. Different solutions are used depending upon the final use of the product.

Particularly good housekeeping was observed in all areas of Plant A. A central vacuum system with an automatic dust bagger serviced all but the braiding areas and was sufficient for most cleaning tasks. In accordance with good work practices, compressed air is not used in the plant for cleaning purposes.

Results of Environmental Measurements

At Plant A, 148 personal asbestos dust samples were taken and the results are summarized in Table II. Because the individual asbestos fiber counts were generally consistent within each job category, it is felt that enough samples were taken to consider the results reported in Table II to be a fair representation of the airborne asbestos dust levels found in this plant. The levels are well below the 1976 OSHA standard of 2 fibers/cc and, when compared to previous surveys (Table II), they represent the marked effect of the modifications of the conventional textile operations incorporated by Plant A and discussed in the previous section. These modifications have lowered the asbestos dust exposures to less than one-tenth of what they were two years previous.

The highest concentrations of airborne asbestos dust were recorded in the carding area with a mean concentration of 0.8 fibers/cc which included the only sample that was above 2 fibers/cc; 10 samples that were greater than 1 but less than 2 fibers/cc; and the remaining 33 samples with levels of less than 1 fiber/cc.

The advantage of processing asbestos yarn which has been encapsulated with an effective dust suppressing solution is clearly shown by the mean concentrations in twisting (0.5 fibers/cc), winding (0.3 fibers/cc), weaving (0.6 fibers/cc) and braiding (0.2 fibers/cc).

Table I gives the results of ventilation measurements taken with an Alnor velometer. The values recorded show a significant difference in face velocities between some of the cards. Equalizing the volume of air ventilated through each card would improve the efficiency of the card room ventilation system.

TABLE II
Personal Samples at Plant A—Secular Trends
(Mean, range, and sample size by operation)[a]

Operation	1965[b] Mean (Range)	1965[b] No. of Samples	1971[c] Mean (Range)	1971[c] No. of Samples	1973[d] Mean (Range)	1973[d] No. of Samples
Fiber Preparation	7.2 (5.3-10.1)	5	7.4 (1.4-7.5)	5	operation deleted[e]	
Carding	8.7 (2.1-23.5)	11	9.6 (1.6-31.0)	23	0.8 (0.2-2.6)	44
Spinning	7.9 (4.8-10.6)	14	operation deleted[e]		operation deleted[e]	
Twisting	9.3 (3.2-22.5)	11	6.9 (1.0-13.7)	35	0.5 (0.1-1.5)	29
Winding	3.5 (0.7-6.7)	8	2.5 (1.0-4.0)	9	0.3 (0.1-1.0)	24
Weaving	6.6 (0.1-22.6)	31	10.0 (2.4-20.2)	16	0.6 (0.1-0.7)	27
Rope, Wick, Braid and Cord			3.5 (3.1-3.8)	2	0.2 (0.0-0.7)	24

[a]All samples expressed as asbestos fibers/cc greater than 5 μm in length, as collected and analyzed by the NIOSH method.
[b]U.S.P.H.S. Survey, January 1965.
[c]NIOSH Survey, Division of Field Studies and Cilnical Investigations, April 1971.
[d]NIOSH Survey, Division of Field Studies and Clinical Investigations, October 1973.
[e]New carding operation performs functions of the old fiber preparation and spinning operations.

Usefulness of the Finished Product

The same modifications which make the achievement of the 2 fibers/cc standard possible in Plant A have imposed characterists upon the products that have limited their usefulness. Conventional yarns are soft and fluffy when compared to yarns which have been encapsulated. Asbestos cloth, which has been woven from encapsulated yarns, is not generally acceptable to consumers due to enlargement of interstices in the cloth caused by the lack of "fuzziness" of the yarn. This problem can be overcome for certain applications by weaving the cloth more tightly (increasing the number of warp and fill yarns per inch) but this process also increases the weight per area of the cloth, making it undesirable in most situations when compared to conventionally produced cloth.

The polyvinyl acetate yarn insert, which is used to reinforce the asbestos yarn during processing, significantly limits the asbestos content of products produced by this method. Presently, Plant A is not producing any products that have more than 95% asbestos.

Possibly, the most significant drawback to the modified conventional processing developed by Plant A is its cost. Any additional expense incurred by producing asbestos textiles with this method places Plant A at a disadvantage when competing against manufacturers who have not yet incurred the extra expense of adding controls and modifying work practices and processing operations for achieving the 2 fibers/cc standard. Plant A does not market any of its asbestos textile products at this time since all production is consumed internally by the company which owns Plant A.

Asbestos Textile Plant B

Description of Processes

The ability to achieve the 2 fibers/cc standard in Plant B is a result of a relatively new yarn forming process which uses chemically opened asbestos dispersions, rather than carded lap, for yarn formation. The discovery of the unique characteristics of chrysotile anionic dispersions by I. J. Novak (United States Patent Number 2,626,213) in the late 1940's is the basis of the new process. Heron and Huggett[7] describe several approaches which have been proposed for the conversion of the Novak type dispersions into useful yarn products. Some of these have been included in the patent literature, while others are still in the development stage. Because the management of Plant B considers their process to be in the development stage, much of the information concerning their specific type of liquid dispersion processing is proprietary. Details of the process, which are unnecessary for the purpose of this paper, have been omitted.

Whereas Plant A controlled the airborne asbestos problem by modifying the fiber preparation area with a well-ventilated, modified carding operation, the liquid dispersion processing of Plant B, which uses a single yarn forming operation and no local exhaust of any kind, does not include the conventional fiber preparation and carding operations. In the liquid dispersion operation, pre-milled asbestos fiber is blended by a "chemical operator" in a process that Hills[8] compares to the production of slurry for paper-making and involves mixing asbestos fibers in water with chemical dispersing agents. The resultant fiber dispersion is discharged into a coagulant to form a tough, wet strand which is slightly twisted as it is spun into wet packages of asbestos yarn. A "yarn forming operator" oversees this operation with the aid of a "combination man," who periodically doffs the packages of asbestos yarn and loads them onto a hand cart for use in the spinning operation. A "porter laborer" aids in the operation with general housekeeping.

Plant B uses conventional spinning/twisting frames, winders, braiders, and weaving looms. None of these machines has local exhaust but the airborne asbestos levels are reduced by keeping the yarn moist with water, oil or other dust suppressors to the extent permitted by product requirements. Another major, if not the most important, factor of dust control in these operations is the encapsulation of the asbestos yarn by the chemical dispersing agents that were added in the yarn forming operation and, subsequently, coagulated. As previously discussed, the encapsulating agents inhibit small asbestos fibrils from breaking away from the asbestos yarn as it is being processed. Fibrils which do break off tend to be combined with other fibrils by the "sticky" agents resulting in a heavier particle that quickly settles out of the air. Extraction of these dispersing agents does add an additional production step which is performed by a "cloth cleaner." The finished yarn, braided cord and woven cloth are soaked in large vats of a cleaning solution which dissolves the dispersing agents. After drying, the finished products are ready to be marketed.

Results of Environmental Measurements

A total of 95 personal asbestos dust samples were taken at Plant B and the results are summarized in Table III. In most asbestos textile plants, dust control in conventional yarn forming operations (fiber preparation and carding) is a major problem. However, with the use of liquid dispersion processing, the yarn forming operation in Plant B is the most dust-free operation in the plant. Typical airborne asbestos concentrations in this area average less than 0.1 fiber/cc. Levels this low may be stretching the limits of the NIOSH fiber counting method, but the results are a good indication of the advantage of processing fibers in a totally wet state.

The relatively low asbestos concentrations found in the twisting, winding, braiding and weaving operations of Plant A were a result of processing yarn which had been treated

TABLE III
Summary of Personal Samples at Plant B
(Mean, range, and sample size by operation)[a]

Operation	No. of Samples	Range Low	Range High	Mean
Yarn Forming Area	58	.01	.51	.05
Chemical operator	8	.01	.04	.03
Yarn forming operator	24	.01	.16	.04
Combination man	15	.01	.12	.04
Porter laborer	4	.07	.51	.20
Supervisory	7	.03	.04	.03
Spinning/Twisting, Winding Area	18	.06	1.40	.59
Spinner/twister	12	.12	1.47	.64
Winder	6	.06	1.44	.50
Weaving Area	10	.12	.53	.24
Cloth weaver	4	.15	.19	.18
Sample placed on loom	6	.12	.53	.28
Braiding Area	4	.04	.08	.06
Cloth Cleaning Area	8	.01	.08	.03

[a]All samples expressed as asbestos fibers/cc greater than 5 μm in length as collected and analyzed by the NIOSH membrane filter method.

with an encapsulating solution in the carding operation and kept moist throughout subsequent operations. The beneficial effect of processing encapsulated yarns is again demonstrated by the asbestos dust concentrations found in these conventional operations in Plant B where the dispersion chemicals used in the yarn forming operation become the encapsulating agents.

Even encapsulated yarns must be kept moist, as is shown by the variation in asbestos fiber counts found in the spinning/twisting and winding area of Plant B. The asbestos levels recorded, but not shown in this paper, for the first day of sampling, which averaged 1.12 fibers/cc, are high when compared to the second day of sampling, which averaged 0.41 fibers/cc, and the thrid day, which averaged 0.25 fibers/cc. This variation is attributed to the processing of packages of asbestos yarn which had been allowed to dry. Similar variations had been confirmed by previous sampling conducted by Plant B personnel.

Mean concentrations in weaving (0.24 fibers/cc) and braiding (0.06 fibers/cc) were surprisingly low since visible dust was observed during the sampling at both operations. Since there is no local exhaust at these operations, the low levels are assumed to be a result of processing moist, encapsulated yarns.

The very low asbestos concentrations found in the cloth cleaning area (mean equals 0.03 fibers/cc) were expected since handling of the finished products in this operation is minimal.

Usefulness of the Finished Products

Although the dramatic success of dust control associated with the production of chemically dispersed asbestos products has been demonstrated in the proceeding discussion, these products are, in some respects, quite distinct from conventional asbestos textiles and it appears they cannot be interchanged on a one-to-one basis. For example, the production of asbestos lap and roving, which is used extensively by the electrical wire and cable industry, is not feasible with liquid dispersion processing since there is no carding operation. Problems related to the unique characteristics of dispersion-based textiles are presently being studied by many industrial scientists who are trying to determine where the dispersion based textiles can be substituted for conventionally processed textiles. In many cases, the dispersion-based product is redesigned to meet the requirements of a specific application. Some applications are easier to design for than others, but the product development researchers at Plant B have not discounted the use of their product as a substitute for conventionally processed textiles in any application which they have studied to date. However, economic factors, including customer acceptance of the finished product and the initial investment for the new processing equipment, will have a major influence on where the new yarn will be used.

Dispersion-based yarns are characterized by a high degree of fiber alignment, with very finely divided fiber structures, generated at the strand formation stage. They are, therefore, smoother and stiffer than carded asbestos yarns which have a fairly random fiber structure with wide fiber diameter distribution and hairy surface characteristics. These differences are apparent in the woven cloth and have complicated the use of dispersion-based textiles for certain applications. For example, the smooth, clean surface of dispersion-based cloth may be easier to paint as claimed by the American Asbestos Textile Corporation,[9] but harder to finish or impregnate with another material. This lack of flexibility has been a major problem with the new products in many applications, such as safety clothing.

Since there is no carding with the liquid dispersion method, blending asbestos with cotton or rayon in the usual manner is not feasible. Textile products made at Plant B, with this method, are presently 100% asbestos as opposed to the normal 85-90% range. This feature enhances the product's ability to resist chemical and biological attack and greatly improves the tensil strength retained at high temperatures. However, these additional characteristics of all Grade AAAA (99-100% asbestos content)[5] asbestos products are not necessary for most present day applications. Therefore, few consumers will voluntarily convert to dispersion-based products for these characteristics unless the price of the new products competes with the cost of the lower grade, conventionally processed products they are presently using.

Conclusions and Recommendations

It was a primary objective of this study to find an asbestos textile production facility which had developed dust control methods necessary to achieve the OSHA 2 fibers/cc standard. This paper has presented the results of industrial hygiene surveys, including 243 asbestos dust samples, conducted at two asbestos textile plants. The results indicate that these two plants have adopted sufficient dust control practices to meet this standard in all of their production operations. However, it would be improper to conclude from the results given that it is "technically feasible" for the asbestos textile industry to achieve the 2 fibers/cc standard through work practices and/or engineering controls for certain operations without considering the following:

1. Both Plant A and Plant B are limited production facilities. An incerase in asbestos dust exposures might be expected with the development of these plants into full production facilities. But, considering the degree to which these two plants were below the 2 fibers/cc level, and making the assumption that the majority of asbestos dust to which a worker is exposed is produced by the machines in his immediate work area, it is doubtful that an increase in production capacity would raise the dust concentrations above the standard in either plant.

2. The production techniques used in the two plants have limited the kinds of asbestos textile products which are produced. For example (a) the production of asbestos lap and asbestos roving is not feasible with liquid dispersion processing as used by Plant

B; (b) Plant A discontinued the production of lap and roving since the consumer demand did not warrant the expense of controlling the additional dust problem caused by their production; (c) both production techniques limit the asbestos content of the products which may limit their usefulness for certain atypical applications (*i.e.,* The polyvinyl acetate yarn insert used in the modified carding process prevents Plant A from producing products which have an asbestos content of more than 95% and, conversely, liquid dispersion processing prevents Plant B from producing products which are less than 99% pure asbestos); and (d) both techniques depend heavily on the use of wetting solutions for dust control and, therefore, can not be used in producing "dry processed" products which have traditionally been the most desirable. (The conventional "damp processing," used by most asbestos textile manufacturers, already represents a compromise from totally dry processing methods which typically cause excessive dust problems. The acceptance of the yarns produced by the processing methods of Plant A and Plant B would represent a further compromise from the desired characteristics of yarns produced with dry processing methods.)

It is particularly important for future research to determine the differences in characteristics between dry, damp and wet processed asbestos textile products in terms of performance in actual applications. The OSHA regulations specifically require that, "Insofar as practicable, asbestos shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers in excess of the (standard) . . ., *unless* the usefulness of the product would be diminished thereby." A determination that dry processed products are more useful for certain applications than damp or wet processed products, accompanied with the knowledge that engineering controls have failed to sufficiently reduce the dust produced by dry processing operations, could form the foundation of manufacturers' requests for the use of personal respirators for compliance purposes. Also, a determination that the products produced by the methods used by Plant A and Plant B can be interchanged with conventionally produced products must be made before consumers can be motivated to switch to the new products.

The numerous kinds of legislation which could be used to motivate producers and consumers of asbestos textile products into switching from conventionally produced products to those produced by the methods described for Plant A and Plant B, are beyond the scope of this paper. But at least two areas should be considered to insure fair competition between producers: strict enforcement of the 1976 OSHA asbestos standards and protection from foreign imports. The additional overhead expenses associated with converting to the new methods of production will have to be passed on to the consumer in the form of a price increase. By strict and equal enforcement of the 1976 OSHA asbestos regulations, the prices of asbestos products made by all domestic manufacturers will include an increase caused by expenses incurred in meeting the OSHA standards, an increase which will encourage the use of substitute materials for asbestos. With domestic prices up, some form of protective legislation would then be required to insure that foreign facilities which produce asbestos products do not take advantage of the occupational health movement in the United States. Foreign facilities, which may be owned by domestic companies, typically have a competitive advantage over domestic producers since they do not have to pay for environmental controls capable of meeting the OSHA standards. Consumers are already turning to foreign suppliers for dry processed asbestos products which have been discontinued by domestic producers in order to comply with OSHA standards.

Secondary opening operations of mined asbestos fibers compose still another example of performing comparatively dusty operations out of the jurisdiction of OSHA. These operations, which were once common operations of the domestic asbestos textile industry, are now being performed, in some instances, in a foreign country which then sells pre-milled asbestos fibers to the domestic industry. Condoning the practice of performing dusty operations in a foreign country as a means of bypassing OSHA regulations may be equated with the acceptance of exposing workers to health hazards as long as the workers are not United States residents. Besides imposing health risks upon foreign workers, this practice also reduces the number of workers employed by the domestic industry.

In conclusion, the modified carding and liquid dispersion methods described in this paper are capable of producing asbestos textile products while maintaining airborne asbestos dust exposures below the two fibers/cc standard. The success of these two methods, however, will be determined by the acceptability and marketability of the asbestos products which they produce.

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Committee on Threshold Limits

1975 Notice of Intended Changes

See pages A-10 and A-11 for the full text of the American Conference of Governmental Industrial Hygienists Committee on Threshold Limits 1975 notice of intended changes and additions to the list of Threshold Limit Values.