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A STUDY OF DUST CONTROL METHODS IN AN ASBESTOS FABRICATING PLANT

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REPRINT No. 1883
FROM THE
PUBLIC HEALTH REPORTS
VOL. 52, No. 48, NOVEMBER 26, 1937
(Pages 1713–1727)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1938

For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents

A STUDY OF DUST CONTROL METHODS IN AN ASBESTOS FABRICATING PLANT

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An extensive medical and engineering study of the health of asbestos workers has been conducted by the United States Public Health Service (*5*). The material contained in this paper supplements the general study with a detailed study of the dust control methods used in an asbestos fabricating plant. It is a report on present conditions and how they have been obtained and is presented as an example of the results of the application of scientific methods of dust control. These data should be interesting not only to the asbestos industry but also to other industries having similar dusty processes.

The plant studied has only partly completed an extensive dust control program, and conditions are being improved continually; consequently, these results should not be interpreted as representing the maximum possible efficiency in the control of asbestos dust, but it is believed that they are representative of the best practice in this country at this time. The dust control systems in use with the various processes in each department are described. An occupational analysis of employees is presented, with a comparison of the atmospheric dust concentrations associated with controlled and similar uncontrolled processes.

FABRICATION OF ASBESTOS TEXTILES

Asbestos is the class name for several different fibrous minerals, but the asbestos of commerce (*1*) is mainly the fibrous form of serpentine known as chrysotile.[1] Due to its fibrous nature, flexibility, and heat-resistant properties, asbestos fiber finds many practical applications. One of its important industrial uses is in the manufacture of fire-resistant textiles.

In the plant studied, practically all raw material was crude Canadian or South African asbestos. Some imported short fiber was used, as well as some of the short fiber salvaged in the recovery process, but most of the short recovered fiber was shipped to other plants. Significant variations in atmospheric dust concentrations due to the grade of fiber being processed were not evident in controlled processes in this plant. Consequently, the type of fiber used has not been considered in the analysis of the data. Each dust controlled process tended to decrease the amount of dust generated in subsequent

[1] Chrysotile is a hydrous magnesium silicate ($H_4Mg_3Si_2O_9$ or $2H_2O \cdot 3MgO \cdot 2SiO_2$) containing 44.1 percent silica, 43.0 percent magnesia, and 12.9 percent water. Other types of asbestos often contain silicates of iron, calcium, and aluminum as well as magnesium (*8*).

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processes. These factors must be considered when comparing dust concentrations reported in this plant with the data which have been reported for other plants.

Approximately 300 persons were employed in this plant, of whom 180 worked in departments having a potential asbestos dust hazard. This study was confined to these departments; namely, preparation; carding; spinning, twisting and winding; and weaving. The occupational distribution of exposed workers is shown in table 1.

TABLE 1.—*Occupations and dust exposures of workers in an asbestos textile plant*

Occupation	Number of workers	Average dust concentration, M. P. P. C. F.	
		Normal	Without exhaust ventilation
Preparation:			
Crushermen	2	3.5	[2] 59.6
Cotton openers	1		
Asbestos openers	2	[1] 3.5	
Bed builders	3	[1] 5.4	
Pickermen	2	[1] 6.7	
Others	5	[1] 2.4	
Carding:			
Carders	6	[1] 1.7	[2] 62.4
Stock rollers	10	[1] 4.6	[2] 40.4
Card tenders	3	1.7	
Wick, rope, and cord	6	1.7	
Others	6	.3	
Spinning, twisting, and winding:			
Mule spinners and helpers	32	.9	
Ring spinners	6	3.0	
Spoolers	16	[1] 2.9	[2] 9.6
Cop winders	4	6.9	
Twisters	13	11.0	
Universal winders	7	2.8	
Others	16	3.0	
Weaving:			
Weavers:			
Dry cloth	18	1.7	[2] 9.6
Wet cloth		2.7	
Tape and listing		3.0	
Creelers	7	1.3	
Inspectors—Cloth	2	[1] .8	[3] 11.8
Inspectors—Tape	2	3.1	
Others	7	2.3	

[1] Dust exhaust system for this operation.
[2] Sample after 1 hour's operation without exhaust.
[3] Sample taken inside bin during loading.

METHOD OF STUDY

This investigation included a study of atmospheric dust concentrations in the factory workrooms and a study of the exhaust systems used to remove asbestos dust.

Eighty-two atmospheric dust samples were collected at the workers' breathing level with the impinger dust sampling apparatus (*5*). Sixty-nine of these represented present working conditions and 13 represented conditions while exhaust apparatus had been turned off for 1 hour. A collecting medium containing 25 percent ethyl alcohol in distilled water was found to prevent flocculation without causing excessive evaporation in either the sampling flasks or the counting cells. All samples were counted the day after collection. Owing to the low dust concentrations encountered, most of the samples represented the dust in from 20 to 30 cubic feet of air. Samples were diluted with distilled water and counted according to the light-field technique described by Bloomfield and DallaValle (3). A micrometer eyepiece having an engraved square equivalent to one-fourth the standard Whipple square was used in counting. Since it is customary to count only one quadrant of the Whipple field, the same volume of sample (0.25 cubic millimeter) per field was counted (7).

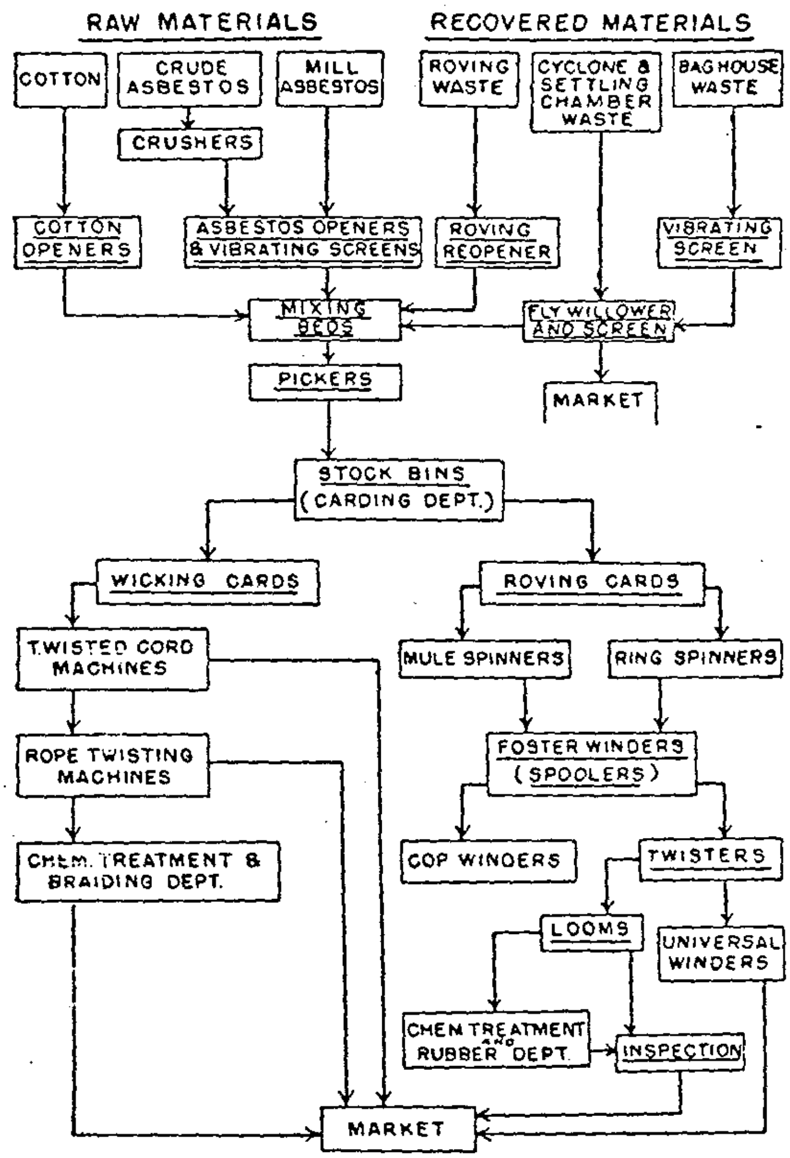
The quantities of air removed through the various exhaust systems were calculated from pitot tube measurements of center-line velocities in the pipe lines (4). Average exhaust rates per process are listed in table 2 and discussed a little later in the description of exhaust systems. Entrance velocities at open hoods were measured with an Alnor velometer and checked with a vane anemometer. Most of the hoods were of the enclosed type designed to exhaust only enough air to prevent the escape of asbestos dust into the workroom. Where individual measurements were impractical, air volumes exhausted through each hood were calculated from measurements of main-line velocities. Whenever differences in exhaust volumes were noted between similar hoods on the same operation, the average value is given.

DESCRIPTION OF PROCESSES AND DUST CONTROL MEASURES

Asbestos is received in burlap bags containing 100 pounds of fiber. Cotton is received in standard bales. These are the only raw materials used in the preparation of asbestos yarn at this plant. Unloading, storage, and transportation of the packed raw materials were not hazardous occupations. The progress of the material from raw fiber to completed fabric is shown by means of a flow sheet (fig. 1). Individual processes and the measures for dust control are described below.

PREPARATION DEPARTMENT

Crushing.—Some of the asbestos fiber arrives at the plant as "precrushed" fiber, but most of the crude fiber has received no treatment other than mining, sorting, and screening. This latter type is hand dumped from the bags into rim-wheel crushers and crushed from 5 to 15 minutes. These crushers have two heavy rollers attached to a radial axle, and revolve on a smooth-surfaced tray in which the asbestos is placed. During the crushing, the asbestos fiber is constantly stirred by revolving scrapers. After being crushed, the fiber is replaced in the bags and carried to the asbestos opener. Crushers were not enclosed or exhausted in any way, but the general ventilation in the preparation department was sufficient to prevent high concentrations of dust near this operation. Crusher men had res-



NOTE: UNDERLINED PROCESSES HAVE DUST EXHAUST SYSTEMS.

FIGURE 1.—Process flow-sheet, asbestos textile plant.

pirators[3] and usually wore them while loading or unloading the crushers. The average exposure of a crusher man tending three crushers was 3.5 M. P. P. C. F.

[3] All employees in the preparation department and all repairmen and janitors were provided with respirators of a type approved by the U. S. Bureau of Mines against high concentrations of fine silica dust.

Asbestos opening and screening.—The crushed fiber is dumped from bags to the floor beside the asbestos openers and lifted into the feed lattice hopper with wooden hand forks. Two openers of different design were in operation, but the method of exhaust hooding was the same on both. (See schematic design, fig. 2.) The feed lattice hopper was partially enclosed and exhausted at the top (hood A). A second hood exhausted the bottom fly and settled dust from the bottom of the opener (hood B). The opened fiber was picked up by hood C and pneumatically transported to a cyclone separator where the fibers were removed and dropped onto an enclosed vibrating screen. A large portion of the dust and fine fibers entering the asbestos opener

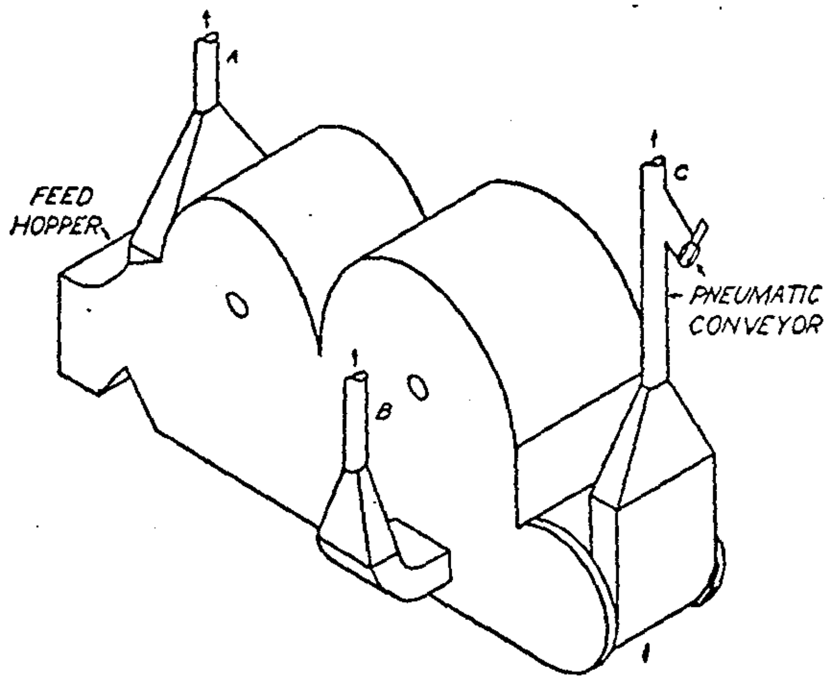


FIGURE 2.—Schematic view of exhaust system applied to an asbestos opener.

was removed by hoods A and B. Clumps of unopened fibers and pieces of rock too heavy to be lifted by the pneumatic fiber conveyor fell onto an enclosed belt conveyor serving both openers, and were carried to the recovery process. (Belt conveyor is not shown in fig. 2.) Exhaust volumes through the hoods were as follows: Hood A, 400 cfm; hood B, 400 cfm; hood C (pneumatic conveyor), 1,800 cfm; conveyor velocity, 2,730 feet per minute.

Each opener had its own cyclone separator and enclosed and exhausted vibrating screen. One screen had two exhaust hoods, one beside the charging hopper drawing 400 cfm and one over the dis-

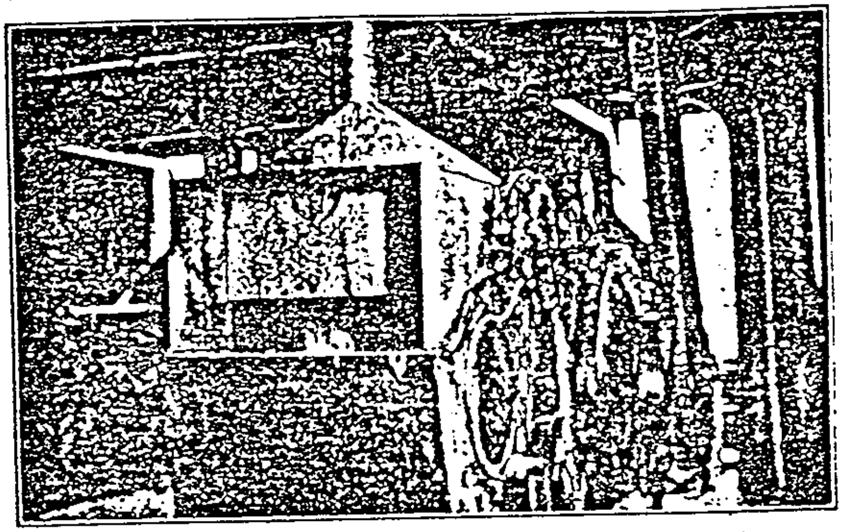


FIGURE 3.—Picker mixing machine

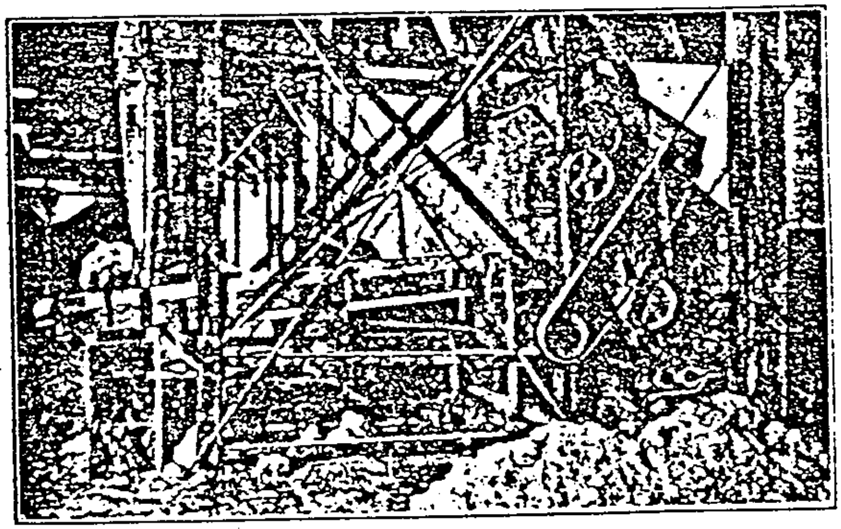


FIGURE 4.—Fiber recovery process. Willower and vibrating screens.

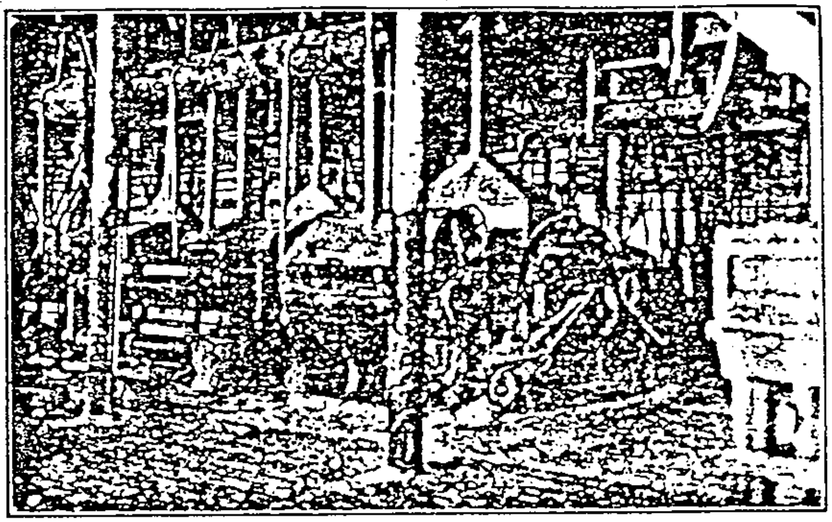


FIGURE 5.—Breaker and roving cards.

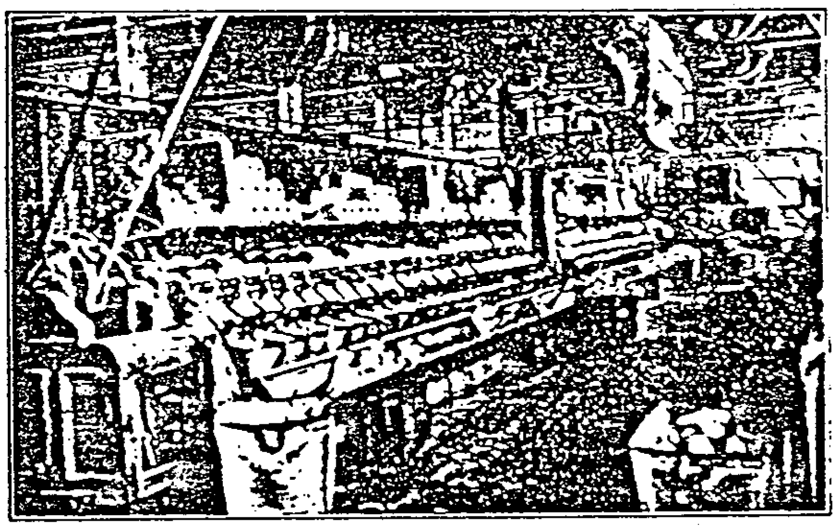


FIGURE 6.—Foster winding machines (spoolers).

charge end of the screen and the stock car, drawing 770 cfm. The second screen had one hood only, over the discharge end, drawing 615 cfm. Short fibers and rock particles passing the screens fell through a chute to the enclosed recovery conveyor. Fiber failing to pass these screens dropped into a stock car. Full stock cars were pushed to a platform scale and then to the mixing beds.

The same men charged the openers and filled the stock cars. The average dust exposure of asbestos-opener operators was 3.6 M. P. P. C. F.

Cotton openers.—The best grades of insulation contain very small amounts of cotton, if any; but in all other cases, cotton fiber is mixed with asbestos fiber to improve its spinning qualities. At this plant the batch seldom contained more than 15 percent of cotton by weight but as much as 20 percent cotton was used in lower grade yarns. The two-stage Saco-Lowell cotton opener was provided with exhausts at three points; 770 cfm of air were exhausted through a canopy hood over the feed lattice, 270 cfm from the bottom of the primary opener, and 1,120 cfm from the bottom of the secondary opener. Opened cotton fiber was discharged into stock cars. No samples were taken at the cotton openers, but the operators' average exposure was about 2.4 M. P. P. C. F. (general air, preparation department).

Mixing.—Weighed quantities of asbestos and cotton were placed in alternate layers in the mixing beds. Occasionally, layers of roving waste from the carding room were reopened and added to the bed. Mixing was done in six "exhausted" booths, each 10 feet 2 inches deep by 6 feet 10 inches wide by 6 feet high. Sides of the booths were permanent, while the back consisted of a removable wood and canvas section. Each booth was covered by a pyramid hood 32 inches high, through which approximately 1,025 cubic feet of air per minute per hood were exhausted. The velocity of air motion into these booths averaged 50 feet per minute during bed making and about 30 feet per minute during picker loading. Dust concentration averaged 5.4 M. P. P. C. F. for the bed-making operation.

After a bed had been placed, the picker operator removed the rear partition of the booth and forked the batch into the charging hopper of a picker (fig. 3). The picker machine mixes the fibers in revolving beaters. The four machines represented three different operations and two different types of exhaust systems. The first machine, not in operation during this study, discharged mixed fiber into a stock car. This material was then passed through a second picker for remixing. The second and third machines discharged mixed fiber onto a belt conveyor which transported it to bins in the carding room. The product of the fourth picker was carried to the carding room by a pneumatic conveyor. Each of the first three machines had a hood over the charging lattice, exhausting approximately 500 cfm, a pipe exhausting about 1,650 cfm from the bottom-fly settling chambers under the main picker drum, and a hood over the end of the discharge lattice exhausting about 400 cfm. The fourth picker had the same hood arrangement over the charging lattice but had no bottom-fly exhaust, and the mixed fiber was removed by a pneumatic conveyor exhausting approximately 2,000 cfm of air at a velocity of 2,550 feet per minute. The picker operators wear respirators during the charging operation. Dust concentrations during picker charging varied from 4.0 to 9.5 M. P. P. C. F., averaging about 6.7 M. P. P. C. F.

Recovery processes.—Waste roving from the card room was returned to the preparation department for reopening. The roving reopener was exhausted only from the pit below the last beater, but the 1,780 cfm of air drawn through this hood were sufficient to prevent the escape of dust through the discharge lattice.

The dusty air collected by the exhaust systems in the preparation and carding department was blown into a large settling chamber occupying two stories in the end of a separate building. Air was displaced from this room to a bag house occupying the second floor on the other end of this building. Dust was filtered out by burlap filters stretched on A-frames. The filters were beaten down by hand daily during the noon rest period. The collected dust was removed during the week end shut-down, and stored in bins in the preparation department. Bag-house dust was screened on a completely enclosed and exhausted vibrating screen (background, fig. 4), and the long fibers were removed to a cyclone collector by a pneumatic conveyor. The dust from the settling chamber, the long fibers from the bag-house dust, and fibers separated by cyclones on the exhaust lines from the spooling operation and the weaving department were passed through a fly-willower and vibrating screen (fig. 4). Approximately 250 cfm of air were exhausted from the top of the charging lattice and 620 cfm from the discharge side of the opening drum. Dirt passing the screen dropped onto an inclined tray and was removed by an exhaust hood drawing 730 cfm. Fibers which did not fall through the screen were removed by the hood at the lower end of the screen (1,710 cfm) and pneumatically conveyed to a cyclone collector. Rock and other impurities not picked up by the pneumatic conveyor fell into a waste box below the end of the screen. The market for recovered fiber is limited, and such fiber is usually too soiled for use in high-grade textiles. Consequently only part of the collected dust was passed through this process. Average exposure of operators was estimated at between 3 and 5 M. P. P. C. F.

As a measure of the effectiveness of the dust control system in the preparation department, the exhaust fans were shut off for 1-hour. Pneumatic conveyors remained in operation. Dust concentrations increased steadily to about 50 M. P. P. C. F., at which time the exhaust fans were turned on. The samples taken during this period were only a partial measure of uncontrolled conditions, since the hoods and enclosures had a definite control value.

While the location and design of hoods were the most important factors in dust control in the preparation department, general ventilation helped prevent high dust concentrations. This department occupied approximately 320,000 cubic feet of space, from which approximately 34,650 cfm of air were exhausted. Consequently 6.5 air changes per hour were produced by mechanical ventilation, which was supplemented by natural ventilation through doors, windows, and roof ventilators. Fortunately heating was not a problem in this plant.

CARDING DEPARTMENT

Mixed fiber from the preparation department was dropped from pneumatic or mechanical conveyors into bins in the carding department. The total volume of exhaust from four bins was 6,850 cfm, the major portion of this air being drawn through the one or two bin doors left open during the loading of carding room stock cars. Dust concentrations as high as 40.4 M. P. P. C. F. were measured inside an active bin while the dust concentration just outside the door of the same bin was only 4.6 M. P. P. C. F. Workers, classed as stock rollers, fork the mixed fiber from the bin into stock cars. This operation is supposed to be performed with both stock car and stock roller outside the bin door. This rule of keeping out of the bins should be strictly enforced. However, stock rollers, wearing respirators, like to push their cars under the chute and then climb into the car and "tread-down" the stock.

The cards are machines having a series of revolving cylinders wound diagonally with strips of leather set with fine, sharp, steel bristles. Carding removes remaining small bits of rock and combs the fibers into a more or less parallel condition to facilitate spinning. At the time of this study, 31 roving card units and 2 wicking cards were being operated. A roving card unit (fig. 5) consisted of two cards, a breaker, or primary card, and a finisher or roving card.

The mixed fiber was fed by hand from the stock car to the feed hopper of the breaker card. The stock roller wore a respirator during this operation. The fiber passed through the breaker card, emerging as a loose blanket or web. It was carried to the finishing card by a lattice conveyor or camel back. The fiber was stripped from the last cylinder of the finisher onto a moving leather apron, where a set of reciprocating rubbers condensed it into loose rovings of unspun yarn. These rovings are wound on long "jack" spools to be taken to the spinning department. The rovings at the extreme ends of the cards cannot be used for spinning because they lack uniform thickness. These rovings are collected by two small hoods and pneumatically conveyed to a collection bin for return to the preparation department.

The exhaust system applied to roving cards is shown schematically in figure 7. The quantity of air exhausted varied from 1,100 cfm to 1,800 cfm on different carding units with an average exhaust of 1,440 cfm per unit. Cards are partially enclosed and only sufficient air is exhausted to prevent the escape of dust.

Each breaker card is exhausted at three points. Hood B exhausts from the top of the feed hopper over the feed apron. This hopper was enclosed and covered, the cover being lifted during filling. About 160 cfm of air were exhausted through the hood. Hood A exhausted the top fly from the enclosure covering the main carding cylinder. Hood

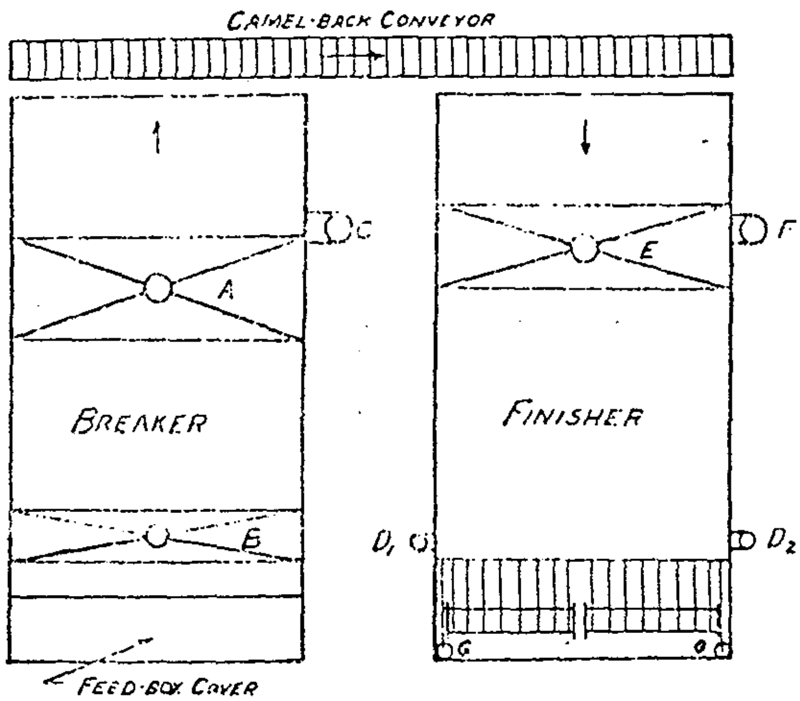


FIGURE 7.—Schematic plan of card exhaust system

C exhausted the bottom fly from the settling chamber under the carding cylinder. Approximately 285 cfm were exhausted through each of these hoods.

The finishing card had four exhaust connections besides the two small hoods G which removed the waste roving. Hoods E and F correspond to hoods A and C, respectively, on the breaker card, providing an exhaust of approximately 285 cfm each. The doffer card cylinder, doffer combs, and roving apron were exhausted from below, through hoods D^1 and D^2 at 70 cfm each. About 40 cfm were exhausted through each roving collector.

The volumes of air exhausted through each hood were estimated on the basis of pipe areas. Actual volumes showed wide variations on different units.

Single cards were used in the manufacture of asbestos wick and rope, since a thick roving was desired. The wick or rope was twisted from the unspun roving. The wicking cards were exhausted at three points. Approximately 380 cfm of air were drawn from under the feed lattice, 490 cfm were exhausted from the top of the main cylinder cover to remove the top fly, and 550 cfm were exhausted from the bottom-fly settling chamber.

Dust concentrations during carding averaged 1.7 M. P. P. C. F. This was also the average exposure of wicking card operators and wick and rope twisters. Samples taken near the carding department weight scales showed less than 0.5 M. P. P. C. F.

Card rolls were cleaned and ground at night, except in cases of emergency. Cleaning was done with hand scrapers made of strips of card cloth, and the card cylinder was turned by hand. Grinding was done with the usual type of card grinders. The large roll was ground in place in the carding machine. Slightly greater quantities of air were exhausted during grinding due to the decreased loss of head resulting from removal of the wooden card covers. The small card cylinders were ground in a grinding frame. These frames were partially enclosed and covered with a canopy hood exhausting 2,330 cfm per grinder. Dust concentrations averaged 0.65 M. P. P. C. F. during grinding.

A special run of a group of carding machines made with all exhaust ventilation turned off and windows closed showed that dust concentrations steadily increased. At the end of 1 hour the concentration was 62.4 M. P. P. C. F. in the air. Under normal operating conditions about 64,000 cfm of air are exhausted from the carding department. This is equivalent to about 5.5 air changes per hour, disregarding natural ventilation through windows on all four sides of the room.

Spinning, twisting, and winding.—The yarn as roving is twisted or spun into compact threads on either mule or ring spinning frames. In this plant most of the spinning was done on mule spinners. The spun thread was transferred from the spinning spindles to spools, on Foster winding machines (spoolers). Spooled thread to be used as filler (or woof) in woven cloth was rewound on a cop winder into cops which will fit into the loom shuttles. The remaining spooled thread was respooled on twisters which twist several threads into a yarn. The number of strands used determined the size of yarn. Both plain and metallic yarns were twisted. Metallic yarn contains one or more strands of fine wire. Part of the twisted yarn was used in cloth weaving while the remaining yarn was rewound on Universal winding frames for the market.

Mule spinning was separated from other operations in this department by partial partitions. Natural ventilation was good and no exhaust systems were used. The average dust concentration was 0.85 M. P. P. C. F. with a maximum of 1.3 M. P. P. C. F. recorded.

Ring spinning, cop winding, and Universal winding machines were located in the same room with the twisting machines. Average exposures in the first three operations, which were not themselves especially dusty, were due to dust from the twisting operation. With the exception of a trial exhaust system on one twister, the remaining machines were not provided with exhaust. The trial system was reported to be satisfactory and is to be installed on all twisting

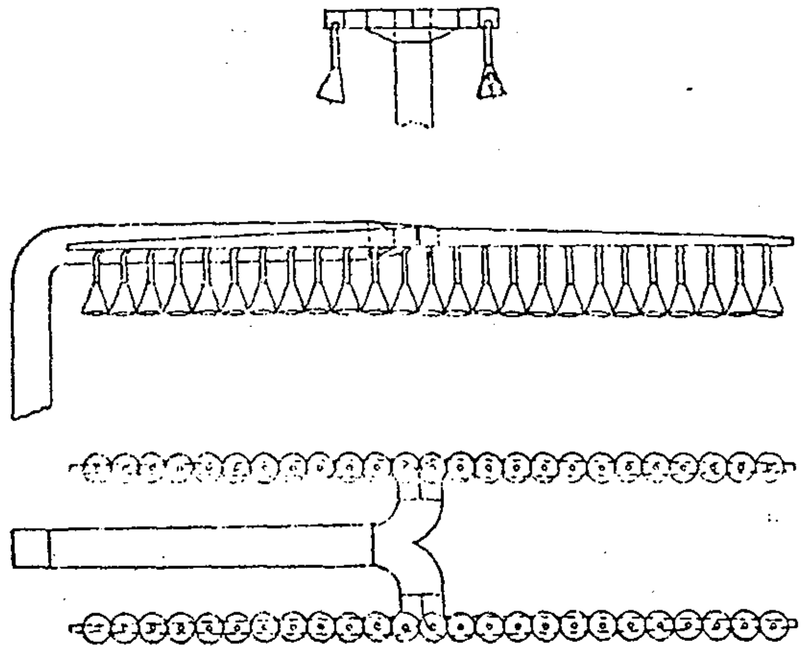


FIGURE 8.—Schematic views of exhaust system applied to Foster winders.

machines. In this system, the bottom of the twisting frame was enclosed and a total of 1,700 cfm of air per machine was drawn downward past the twisting yarns and through five conical hoods distributed along a central exhaust duct.

Average dust concentrations at the various operations in this room were ring spinning, 5.0 M. P. P. C. F.; cop winding, 6.9 M. P. P. C. F.; Universal winding, 2.8 M. P. P. C. F.; and twisting, 11.0 M. P. P. C. F., with a maximum of 18.8 M. P. P. C. F. recorded beside a twisting frame. No accurate measurements of the efficiency of the exhaust system on the single exhausted twistor could be secured, but simultaneous samples on both sides of this frame showed a dust

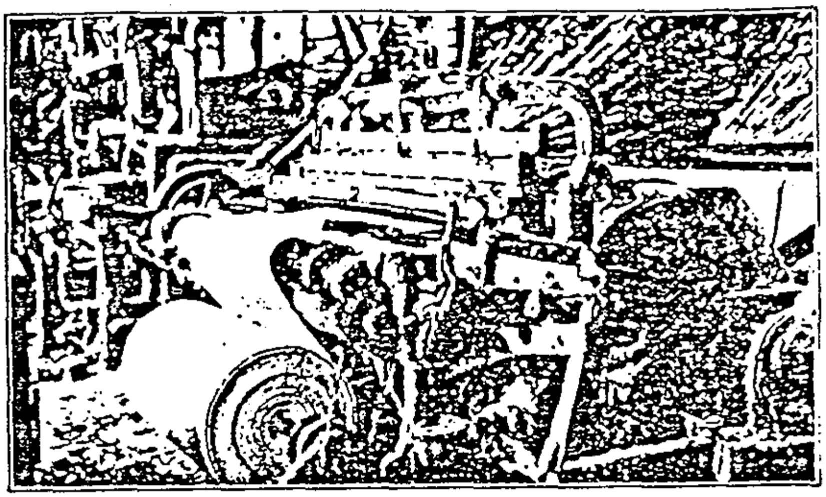


FIGURE 9.—Unexhausted broad loom.

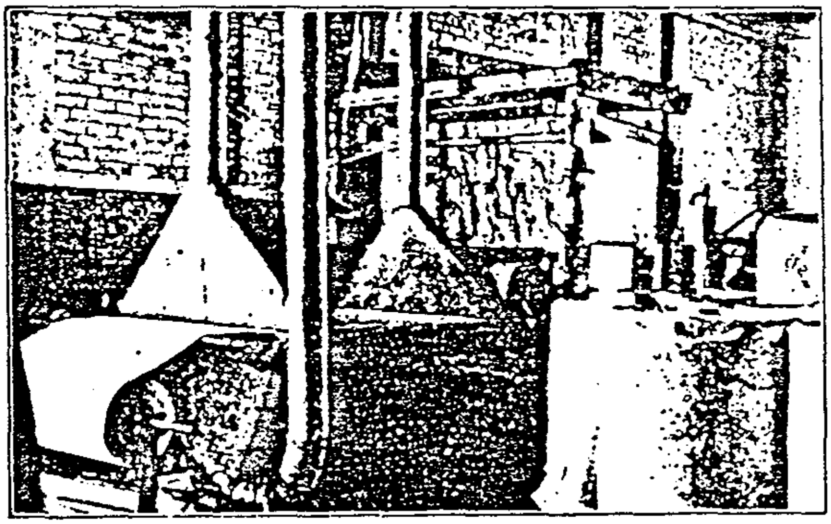


FIGURE 10.—Table for inspecting, calendering, and brushing woven cloth.

concentration of 18.0 M. P. P. C. F. on the side toward the unexhausted twisting frames and a concentration of 6.3 M. P. P. C. F. on the other side.

Four Foster winders (spoolers) were partially separated from the other operations by partitions (fig. 6). The exhaust system consisted of an individual conical hood around each spindle holder (fig. 8). Approximately 46.5 cfm were exhausted through each hood, or a total of 9,270 cfm through the 200 hoods on the 4 spooling frames. Dust concentrations at the spoolers averaged 2.9 M. P. P. C. F. and increased to 9.6 M. P. P. C. F. within 30 minutes after the ventilation had been shut off.

WEAVING AND INSPECTION

Cloth, tape, listing, and brake bands were woven on different types of looms. In this plant, exhaust systems had been applied to the dry cloth looms, since these were considered to be the most important source of dust. The dust control program calls for installation of exhaust systems on dry tape, listing, and brake-band looms. At present these operations are mainly performed wet or partially wet. Brake-band looms were not in operation during this study. Significant differences could not be noted between dust samples collected around the various tape and listing looms. Dust concentrations ranged from 1.2 to 4.0 M. P. P. C. F. and averaged 3.0 M. P. P. C. F.

Nineteen cloth looms were in operation in this department. One of these was a wet loom not provided with exhaust hoods, 4 were dry looms provided with exhaust hoods, and the other 14 were so provided but could be operated either wet or dry. A loom without exhaust hoods is shown in figure 9. The exhaust system is shown schematically in figure 11. A double exhaust hood drew air from under the warp while a second hood was attached to the top of the loom lay with exhaust ducts running down the side of each picker arm to an airtight swing joint at the bottom. The openings in the loom-lay hood consisted of four slots nine inches long by 1 inch wide extending over a space of 4 feet across the woven fabric at right angles to the warp. A total volume of approximately 10,500 cfm of air was exhausted from the 18 hooded looms. This averaged about 580 cfm per loom; but since it was seldom necessary to operate more than 10 dry looms at one time, the average quantity of air exhausted was close to 1,000 cfm per loom. Exhaust dampers were provided on all looms, and a sufficient number to balance the system are closed on wet or idle looms. The average dust exposure of a weaver operating a dry loom with exhaust was 0.7 M. P. P. C. F., while the average exposure in wet weaving without exhaust was 2.6 M. P. P. C. F. Samples taken beside a dry loom without exhaust showed dust concentrations of 9.6 M. P. P. C. F.

after 45 minutes. Average dust concentrations during dry weaving have been shown as 49.7 M. P. P. C. F. (5).

Woven cloth was inspected, brushed, and calendered on the inspection table shown in figure 10. Each of the power-driven brushes was

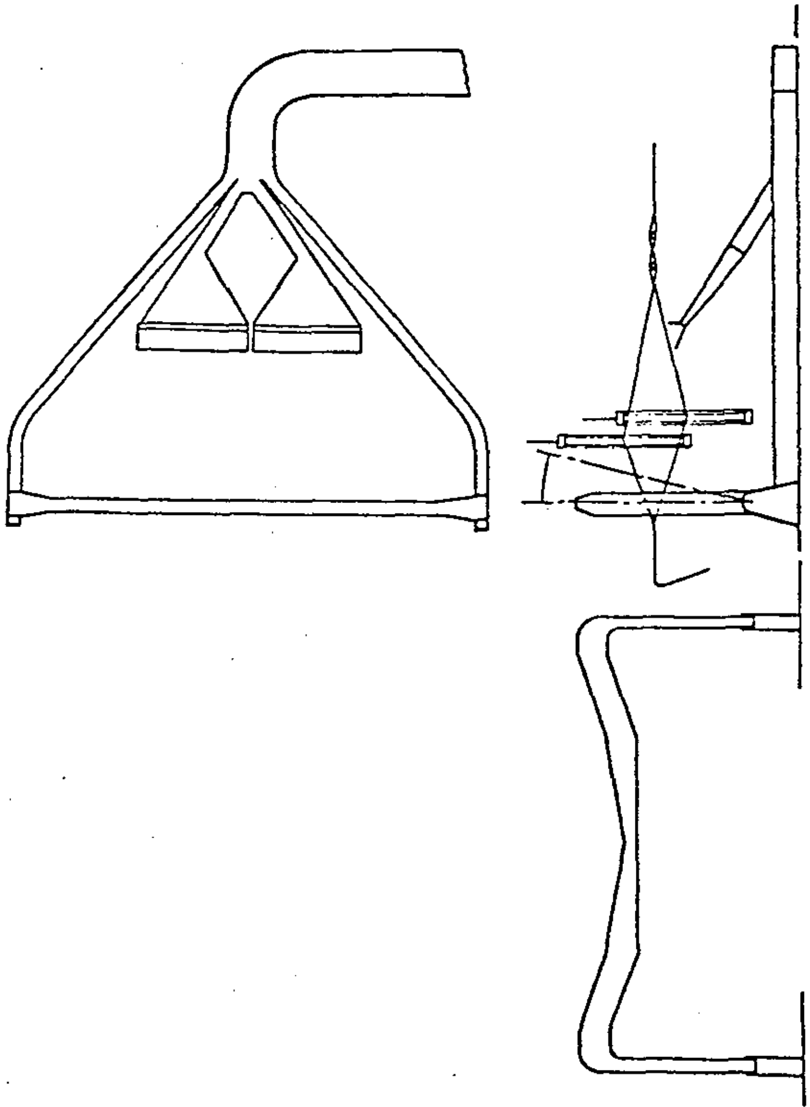


FIGURE 11.—Schematic views of exhaust system applied to broad looms.

partially enclosed and exhausted. Approximately 750 cfm of air were drawn through each of the two hoods at the front of the table and about 200 cfm were drawn through the cleaning hood at the back of the table. Dust concentrations during inspection averaged 0.5 M. P. P. C. F. A sample taken while a roll of fabric was passed across the table without benefit of exhaust showed a dust concentration of 11.8 M. P. P. C. F.

Doffing, inspection, and calendering of tape and listing were hand operations and were not provided with exhaust. Dust concentrations of 5.0 M. P. P. C. F. were recorded during these operations but the exposure was intermittent.

Creelers had an average exposure of about 1.3 M. P. P. C. F. while placing spools and threading looms.

An exhaust of 12,200 cfm of air was provided in the weaving department, corresponding to approximately three air changes per hour. In cold weather, warm air was distributed through the department from a plenum system, while in warm weather natural ventilation was secured through use of windows on all four sides of the department.

OTHER OPERATIONS

Other operations in this plant consisted of processes in which the yarn was chemically treated and fabricated, or processes for chemically treating or rubberizing fabricated cloth. No potential asbestos hazard was associated with these processes, with the exception of one braiding machine used to make large diameter asbestos tubing. This machine was covered with a conical canopy hood about 6 feet in diameter, which provided an exhaust of approximately 200 cfm of air. A sample taken beside this machine showed a dust concentration of 0.4 M. P. P. C. F. at the operators' breathing level.

TABLE 2.—*Volumes of air exhausted per machine in various operations in an asbestos textile plant*

Operation	Connections	Total volume of air exhausts per minute (cu. ft./min.)	Dust concentration with exhaust, M.P.P.C.F.	Dust concentration without exhaust, M.P.P.C.F.
Asbestos opener	[1] 2	625-1,000	2.5	[2] 11.1-96.0
Vibrating screen	1	700		
Cotton opener	3	2,160		
Mixing beds	1	1,025	4.4	[2] 3.1-10.6
Picker	3	2,670	6.7	[3] 34.9-74.3
Roving reopener	1	1,780		
Fly willower and screen	[1] 2	1,600		
Roving cards:				
Breaker (primary)	3	1,420		
Finisher	4	1,440	1.7	62.4
Wicking card	3	1,420		
Card grinders	1	2,830	.7	
Potter winders (spoolers) [4]	[4] 1	2,225	2.9	[3] 13.1
Twisters	1	1,700		11.0
Weaving (broad looms)	2	1,300	.7	[3] 49.7
Brusher—Calenderer	3	1,650	.6	11.8

[1] Equipped with pneumatic conveyor—exhaust through conveyor not included.
[2] Unpublished data, other plants (J. M. DallaValle, U. S. P. H. S.)
[3] Fulton, et al. Ref. (2).
[4] Individual cone for each spindle connected to exhaust manifold.

SUMMARY

Table 2 gives a summary of the operations provided with exhaust, listing the number of exhaust ducts and the rate of ventilation per machine, as well as the average dust concentrations to which operators are exposed. Average dust concentrations measured near corresponding operations without exhaust are tabulated to show the effectiveness of the control methods which have been described.

CONCLUSION

This study of actual results secured by a dust control program in an asbestos fabricating plant is presented as an example of engineering control of an industrial hazard. Adequate data have not yet been published to justify the determination of threshold limits of dustiness which will produce asbestosis in any definite period of time. In the absence of such threshold values it is not possible to determine permissible limits of dustiness on a medical basis. Nevertheless, any appreciable decrease in the amount of asbestos dust will cause a decrease in the incidence and severity of the resulting asbestosis. The elimination of all the dust in an industrial workroom is rarely necessary from a physiological standpoint and usually economically impracticable. Consequently, actual atmospheric conditions in an industry resulting from the application of practical methods of dust control can be used as temporary standards by that industry (*6*).

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U. S. TREASURY DEPARTMENT
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PUBLIC HEALTH SERVICE
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A STUDY OF DUST CONTROL METHODS IN AN ASBESTOS FABRICATING PLANT

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REPRINT No. 1883
FROM THE
PUBLIC HEALTH REPORTS
Vol. 52, No. 48, November 26, 1937
(Pages 1713-1737)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1938

For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents

A STUDY OF DUST CONTROL METHODS IN AN ASBESTOS FABRICATING PLANT

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An extensive medical and engineering study of the health of asbestos workers has been conducted by the United States Public Health Service (*5*). The material contained in this paper supplements the general study with a detailed study of the dust control methods used in an asbestos fabricating plant. It is a report on present conditions and how they have been obtained and is presented as an example of the results of the application of scientific methods of dust control. These data should be interesting not only to the asbestos industry but also to other industries having similar dusty processes.

The plant studied has only partly completed an extensive dust control program, and conditions are being improved continually; consequently, these results should not be interpreted as representing the maximum possible efficiency in the control of asbestos dust, but it is believed that they are representative of the best practice in this country at this time. The dust control systems in use with the various processes in each department are described. An occupational analysis of employees is presented, with a comparison of the atmospheric dust concentrations associated with controlled and similar uncontrolled processes.

FABRICATION OF ASBESTOS TEXTILES

Asbestos is the class name for several different fibrous minerals, but the asbestos of commerce (*1*) is mainly the fibrous form of serpentine known as chrysotile.[1] Due to its fibrous nature, flexibility, and heat-resistant properties, asbestos fiber finds many practical applications. One of its important industrial uses is in the manufacture of fire-resistant textiles.

In the plant studied, practically all raw material was crude Canadian or South African asbestos. Some imported short fiber was used, as well as some of the short fiber salvaged in the recovery process, but most of the short recovered fiber was shipped to other plants. Significant variations in atmospheric dust concentrations due to the grade of fiber being processed were not evident in controlled processes in this plant. Consequently, the type of fiber used has not been considered in the analysis of the data. Each dust controlled process tended to decrease the amount of dust generated in subsequent

[1] Chrysotile is a hydrous magnesium silicate ($H_4Mg_3Si_2O_9$ or $2H_2O \cdot 3MgO \cdot 2SiO_2$) containing 44.1 percent silica, 43.0 percent magnesia, and 12.9 percent water. Other types of asbestos often contain silicates of iron, calcium, and aluminum as well as magnesium (*5*).

[illegible]

processes. These *factors* must be considered when comparing dust concentrations reported in this plant with the data which have been reported for other plants.

Approximately 300 persons were employed in this plant, of whom 180 worked in departments having a potential asbestos dust hazard. This study was confined to these departments; namely, preparation; carding; spinning, twisting and winding; and weaving. The occupational distribution of exposed workers is shown in table 1.

TABLE 1.—*Occupations and dust exposures of workers in an asbestos textile plant*

Occupation	Number of workers	Average dust concentration, M. P. P. C. F.	
		Normal	Without exhaust ventilation
Preparation:			
Crushermen	2	2.5	[3] 98.6
Cotton openers	1		
Asbestos openers	2	[1] 2.5	
Bed builders	3	[1] 4.4	
Pickermen	3	[1] 8.7	
Others	6	[1] 2.4	
Carding:			
Carders	8	[1] 2.7	[2] 62.6
Stock rollers	30	[1] 4.6	[2] 40.4
Card tenders	8	1.7	
Wick, rope, and cord	6	1.7	
Others	6	.3	
Spinning, twisting, and winding:			
Mule spinners and helpers	22	.9	
Ring spinners	6	8.0	
Spoolers	16	[1] 2.9	[2] 8.6
Cop winders	4	4.9	
Twisters	13	11.0	
Universal winders	7	2.5	
Others	18	4.9	
Weaving:			
Weavers:			
Dry cloth	18	1.7	[2] 9.8
Wet cloth		2.7	
Tape and listing		4.0	
Creelers	7	1.3	
Inspectors—Cloth	2	1.6	[2] 11.8
Inspectors—Tape	2	2.1	
Others	7	1.3	

[1] Dust exhaust system for this operation.
[2] Sample after 1 hour's operation without exhaust.
[3] Sample taken inside bin during loading.

METHOD OF STUDY

This investigation included a study of atmospheric dust concentrations in the factory workrooms and a study of the exhaust systems used to remove asbestos dust.

Eighty-two atmospheric dust samples were collected at the workers' breathing level with the impinger dust sampling apparatus (3). Sixty-nine of these represented present working conditions and 13 represented conditions while exhaust apparatus had been turned off for 1 hour. A collecting medium containing 25 percent ethyl alcohol in distilled water was found to prevent flocculation without causing excessive evaporation in either the sampling flasks or the counting cells. All samples were counted the day after collection. Owing to the low dust concentrations encountered, most of the samples represented the dust in from 20 to 30 cubic feet of air. Samples were diluted with distilled water and counted according to the light-field technique described by Bloomfield and DallaValle (5). A micrometer eyepiece having an engraved square equivalent to one-fourth the standard Whipple square was used in counting. Since it is customary to count only one quadrant of the Whipple field, the same volume of sample (0.25 cubic millimeter) per field was counted (7).

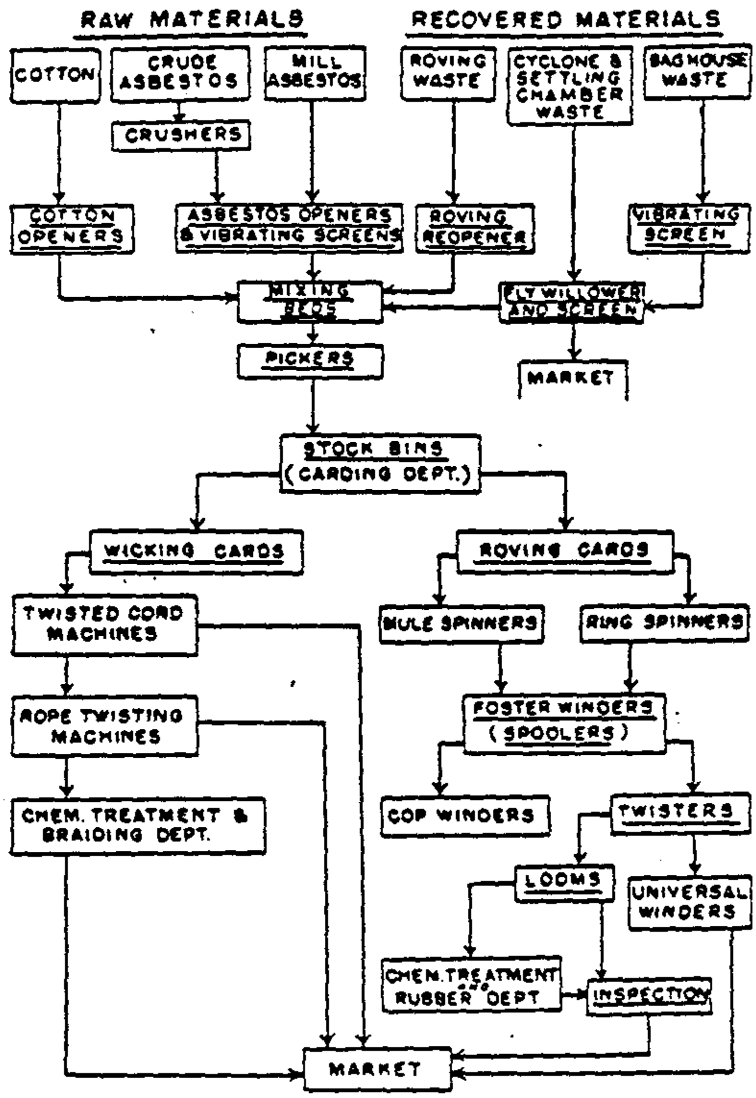
The quantities of air removed through the various exhaust systems were calculated from pitot tube measurements of center-line velocities in the pipe lines (4). Average exhaust rates per process are listed in table 2 and discussed a little later in the description of exhaust systems. Entrance velocities at open hoods were measured with an Alnor velometer and checked with a vane anemometer. Most of the hoods were of the enclosed type designed to exhaust only enough air to prevent the escape of asbestos dust into the workroom. Where individual measurements were impractical, air volumes exhausted through each hood were calculated from measurements of main-line velocities. Whenever differences in exhaust volumes were noted between similar hoods on the same operation, the average value is given.

DESCRIPTION OF PROCESSES AND DUST CONTROL MEASURES

Asbestos is received in burlap bags containing 100 pounds of fiber. Cotton is received in standard bales. These are the only raw materials used in the preparation of asbestos yarn at this plant. Unloading, storage, and transportation of the packed raw materials were not hazardous occupations. The progress of the material from raw fiber to completed fabric is shown by means of a flow sheet (fig. 1). Individual processes and the measures for dust control are described below.

PREPARATION DEPARTMENT

Crushing.—Some of the asbestos fiber arrives at the plant as "precrushed" fiber, but most of the crude fiber has received no treatment other than mining, sorting, and screening. This latter type is hand dumped from the bags into rim-wheel crushers and crushed from 5 to 15 minutes. These crushers have two heavy rollers attached to a radial axle, and revolve on a smooth-surfaced tray in which the asbestos is placed. During the crushing, the asbestos fiber is constantly stirred by revolving scrapers. After being crushed, the fiber is replaced in the bags and carried to the asbestos opener. Crushers were not enclosed or exhausted in any way, but the general ventilation in the preparation department was sufficient to prevent high concentrations of dust near this operation. Crusher men had res-



NOTE: UNDERLINED PROCESSES HAVE DUST EXHAUST SYSTEMS.

FIGURE 1.—Process flow-sheet, asbestos textile plant.

pirators [2] and usually wore them while loading or unloading the crushers. The average exposure of a crusher man tending three crushers was 3.5 M. P. P. C. F.

[2] All employees in the preparation department and all repairmen and janitors were provided with respirators of a type approved by the U. S. Bureau of Mines against high concentrations of fine silica dust.

Asbestos opening and screening.—The crushed fiber is dumped from bags to the floor beside the asbestos openers and lifted into the feed lattice hopper with wooden hand forks. Two openers of different design were in operation, but the method of exhaust hooding was the same on both. (See schematic design, fig. 2.) The feed lattice hopper was partially enclosed and exhausted at the top (hood A). A second hood exhausted the bottom fly and settled dust from the bottom of the opener (hood B). The opened fiber was picked up by hood C and pneumatically transported to a cyclone separator where the fibers were removed and dropped onto an enclosed vibrating screen. A large portion of the dust and fine fibers entering the asbestos opener

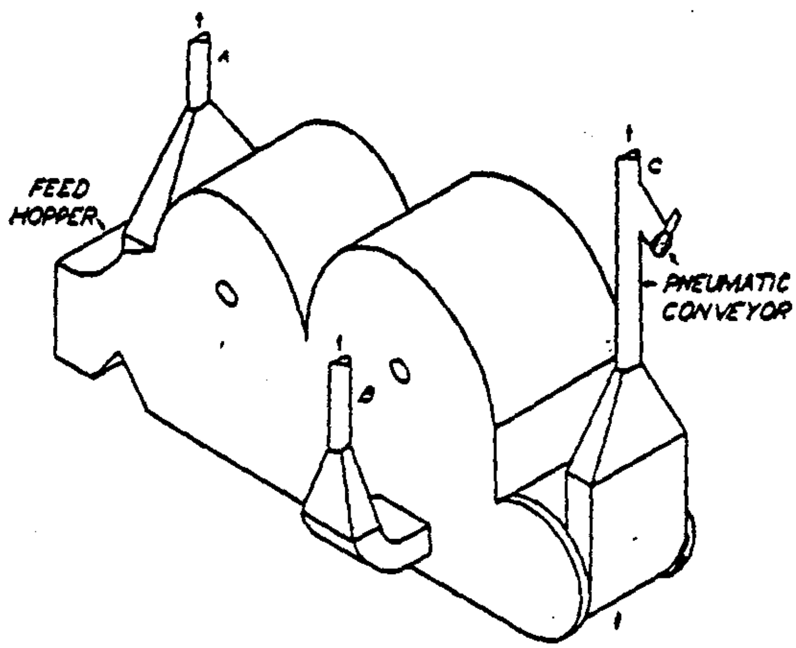


FIGURE 2.—Schematic view of exhaust system applied to an asbestos opener.

was removed by hoods A and B. Clumps of unopened fibers and pieces of rock too heavy to be lifted by the pneumatic fiber conveyor fell onto an enclosed belt conveyor serving both openers, and were carried to the recovery process. (Belt conveyor is not shown in fig. 2.) Exhaust volumes through the hoods were as follows: Hood A, 400 cfm; hood B, 400 cfm; hood C (pneumatic conveyor), 1,800 cfm; conveyor velocity, 2,730 feet per minute.

Each opener had its own cyclone separator and enclosed and exhausted vibrating screen. One screen had two exhaust hoods, one beside the charging hopper drawing 400 cfm and one over the discharge end of the screen and the stock car, drawing 770 cfm. The second screen had one hood only, over the discharge end, drawing 615 cfm. Short fibers and rock particles passing the screens fell through a chute to the enclosed recovery conveyor. Fiber failing to pass these screens dropped into a stock car. Full stock cars were pushed to a platform scale and then to the mixing beds.

The same men charged the openers and filled the stock cars. The average dust exposure of asbestos-opener operators was 3.6 M.P.P.C.F.

Cotton openers.—The best grades of insulation contain very small amounts of cotton, if any; but in all other cases, cotton fiber is mixed with asbestos fiber to improve its spinning qualities. At this plant the batch seldom contained more than 15 percent of cotton by weight but as much as 20 percent cotton was used in lower grade yarns. The two-stage Saco-Lowell cotton opener was provided with exhausts at three points; 770 cfm of air were exhausted through a canopy hood over the feed lattice, 270 cfm from the bottom of the primary opener, and 1,120 cfm from the bottom of the secondary opener. Opened cotton fiber was discharged into stock cars. No samples were taken at the cotton openers, but the operators' average exposure was about 2.4 M. P. P. C. F. (general air, preparation department).

Mixing.—Weighed quantities of asbestos and cotton were placed in alternate layers in the mixing beds. Occasionally, layers of roving waste from the carding room were reopened and added to the bed. Mixing was done in six "exhausted" booths, each 10 feet 2 inches deep by 6 feet 10 inches wide by 6 feet high. Sides of the booths were permanent, while the back consisted of a removable wood and canvas section. Each booth was covered by a pyramid hood 32 inches high, through which approximately 1,025 cubic feet of air per minute per hood were exhausted. The velocity of air motion into these booths averaged 50 feet per minute during bed making and about 30 feet per minute during picker loading. Dust concentration averaged 5.4 M. P. P. C. F. for the bed-making operation.

After a bed had been placed, the picker operator removed the rear partition of the booth and forked the batch into the charging hopper of a picker (fig. 3). The picker machine mixes the fibers in revolving beaters. The four machines represented three different operations and two different types of exhaust systems. The first machine, not in operation during this study, discharged mixed fiber into a stock car. This material was then passed through a second picker for remixing. The second and third machines discharged mixed fiber onto a belt conveyor which transported it to bins in the carding room. The product of the fourth picker was carried to the carding room by a pneumatic conveyor. Each of the first three machines had a hood over the charging lattice, exhausting approximately 500 cfm, a pipe exhausting about 1,650 cfm from the bottom-fly settling chambers under the main picker drum, and a hood over the end of the discharge lattice exhausting about 400 cfm. The fourth picker had the same hood arrangement over the charging lattice but had no bottom-fly exhaust, and the mixed fiber was removed by a pneumatic conveyor exhausting approximately 2,000 cfm of air at a velocity of 2,550 feet per minute. The picker operators wear respirators during the charging operation. Dust concentrations during picker charging varied from 4.0 to 9.5 M. P. P. C. F., averaging about 6.7 M. P. P. C. F.

Recovery processes.—Waste roving from the card room was returned to the preparation department for reopening. The roving reopener was exhausted only from the pit below the last beater, but the 1,780 cfm of air drawn through this hood were sufficient to prevent the escape of dust through the discharge lattice.

The dusty air collected by the exhaust systems in the preparation and carding department was blown into a large settling chamber occupying two stories in the end of a separate building. Air was displaced from this room to a bag house occupying the second floor on the other end of this building. Dust was filtered out by burlap filters stretched on A-frames. The filters were beaten down by hand daily during the noon rest period. The collected dust was removed during the week end shut-down, and stored in bins in the preparation department. Bag-house dust was screened on a completely enclosed and exhausted vibrating screen (background, fig. 4), and the long fibers were removed to a cyclone collector by a pneumatic conveyor. The dust from the settling chamber, the long fibers from the bag-house dust, and fibers separated by cyclones on the exhaust lines from the spooling operation and the weaving department were passed through a fly-willower and vibrating screen (fig. 4). Approximately 250 cfm of air were exhausted from the top of the charging lattice and 620 cfm from the discharge side of the opening drum. Dirt passing the screen dropped onto an inclined tray and was removed by an exhaust hood drawing 730 cfm. Fibers which did not fall through the screen were removed by the hood at the lower end of the screen (1,710 cfm) and pneumatically conveyed to a cyclone collector. Rock and other impurities not picked up by the pneumatic conveyor fell into a waste box below the end of the screen. The market for recovered fiber is limited, and such fiber is usually too soiled for use in high-grade textiles. Consequently only part of the collected dust was passed through this process. Average exposure of operators was estimated at between 3 and 5 M. P. P. C. F.

As a measure of the effectiveness of the dust control system in the preparation department, the exhaust fans were shut off for 1-hour. Pneumatic conveyors remained in operation. Dust concentrations increased steadily to about 50 M. P. P. C. F., at which time the exhaust fans were turned on. The samples taken during this period were only a partial measure of uncontrolled conditions, since the hoods and enclosures had a definite control value.

While the location and design of hoods were the most important factors in dust control in the preparation department, general ventilation helped prevent high dust concentrations. This department occupied approximately 320,000 cubic feet of space, from which approximately 34,650 cfm of air were exhausted. Consequently 6.5 air changes per hour were produced by mechanical ventilation, which was supplemented by natural ventilation through doors, windows, and roof ventilators. Fortunately heating was not a problem in this plant.

CARDING DEPARTMENT

Mixed fiber from the preparation department was dropped from pneumatic or mechanical conveyors into bins in the carding department. The total volume of exhaust from four bins was 6,850 cfm, the major portion of this air being drawn through the one or two bin doors left open during the loading of carding room stock cars. Dust concentrations as high as 40.4 M. P. P. C. F. were measured inside an active bin while the dust concentration just outside the door of the same bin was only 4.6 M. P. P. C. F. Workers, classed as stock rollers, fork the mixed fiber from the bin into stock cars. This operation is supposed to be performed with both stock car and stock roller outside the bin door. This rule of keeping out of the bins should be strictly enforced. However, stock rollers, wearing respirators, like to push their cars under the chute and then climb into the car and "tread-down" the stock.

The cards are machines having a series of revolving cylinders wound diagonally with strips of leather set with fine, sharp, steel bristles. Carding removes remaining small bits of rock and combs the fibers into a more or less parallel condition to facilitate spinning. At the time of this study, 31 roving card units and 2 wicking cards were being operated. A roving card unit (fig. 5) consisted of two cards, a breaker, or primary card, and a finisher or roving card.

The mixed fiber was fed by hand from the stock car to the feed hopper of the breaker card. The stock roller wore a respirator during this operation. The fiber passed through the breaker card, emerging as a loose blanket or web. It was carried to the finishing card by a lattice conveyor or camel back. The fiber was stripped from the last cylinder of the finisher onto a moving leather apron, where a set of reciprocating rubbers condensed it into loose rovings of unspun yarn. These rovings are wound on long "jack" spools to be taken to the spinning department. The rovings at the extreme ends of the cards cannot be used for spinning because they lack uniform thickness. These rovings are collected by two small hoods and pneumatically conveyed to a collection bin for return to the preparation department.

The exhaust system applied to roving cards is shown schematically in figure 7. The quantity of air exhausted varied from 1,100 cfm to 1,800 cfm on different carding units with an average exhaust of 1,440 cfm per unit. Cards are partially enclosed and only sufficient air is exhausted to prevent the escape of dust.

Each breaker card is exhausted at three points. Hood B exhausts from the top of the feed hopper over the feed apron. This hopper was enclosed and covered, the cover being lifted during filling. About 160 cfm of air were exhausted through the hood. Hood A exhausted the top fly from the enclosure covering the main carding cylinder. Hood

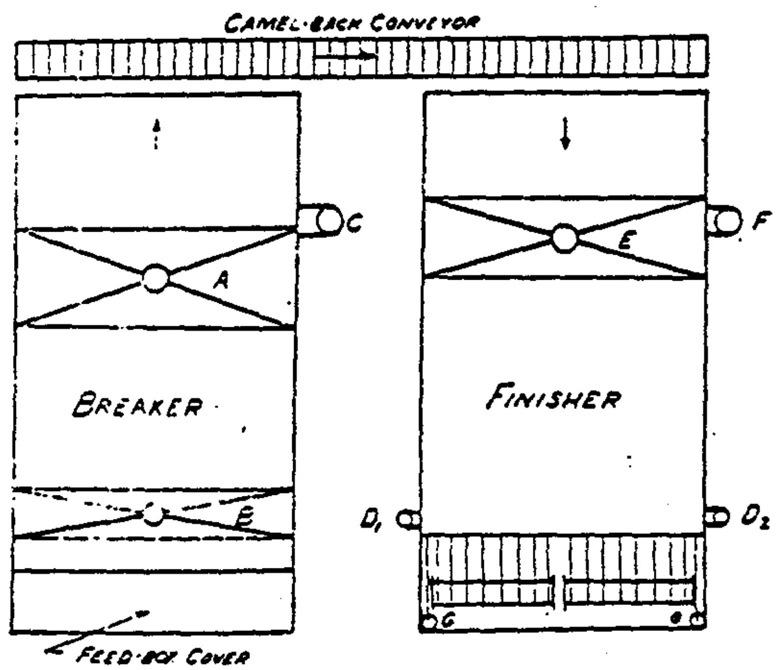


Figure 7.—Schematic plan of card exhaust system.

C exhausted the bottom fly from the settling chamber under the carding cylinders. Approximately 285 cfm were exhausted through each of these hoods.

The finishing card had four exhaust connections besides the two small hoods G which removed the waste roving. Hoods E and F correspond to hoods A and C, respectively, on the breaker card, providing an exhaust of approximately 285 cfm each. The doffer card cylinder, doffer combs, and roving apron were exhausted from below, through hoods D^1 and D^2 at 70 cfm each. About 40 cfm were exhausted through each roving collector.

The volumes of air exhausted through each hood were estimated on the basis of pipe areas. Actual volumes showed wide variations on different units.

Single cards were used in the manufacture of asbestos wick and rope, since a thick roving was desired. The wick or rope was twisted from the unspun roving. The wicking cards were exhausted at three points. Approximately 380 cfm of air were drawn from under the feed lattice, 490 cfm were exhausted from the top of the main cylinder cover to remove the top fly, and 550 cfm were exhausted from the bottom-fly settling chamber.

Dust concentrations during carding averaged 1.7 M. P. P. C. F. This was also the average exposure of wicking card operators and wick and rope twisters. Samples taken near the carding department weight scales showed less than 0.5 M. P. P. C. F.

Card rolls were cleaned and ground at night, except in cases of emergency. Cleaning was done with hand scrapers made of strips of card cloth, and the card cylinder was turned by hand. Grinding was done with the usual type of card grinders. The large roll was ground in place in the carding machine. Slightly greater quantities of air were exhausted during grinding due to the decreased loss of head resulting from removal of the wooden card covers. The small card cylinders were ground in a grinding frame. These frames were partially enclosed and covered with a canopy hood exhausting 2,330 cfm per grinder. Dust concentrations averaged 0.65 M. P. P. C. F. during grinding.

A special run of a group of carding machines made with all exhaust ventilation turned off and windows closed showed that dust concentrations steadily increased. At the end of 1 hour the concentration was 62.4 M. P. P. C. F. in the air. Under normal operating conditions about 64,000 cfm of air are exhausted from the carding department. This is equivalent to about 5.5 air changes per hour, disregarding natural ventilation through windows on all four sides of the room.

Spinning, twisting, and winding.—The yarn as roving is twisted or spun into compact threads on either mule or ring spinning frames. In this plant most of the spinning was done on mule spinners. The spun thread was transferred from the spinning spindles to spools, on Foster winding machines (spoolers). Spooled thread to be used as filler (or woof) in woven cloth was rewound on a cop winder into cops which will fit into the loom shuttles. The remaining spooled thread was respooled on twisters which twist several threads into a yarn. The number of strands used determined the size of yarn. Both plain and metallic yarns were twisted. Metallic yarn contains one or more strands of fine wire. Part of the twisted yarn was used in cloth weaving while the remaining yarn was rewound on Universal winding frames for the market.

Mule spinning was separated from other operations in this department by partial partitions. Natural ventilation was good and no exhaust systems were used. The average dust concentration was 0.85 M. P. P. C. F. with a maximum of 1.3 M. P. P. C. F. recorded.

Ring spinning, cop winding, and Universal winding machines were located in the same room with the twisting machines. Average exposures in the first three operations, which were not themselves especially dusty, were due to dust from the twisting operation. With the exception of a trial exhaust system on one twister, the remaining machines were not provided with exhaust. The trial system was reported to be satisfactory and is to be installed on all twisting

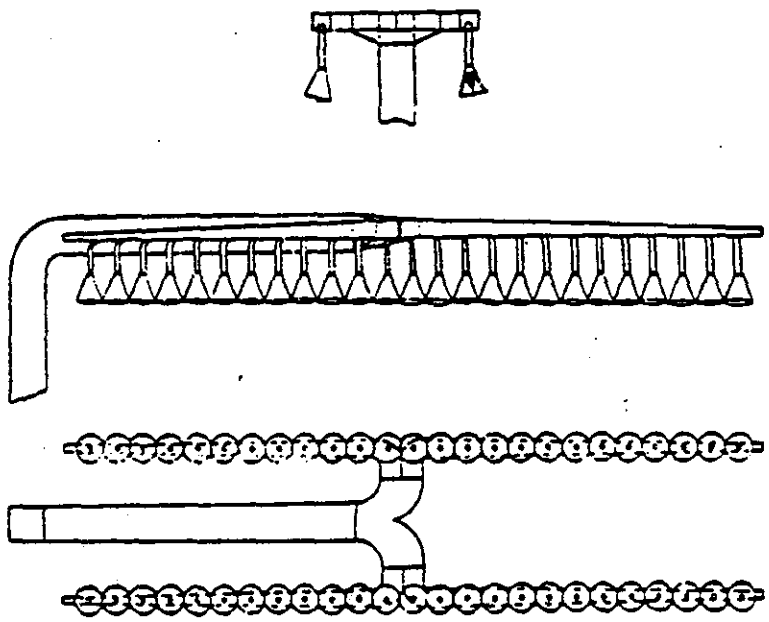


FIGURE [illegible].—Schematic views of exhaust system applied to Foster winders.

machines. In this system the bottom of the twisting frame was enclosed and a total of 1,700 cfm of air per machine was drawn downward past the twisting yarns and through five conical hoods distributed along a central exhaust duct.

Average dust concentrations at the various operations in this room were ring spinning, 5.0 M. P. P. C. F.; cop winding, 6.9 M. P. P. C. F.; Universal winding, 2.8 M. P. P. C. F.; and twisting, 11.0 M. P. P. C. F., with a maximum of 18.8 M. P. P. C. F. recorded beside a twisting frame. No accurate measurements of the efficiency of the exhaust system on the single exhausted twister could be secured, but simultaneous samples on both sides of this frame showed a dust concentration of 18.0 M. P. P. C. F. on the side toward the unexhausted twisting frames and a concentration of 6.3 M. P. P. C. F. on the other side.

Four Foster winders (spoolers) were partially separated from the other operations by partitions (fig. 6). The exhaust system consisted of an individual conical hood around each spindle holder (fig. 8). Approximately 46.5 cfm were exhausted through each hood, or a total of 9,270 cfm through the 200 hoods on the 4 spooling frames. Dust concentrations at the spoolers averaged 2.9 M. P. P. C. F. and increased to 9.6 M. P. P. C. F. within 30 minutes after the ventilation had been shut off.

WEAVING AND INSPECTION

Cloth, tape, listing, and brake bands were woven on different types of looms. In this plant, exhaust systems had been applied to the dry cloth looms, since these were considered to be the most important source of dust. The dust control program calls for installation of exhaust systems on dry tape, listing, and brake-band looms. At present these operations are mainly performed wet or partially wet. Brake-band looms were not in operation during this study. Significant differences could not be noted between dust samples collected around the various tape and listing looms. Dust concentrations ranged from 1.2 to 4.0 M. P. P. C. F. and averaged 3.0 M. P. P. C. F.

Nineteen cloth looms were in operation in this department. One of these was a wet loom not provided with exhaust hoods, 4 were dry looms provided with exhaust hoods, and the other 14 were so provided but could be operated either wet or dry. A loom without exhaust hoods is shown in figure 9. The exhaust system is shown schematically in figure 11. A double exhaust hood drew air from under the warp while a second hood was attached to the top of the loom lay with exhaust ducts running down the side of each picker arm to an airtight swing joint at the bottom. The openings in the loom-lay hood consisted of four slots nine inches long by 1 inch wide extending over a space of 4 feet across the woven fabric at right angles to the warp. A total volume of approximately 10,500 cfm of air was exhausted from the 18 hooded looms. This averaged about 580 cfm per loom; but since it was seldom necessary to operate more than 10 dry looms at one time, the average quantity of air exhausted was close to 1,000 cfm per loom. Exhaust dampers were provided on all looms, and a sufficient number to balance the system are closed on wet or idle looms. The average dust exposure of a weaver operating a dry loom with exhaust was 0.7 M. P. P. C. F., while the average exposure in wet weaving without exhaust was 2.6 M. P. P. C. F. Samples taken beside a dry loom without exhaust showed dust concentrations of 9.6 M. P. P. C. F.

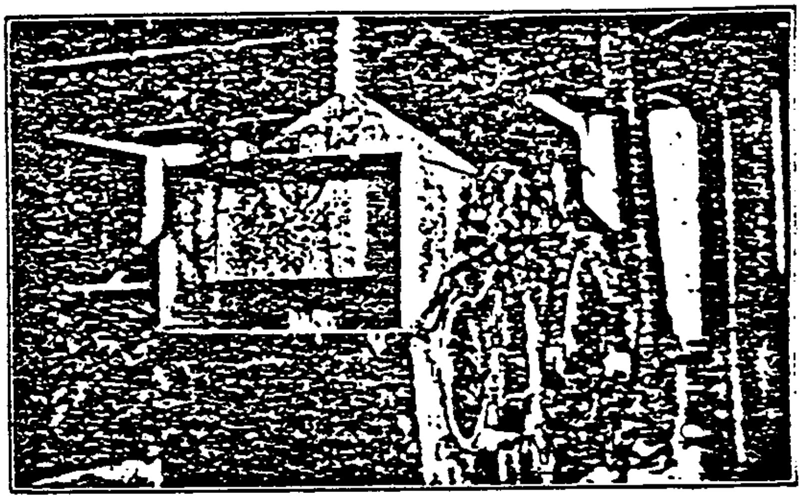


FIGURE 3.—Picker mixing machine

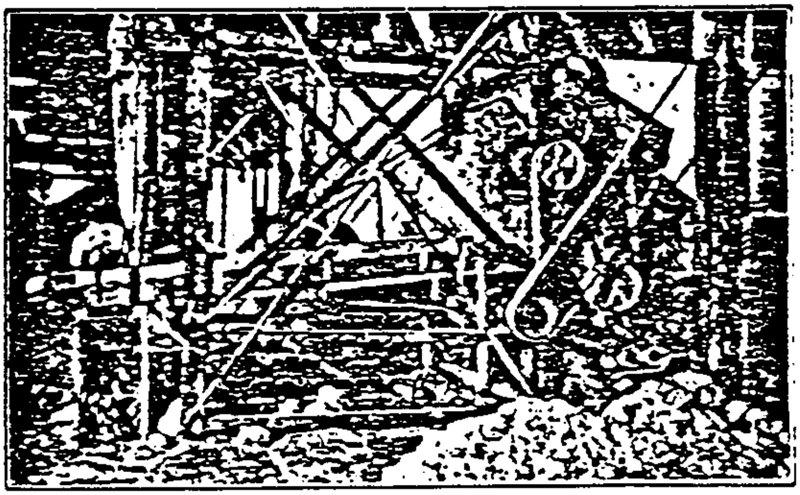


FIGURE 4.—Fiber recovery process. Willower and vibrating screens.

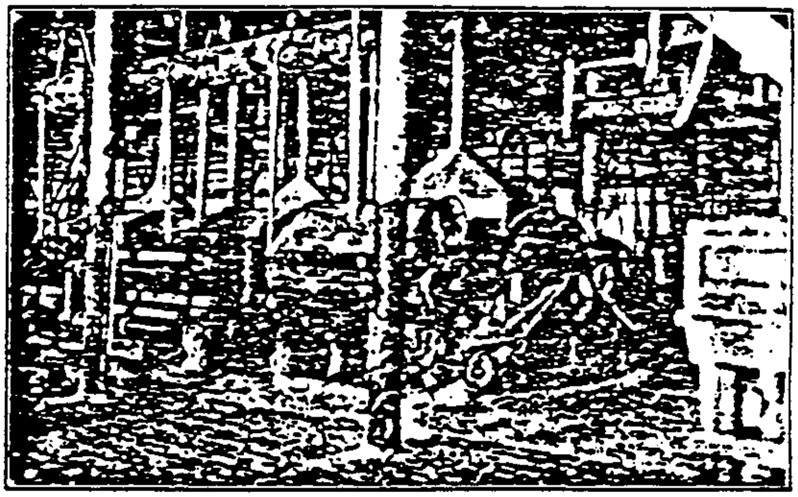


FIGURE 5.—Breaker and roving cards.

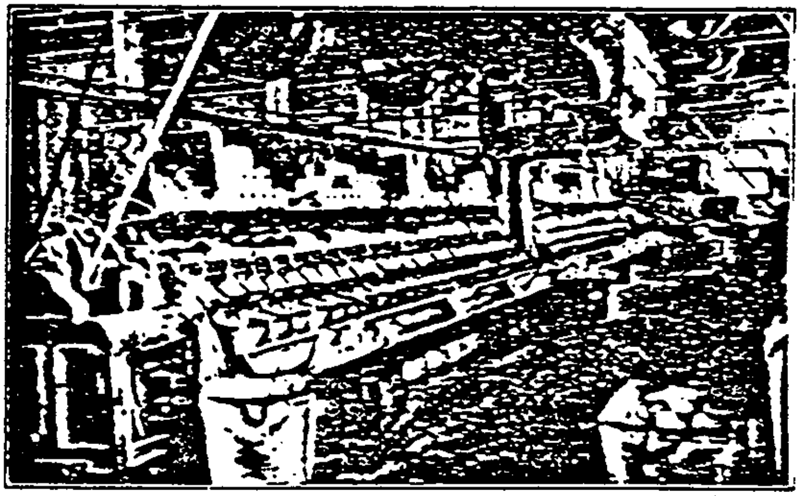


FIGURE 6.—Foster winding machines (spoolers).

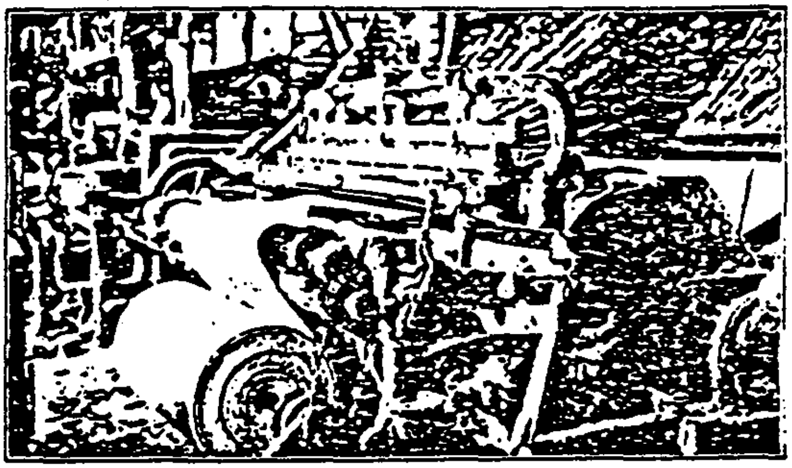


FIGURE 9.—Unexhausted broad loom.

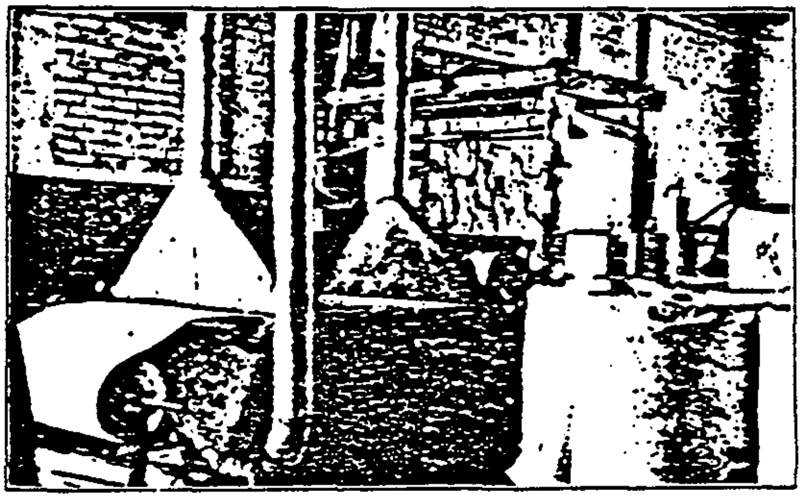


FIGURE 10.—Table for inspecting, calendering, and brushing woven cloth.

after 45 minutes. Average dust concentrations during dry weaving have been shown as 49.7 M. P. P. C. F. (5).

Woven cloth was inspected, brushed, and calendered on the inspection table shown in figure 10. Each of the power-driven brushes was

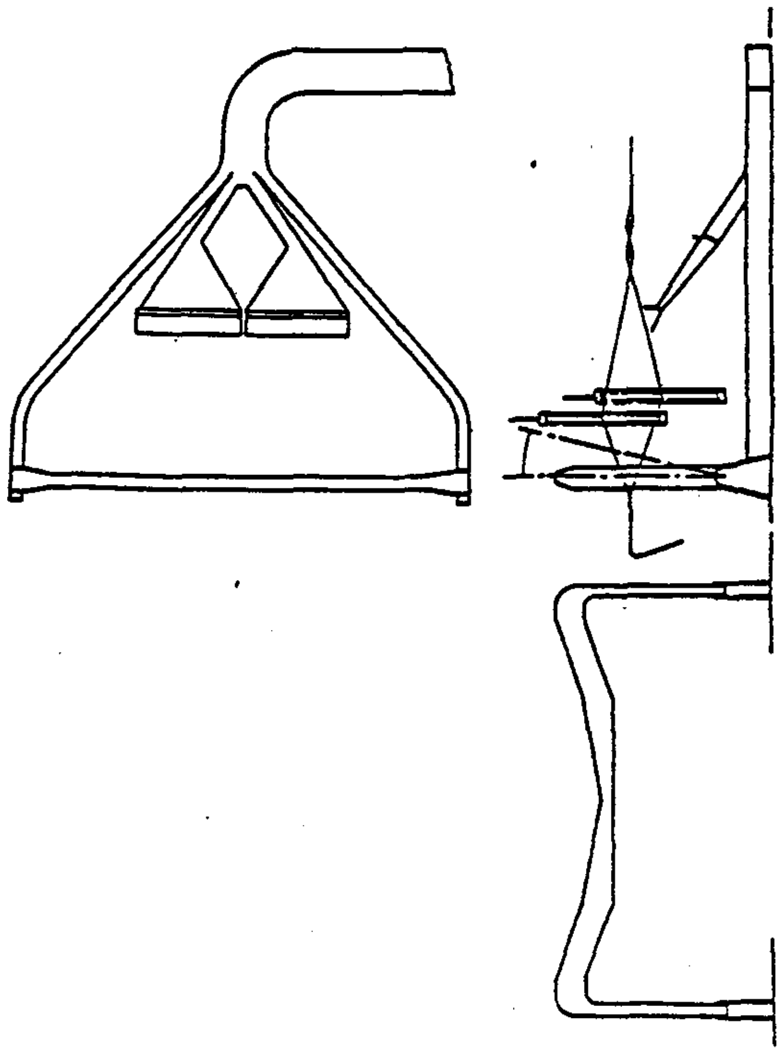


FIGURE 11.—Schematic views of exhaust system applied to broad looms.

partially enclosed and exhausted. Approximately 750 cfm of air were drawn through each of the two hoods at the front of the table and about 200 cfm were drawn through the cleaning hood at the back of the table. Dust concentrations during inspection averaged 0.5 M. P. P. C. F. A sample taken while a roll of fabric was passed across the table without benefit of exhaust showed a dust concentration of 11.8 M. P. P. C. F.

Doffing, inspection, and calendering of tape and listing were hand operations and were not provided with exhaust. Dust concentrations of 5.0 M. P. P. C. F. were recorded during these operations but the exposure was intermittent.

Creelers had an average exposure of about 1.3 M. P. P. C. F. while placing spools and threading looms.

An exhaust of 12,200 cfm of air was provided in the weaving department, corresponding to approximately three air changes per hour. In cold weather, warm air was distributed through the department from a plenum system, while in warm weather natural ventilation was secured through use of windows on all four sides of the department.

OTHER OPERATIONS

Other operations in this plant consisted of processes in which the yarn was chemically treated and fabricated, or processes for chemically treating or rubberizing fabricated cloth. No potential asbestos hazard was associated with these processes, with the exception of one braiding machine used to make large diameter asbestos tubing. This machine was covered with a conical canopy hood about 6 feet in diameter, which provided an exhaust of approximately 200 cfm of air. A sample taken beside this machine showed a dust concentration of 0.4 M. P. P. C. F. at the operators' breathing level.

TABLE 2.—*Volumes of air exhausted per machine in various operations in an asbestos textile plant*

Operation	Connections	Total volume of air exhausts per minute (cu. ft./min.)	Dust concentration with exhaust, M.P.P.C.F.	Dust concentration without exhaust, M.P.P.C.F.
Asbestos opener	[1] 2	620–1,000	2.6	[2] 11.1–66.0
Vibrating screen	1	700		
Cotton opener	3	2,160		
Mixing beds	1	1,025	4.4	[2] 8.1–10.0
Picker	3	2,570	6.7	[2] 24.3–74.3
Roving reopener	1	1,780		
Fly willower and screen	[1] 8	1,600		
Roving cards:				
Breaker (primary)	8	1,420	1.7	62.4
Finisher	4	1,440		
Wicking card	3	1,420		
Card grinders	1	2,330	.7	
Foster winders (spoolers) [4]	[4] 1	2,225	2.0	[3] 12.1
Twisters	1	1,700		11.0
Weaving (broad looms)	2	1,200	.7	[3] 48.7
Brusher—Calenderer	3	1,480	.5	11.8

[1] Equipped with pneumatic conveyor—exhaust through conveyor not included.
[2] Unpublished data, other plants (J. M. DallaValle, U. S. P. H. S.)
[3] Fulton, et al. Ref. (2).
[4] Individual ones for each spindle connected to exhaust manifold.

SUMMARY

Table 2 gives a summary of the operations provided with exhaust, listing the number of exhaust ducts and the rate of ventilation per machine, as well as the average dust concentrations to which operators are exposed. Average dust concentrations measured near corresponding operations without exhaust are tabulated to show the effectiveness of the control methods which have been described.

CONCLUSION

This study of actual results secured by a dust control program in an asbestos fabricating plant is presented as an example of engineering control of an industrial hazard. Adequate data have not yet been published to justify the determination of threshold limits of dustiness which will produce asbestosis in any definite period of time. In the absence of such threshold values it is not possible to determine permissible limits of dustiness on a medical basis. Nevertheless, any appreciable decrease in the amount of asbestos dust will cause a decrease in the incidence and severity of the resulting asbestosis. The elimination of all the dust in an industrial workroom is rarely necessary from a physiological standpoint and usually economically impracticable. Consequently, actual atmospheric conditions in an industry resulting from the application of practical methods of dust control can be used as temporary standards by that industry (*6*).

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