ASBESTOS EXPOSURES DURING THE CUTTING AND MACHINING OF ASBESTOS CEMENT PIPE

Prepared for

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March 16, 1977

EXHIBIT F

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INTRODUCTION

This is a report on the concentrations of airborne asbestos and total dust produced during typical field cutting and machining operations employed in the installation of asbestos cement (A/C) pipe. The study was carried out by Equitable Environmental Health, Inc., under a contract from the A/C Pipe Producers Association and was specifically designed to obtain quantitative information on the potential exposures of workers in the construction trades. The information was needed to predict how A/C pipe field operations would be affected by alternative health standards for asbestos in the construction industry.

BACKGROUND

Production of asbestos cement pipe began in the United States in 1929. It is used extensively for the transport of water and sewage. Current production is estimated at 60 to 65 million linear feet with consumption of approximately 100-140,000 short tons of asbestos per year. This accounts for 15 to 20 percent of U.S. asbestos consumption. Chrysotile (80%) and to a lesser degree, crocidolite (20%) asbestos are incorporated in the pipe.

There are two general categories of A/C pipe, pressure or water pipe, and non-pressure or sewer pipe, made in diameters ranging from 4 to 42 inches. The former, as the name implies, must withstand internal hydrostatic pressures and are tested up to 900 pounds per square inch, depending on pressure class rating. It usually contains about 17% asbestos. Non-pressure pipe is designed to withstand external "crush" loads, and usually contains 10 to 12% asbestos plus 10-15% ground scrap pipe ("fines"). The cementitious component of the pipe is about 60% cement and 40% silica flour which react to reduce the free lime content below 1% during the autoclave cure.

RELEVANT STANDARDS

In interpreting data in the report, it is useful to review recent, current, and proposed occupational standards for asbestos. It was not until the development of the membrane filter method for direct counting of fibers that occupational standards were based upon fiber concentrations. Prior to that, total dust counts were the basis for control. In 1968, the American Conference of Governmental Industrial Hygienists recommended a time-weighted average limit of 12 fibers per cubic centimeter, based on fibers greater than 5 micrometers in length (and alternatively a 2 million particles per cubic foot total particle count limit). The 12-fiber limit was adopted by the Department of Labor under the Walsh-Healey Public Contracts Act in 1969, and was incorporated in OSHA tentative standards in 1971.

A reduced standard was announced by OSHA June 7, 1972, to be effected in two steps. As of July 7, 1972, the permissible exposure was set at

5 fibers/cc as an 8-hour time-weighted average (TWA), with a ceiling of 10 fibers/cc. As before, only fibers longer than 5 micrometers were counted. As of July 1, 1976, the permissible TWA was lowered to 2 fibers/cc.

On October 9, 1975, OSHA proposed a still more restrictive occupational standard, the new permissible TWA to be 0.5 fibers/cc and the permissible ceiling concentration to be 5 fibers/cc (fibers longer than 5 micrometers). This standard was to be applicable only to the manufacturing sector, with a separate standard to be promulgated later for the construction industry. This more stringent standard has not yet been adopted, nor has a standard been proposed for the construction industry. In the meantime, the National Institute for Occupational Safety and Health (NIOSH) has announced its intent to recommend a further reduction of the occupational standard to a permissible TWA of 0.1 fiber/cc, i.e. 100 fibers greater than 5 micrometers per liter of air.

STUDY DESIGN

In its request for a proposal, the A/C Pipe Producers Association requested quantitative exposure data on the following field operations, to cover both non-pressure pipe and pressure pipe:

(1) Machining with a manual field lathe

(2) Machining with a power-driven field lathe

(3) Cutting with an abrasive disc

(4) Power hole cutting

(5) Cutting with chisel, using hammer and rasp

When possible, contractors avoid cutting and machining A/C pipe in the field because of the expense. The usual procedure is to have appropriate sizes pre-cut and pre-machined before being taken to the construction sites. Because of this, it was not feasible to study all operations at the sites where pipe was being installed. Instead, it was decided to simulate field conditions.

Arrangements were made to carry out the study on the premises of a manufacturer of A/C pipe cutting equipment. A workman experienced in the use of all the tools performed the individual operations, with a helper provided by EEH. EEH independently purchased 8-inch diameter sewer pipe (Class 2400) and 8-inch diameter pressure pipe (Class 150) from a local supply house. No engineering control or ventilation was utilized, since these are not available in the field. NIOSH-approved disposable respirators were worn by operators and EEH personnel during test periods which produced high dust concentrations.

Each cutting operation, when performed in the field, is of short duration compared to an 8-hour workday. Consequently, the ceiling standard, which covers short time periods of relatively intense exposure, would be more likely to be exceeded than the 8-hour time-weighted average exposure standard. While the number of minutes defined by the ceiling standard has not been uniformly defined in regulations, a sampling period of 15 minutes is often used as an effective compromise between catching the "peak" and obtaining an adequate sample for analysis.

It was determined in advance that a single cutting or machining operation rarely took as long as 15 minutes. For the operations of major interest, the average time per operation was from 3 to 6 minutes. It was decided, therefore, that several successive operations would be made during each sampling period. The short term sampling period would be approximately 15 minutes unless, in the industrial hygienist's judgement, a sufficiently large sample could be obtained in a shorter period.

In order to assess reproducibility, three replicate short-term or "peak" breathing zone samples on both the operator and his helper were to be collected for each operation.

Simultaneously, longer-term "integrated" personal samples were to be collected on the operator and helper and area samples at a site located approximately 15 feet away and downwind (if there were air movement). These integrated samples were to be collected over periods of 2 or 3 hours, each one to span more than one type of field operation.

Another area sampler was to be used to collect total dust for gravimetric analysis. This was to be located 5 to 10 feet from the field operation. The samples were to be less than one hour in duration to span the three replicate tests for one operation.

Background samples of 1 to 2 hours each were to be collected before and after each day's work to ascertain the prevailing ambient asbestos concentrations.

METHODS

Air samples were collected on 37-millimeter diameter, 0.8 micron pore size Millipore cellulose ester membrane filters in accordance with OSHA and NIOSH recommendations. They were all "open-face" (with the cover of the filter cassette removed) samples. Personal sampling pumps were operated at flow rates ranging from 1.6 to 2 liters per minute. The pumps were calibrated by the soap bubble technique before use. Both area and personal (breathing-zone) samples were taken. In the latter, the pump was attached to the worker's belt and the filter clipped to his lapel near his face. Figure 1 illustrates worker and helper with samplers in place. Figure 2 shows the test site with area samplers located near the operation.

All samples were analyzed by LFE Environmental, a laboratory accredited by the American Industrial Hygiene Association, following OSHA and NIOSH methods. Briefly, the analytic procedure consisted of rendering the filter transparent with a high viscosity solution of membrane filter material in a mixture of diethyl oxalate and dimethyl phthalate. The asbestos fibers which lie on the surface of the filter are counted with a phase contrast microscope at 400x magnification. The count area was delineated with a Porton graticule. Only fibers exceeding 5 micrometers in length were counted. The laboratory examined 100 microscopic fields or counted 100 fibers, whichever came first. Fiber identification depended upon a particle having an aspect ratio of at least 3:1 and having approximately parallel sides. No attempt was made to identify individual fibers mineralogically in view of the known chrysotile and crocidolite content of the material under examination. No estimate was made of the number of fibers less than 5 micrometers in length, nor the number in the electron microscope range. Samples were stored for such studies if they should appear desirable at some later time.

It should be emphasized that estimates of fiber concentrations below 5 fibers/cc are subject to increasing lack of precision, and that those below 0.5 fibers/cc have a fairly wide margin of error, often being based on the observation of relatively few fibers. Thus, although counts are reported as calculated, to two decimal places, differences in counts in these ranges should not be overinterpreted.

STUDY OPERATIONS

Preliminary Survey

On 31 January 1977, Mr. Wesley Noble and Mrs. Barbara Kawahara conducted a preliminary survey to obtain information needed for efficient conduct of the main survey. The operation of the field cutting and machining tools was demonstrated. Air samplers were taken to determine if a 15-minute sampling period would be adequate.

Main Survey

On February 8 and 9, 1977, Mr. Noble, Mrs. Kawahara, and Mr. Ronald LaSalle returned to the plant to perform the main survey. Both days were hazy, with the temperature in the 60's and 70's. There was virtually no wind in the morning and only light breezes from the west in the afternoons.

The five cutting and machining operations specified under Study Design were studied, plus use of one cutter (Wheeler) which was introduced for a limited test. Descriptions of these operations follow:

(1) Hand machining with a manual field lathe. The lathe (Pilot Ratchet Field Lathe, Model B-12R) was attached to the end of an 8-inch pipe supported 2 to 3 feet from the ground (Figures 3 and 4). The lathe had two sets of blades, one for the actual cut and the other to machine and profile the end. The depth of cut could be adjusted manually with screws. A ratchet allowed the operator to turn the lathe by pumping a handle. The helper adjusted the depth of cut as the lathe rotated about the pipe and would also aid in turning the lathe. For sewer pipe, one complete cycle took about 8 minutes, i.e. 2 minutes to cut and 6 to 7 minutes

for set-up and machining. Each short-term peak sample represented two cycles. Cutting pressure pipe took longer, 4 minutes for cutting and 8 to 9 minutes for set-up and profiling. Each short-term sample covered a single cut.

(2) Power machining with power-driven field lathe. This electric-powered lathe (Pilot Powered Field Lathe, Model B-12P) worked on the same principle as the manual lathe (Figures 5 and 6). Due to the ease of operation, a helper was not really necessary. Sewer pipe took 1/2 to 1 minute to cut and 4-1/2 to 5-1/2 minutes to profile. Two cycles were completed for each short-term ("peak") sample. Again, cutting pressure pipe took longer, 1-1/2 minutes to cut and 5 to 6 minutes to profile; two cycles were used per sample.

(3) Cutting with abrasive disc. This was a gasoline powered abrasive disc saw (Stihl) with a 10" diameter carbide blade (Figure 7). When cutting with the saw, the operator held the saw while the helper rolled the pipe along the ground toward or away from him. No machining of the ends was performed with this method of cutting. On both sewer and pressure pipe, one cut could be made in 30 to 45 seconds. Each peak sample included four cuts.

(4) Power hole cutting. The tool used for this (Pilot Hole Cutter, Model HC-38E) is available with either an electric or gasoline engine. The model used in the test was gasoline powered (Figure 8). It cut a 4-1/2" diameter hole with a small center plug. The cutter was secured to the pipe with a chain. The

engine rotated the blade while the operator continuously adjusted the height of the blade. The helper aided in equipment set-up. It took about 1 minute to cut a hole in sewer pipe and 1-1/2 to 2 minutes for pressure pipe. Two minutes set-up time was required between holes. Four holes were cut for each peak sample.

(5) Cutting with hammer, chisel, and rasp. The pipe was cut using a hammer and chisel, and the edges then smoothed with a coarse file (Figures 9 and 10). The helper rotated the pipe as the operator worked. Two cuts of sewer pipe, each taking 4 to 6 minutes, were made during the short-term or peak sampling period. Cutting the pressure pipe lasted 11 minutes, and only one cut was made per sample.

A single test of the Wheeler Chain Cutter (Model 2990) was made. Although this alternative equipment for cutting pipe in the field was not included in the original protocol, its availability and potential usefulness justified a limited trial. It has cutting discs mounted on a chain, which is wrapped around the pipe (Figures 11 and 12). Its action is controlled hydraulically by an operator who could be as far as 10 to 15 feet from the pipe being cut. Set-up and cutting required 2 to 3 minutes. This was tested once on sewer pipe and once on pressure pipe.

Another cutting device, manually operated, was given a single test during the preliminary survey. This, the Pilot Model 4 Pipe Cutter (Figure 13), applies a circumferential cutting action from the pressure of rotating sharpened discs. The tool is rotated around the pipe and pressure is applied by means of handles. The tool can be set up and the cut completed in 2 to 3 minutes. This was tested only once, during the preliminary survey.

RESULTS

Preliminary Survey

The data obtained during the preliminary survey are summarized in Table 1. The asbestos concentrations that were recorded indicated that the air sampling procedures yielded reasonable values for the proposed operations. They also showed the comparatively high asbestos dust production during the abrasive disc operation, a practice not recommended by the A/C pipe industry unless workers are provided with NIOSH approved respirators. The integrated exposure to the operator during an hour's performance of four representative procedures was 4.3 fibers/cc. The integrated area sample showed 2.9 fibers/cc and 16.8 mg/m^3 of total dust.

Main Survey

The operator's "peak" exposures to asbestos during each operation involving sewer pipe and pressure pipe are summarized in Table 2. The conspicuously high concentrations during use of the abrasive disc are apparent.

Table 3 similarly shows the peak exposures of the helper, with the abrasive disc operation again producing high concentrations of airborne asbestos.

Table 4 summarizes the integrated exposures of the operator and helper as they performed several operations in sequence. Area integrated samples during the same operations are also shown. Background levels measured at the beginning and end of each day are included in the table.

Table 5 presents data on total dust, obtained at a distance of 5 to 10 feet, during each of the cutting and machining operations. An unusually high concentration of total dust during the hand lathe operation, using sewer pipe, was not compatible with the industrial hygienist's impression of total dustiness. It was a single determination which cannot be explained.

Table 6 provides a general summary of the average exposures of operator and helper during the operations, and integrated exposures during successive operations, both for operator, helper, and in the area.

Tables 7A, 7B, and 7C show the distribution of time for successive operations which were performed during the collection of the integrated samples.

Representative fibers seen in microscopic examinations of the samples are shown in Figures 14, 15, 16, and 17.

DISCUSSION

Background levels. As expected, the background fiber concentrations which were recorded in the range of 0.01 to 0.02 fibers/cc are near the limit of sensitivity for the volumes of air and the methods employed in this study. They represent approximate values, which indicate very low concentrations. The numbers of fibers found are similar to those found by EEH in previous studies.

Short term or peak exposures. The most notable finding was the high concentration of airborne asbestos produced by cutting with the abrasive disc. The peak personal samples for the operator and helper during this operation ranged from two to six times the current OSHA ceiling standard of 10 fibers/cc and from four to twelve times the proposed ceiling standard of 5 fibers/cc. The helper's exposure was higher, explained by the fact that the rapidly rotating blade of the saw propelled the dust away from the tool and the operator, and often this was directed toward the helper.

None of the other cutting and machining operations produced peak asbestos fiber concentrations which exceeded the most restrictive currently proposed ceiling concentration, i.e. 5 fiber/cc.

A pipe cutter (Wheeler) not included in the basic protocol was used for a single operation with sewer pipe and pressure pipe and yielded peak concentrations well below ceiling levels, for both operator and helper.

Integrated personal exposures. The integrated personal samples represented the exposures of operator and helper over a period of about half a work day. During the first morning of the study, sewer pipe was cut and machined using all tools except the abrasive disc. The operator's integrated exposure over a period of about three hours was 0.09 fibers/cc, and that of the helper was 0.10 fibers/cc. It is obvious that such operations could be continued through an 8-hour working day without exceeding the present TWA of 2.0 fibers/cc, the proposed TWA of 0.5 fibers/cc, or even the stringent NIOSH recommendation of 0.1 fibers/cc.

When essentially similar operations were carried out on pressure pipe for three hours on the second day, the integrated sample for the operator was 0.75 fibers/cc and that of the helper 0.17 fibers/cc. While such operations continued through an 8-hour work day would comply with the current standard of 2 fibers/cc, modifications in work practices or other controls would be needed to ensure compliance with a standard requiring a TWA below 0.5 fibers/cc.

When integrated samples were collected covering the periods when abrasive disc cutting was carried out on sewer and pressure pipe (in addition to chisel and rasp use during the same period), the high dust concentrations produced by the abrasive disc led to integrated exposures for a two-hour period of 3.94 fibers/cc for the operator and 7.07 fibers/cc for the helper. An operator carrying out such work for over 4 hours in an 8-hour day would exceed the 2 fibers/cc standard; one hour of such activity in a day would exceed the 0.5 fibers/cc proposed standard. Similarly, the helper would be in excess of the standard with 2-1/2 hours of such activity per day, while slightly over one-half hour of work would cause him to exceed the 0.5 fibers/cc proposed standard. All of the foregoing calculations presuppose zero exposure during the remaining work day.

It is obvious from the foregoing that without modification, ventilation or engineering control, the abrasive disc cutter produces unacceptable concentrations of airborne asbestos. Its use in cutting A/C pressure or sewer pipe would appear to be in violation of the current OSHA standard, 29 CFR 1910.1001 (c)(1)(iii) which requires that all hand-operated and power-operated tools which may produce or release asbestos fibers in excess of prescribed exposure limits shall be provided with local exhaust ventilation.

Integrated area samples. These represented the possible exposure of a person working about 15 feet from the cutting or machining operation; one who might be in a trade different from that of the operator or his helper. The fiber counts were in reasonable agreement with those of the personal integrated samples. During sewer pipe operations, they were extremely low and did not suggest any potential hazard. For pressure pipe operations, the three-hour value of 0.44 fibers/cc with no abrasive disc operations included was below the current TWA of 2 fibers/cc, even if continued for 8 hours. It provided little margin of safety for an

0.5 fiber/cc standard, however.

The area integrated sample during abrasive disc operation, 4.90 fibers/cc, illustrated again the potential hazard of this operation, since workers 15 feet away were subject to concentrations well in excess of the present occupational TWA.

Total dust concentrations. Estimations were made of the concentrations of all airborne dust, i.e. asbestos + cement + all other particulates, during the various operations. Because the composition of the dust was not determined in terms of free silica, the potential hazard from the concentrations found cannot be evaluated. The present OSHA standard for total dust, even if regarded as inert, is 15 mg/m^3. If it contains crystalline silica (quartz) the permissible TWA is 30 mg/m^3 divided by (the % of silica + 2). For example, if there were 10% quartz in the dust, the permissible TWA would be 2.5 mg/m^3. Review of Table 5 shows several operations which produce concentrations of total dust which if long continued would be approaching the silica standard, if the airborne quartz content were sufficiently high.

Housekeeping needs. During the tests it was observed that considerable amounts of particulate waste and scrap material resulted from the cutting and machining operations. Photographs illustrate this well. In view of the asbestos content, rigorous housekeeping would be necessary, with proper storage and disposal of wastes.

CONCLUSIONS

The use of the abrasive disc saw on A/C sewer pipe and pressure pipe produced high concentrations of airborne asbestos fibers. The peak concentrations in the breathing zone of the saw operator and his helper greatly exceeded the current OSHA standard for short-term or peak exposures. Use of this tool without an exhaust ventilation system would appear to be a violation of current standards. When this tool is used for an appreciable part of the work cycle, it can also result in a time-weighted average (TWA) exposure for the work-day exceeding the current OSHA TWA limit of 2 fibers/cc.

The exposures of the operator and helper during field cutting and machining operations using the manual lathe, power lathe, hole cutter, and hammer, chisel and rasp, indicate peak exposures substantially less than the current OSHA ceiling of 10 fibers/cc and the proposed ceiling of 5 fibers/cc. Limited tests of the Pilot and the Wheeler cutting tools indicated that these also produced ceiling concentrations below current and proposed standards.

It is improbable that field personnel would be exposed throughout a working day to the intensive cutting and machining operations which were set up for the purpose of this study. It is believed therefore that current and proposed occupational standards could be met with available equipment, provided that the abrasive disc saw was eliminated or otherwise modified to reduce dust production to acceptable levels. Until such elimination or modification, saw operators and helpers should be required to wear respirators approved by NIOSH for protection against dust.

Good housekeeping and proper waste disposal would be an essential part of industrial hygiene measures needed during the cutting and machining of A/C pipe.

ACKNOWLEDGEMENTS

We wish to express our appreciation to Mr. J. R. Rawlins of the Pilot Manufacturing Company of Torrance, California, who made arrangements for a satisfactory location to carry out the study and also made appropriate tools available and instructed our staff on their use.

Table 1

Data Obtained in Preliminary Survey of Cutting and Machining Operations on A/C Sewer Pipe

Operation Sampled	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Operator Peak Fibers/ML Air	Integrated Exposure Fibers/ML Air	Total Dust mg/m^3
Abrasive disc	3	8	14.9	14.7		
Pilot pipe cutter*	5	10	18.6	0.086		
Manual lathe	6	15	27.9	0.12		
Power lathe	7	17	31.6	.05		
Operator integrated	4	57	113		4.3	
Area integrated	2	58	109		2.9	
Total dust	101	58	105			16.8

special tool not included in main survey protocol.

te: Background sample taken for 49 minutes before pipe cutting began contained 0.017 fibers/ml air.

Table 2

Operator's Peak Exposures to Asbestos

Tool used for Cutting or Machining	A/C Sewer Pipe				A/C Pressure Pipe			
	1	2	3	4	5	6	7	8
	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Fibers per ML of Air	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Fibers per ML of Air
Manual lathe	19 20 23	11 11 9	21.9 21.9 17.9	0.22 0.14 0.09 av. 0.15	72 75 76	13 12 20	24.2 22.3 37.2	0.72 0.64 0.17 av. 0.51
Power lathe	5 8 11	13 14 14	25.6 27.9 27.9	0.12 <.06 .06 av. 0.08	55 59 61	20 17 15	37.2 31.6 27.9	0.34 0.09 0.57 av. 0.33
Power hole cutter	13 15 17	11 15 14	21.9 29.8 27.6	0.51 0.69 0.11 av. 0.44	63 65 68	18 14 18	33.5 26.0 33.5	1.47 1.82 1.66 av. 1.65
Abrasive disc	36 38 40	4 5 4	8.0 9.9 8.0	16.7 40.4 49.3 av. 35.5	41 43 45	7 5 7	13.9 9.9 13.9	19.8 23.9 17.1 av. 20.3
Chisel and rasp	27 30 34	14 11 9	27.9 21.9 17.9	0.23 0.22 0.44 av..30	47 49 51	12 14 10	23.9 27.9 19.9	3.71 1.70 0.56 av. 1.99
Wheeler pipe cutter	24	14	27.9	<.06	70	4	7.4	0.85

Table 3

Helper's Peak Exposures To Asbestos

Tool used for Cutting or Machining	A/C Sewer Pipe				A/C Pressure Pipe			
	1 Sample No.	2 Duration (Min.)	3 Vol. of Air Sampled (Liters)	4 Fibers per ML of Air	5 Sample No.	6 Duration (Min.)	7 Vol. of Air Sampled (Liters)	8 Fibers per ML of Air
Manual lathe	18 21 22	12 12 10	23.9 23.9 19.9	0.13 0.07 0.20 av. 0.13	73 74 77	16 12 20	29.0 21.7 36.2	0.55 <0.07 0.04 av. 0.22
Power lathe	2 7 10	14 15 16	27.9 29.8 31.8	0.06 0.16 <0.05 av. 0.09	57 60 62	18 18 14	32.6 32.6 25.3	0.55 0.39 0.75 av. 0.56
Power hole cutter	12 14 16	11 14 13	21.9 27.9 25.9	0.29 0.28 0.12 av. 0.23	64 66 69	18 14 19	32.6 25.3 34.4	0.29 0.44 0.41 av. 0.38
Abrasive disc	35 37 39	4 5 5	8.0 9.9 9.9	58.2 52.6 81.2 av. 64.0	42 44 46	5 5 7	9.9 9.9 13.9	62.0 62.0 55.2 av. 59.7
Chisel and rasp	26 28 33	14 12 10	27.9 23.9 19.9	<0.06 0.13 0.56 av. 0.25	48 50 52	11 14 11	21.9 27.9 21.9	1.37 0.40 0.94 av. 0.90
Wheeler pipe cutter	25	13	25.9	<0.06	71	5	9.0	0.87

Table 4.1

Asbestos Levels in Operator, Helper and Area Integrated Samples and in Background Samples

Operations	Operator Integrated Sample				Helper Integrated Sample				Area Integrated Sample			
	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Fibers per ML of Air	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Fibers per ML of Air	Sample No.	Duration (Min.)	Vol. of Air Sampled (Liters)	Fibers per ML of Air
. 8, a.m. Sewer ipe: power lathe, le cutter, nual lathe, isel and rasp.	4	184	366	0.09	3	181	246	0.10	6	184	342	0.04
. 8, p.m. Sewer pe: chisel and sp, abrasive disc essure pipe: abrasive disc chisel and rasp.	31	112	221	3.94	29	113	154	7.07	32	115	214	4.90
. 9, a.m. essure pipe: wer lathe, le cutter, nual lathe.	54	182	248	0.75	56	185	368	0.17	58	194	386	0.44
ground, b. 8, a.m.	1	97	175	0.01								
ground, b. 8, p.m.	53	83	150	0.02								
ground, b. 9, a.m.	67	68	135	0.01								
ground, b. 9, p.m.	78	130	259	<0.01								

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Table 5

Total Dust From Cutting and Machining Operations

Tool used for Cutting or Machining	A/C Sewer Pipe				A/C Pressure Pipe			
	1 Sample No.	2 Duration (Min.)	3 Vol. of Air Sampled (Liters)	4 Total Dust (mg/m^3)	5 Sample No.	6 Duration (Min.)	7 Vol. of Air Sampled (Liters)	8 Total Dust (mg/m^3)
Manual lathe	104	37	67.0	51.5*	113	51	95.9	8.13
Power lathe	102	53	95.9	5.74	110	57	107	2.99
Power hole cutter	103	42	76.0	1.84	111	50	94.0	0.21
Abrasive disc	107	19	34.4	37.5	108	13	23.5	34.0
Chisel and rasp	106	39	70.6	<0.1	109	42	76.0	2.89

*This single value was much greater than would have been expected from the apparent dustiness of the operation - we have no explanation.

Summary of Data Obtained in Survey of A/C Pipe Cutting and Machining Operations

Type of A/C Pipe	Tool In Operation	Operator's Exposure Fibers/cc Air		Helper's Exposure Fibers/cc Air		Area Integrated Fibers/cc Air	Total Dust mg/m^3	Background* Fibers/cc Air
		Peak	Integrated	Peak	Integrated			
Sewer pipe	Power lathe	av.08		av.09			5.74	0.1
	Hole cutter	av.44	0.09	av.23	0.10	0.04	1.84	
	Manual lathe	av.15		av.13			51.5	
	Wheeler cutter	<0.06		<0.06			29.0	
	Chisel and rasp	av.30		av.25			<0.1	
	Abrasive disc	av35.5		av64.0			37.5	
ressure pipe	Abrasive disc	av20.3	3.94	av59.7	7.07	4.90	34.0	
	Chisel and rasp	av1.99		av.90			2.89	0.02
	Power lathe	av.33		av.56			2.99	0.1
	Hole cutter	av1.65	0.75	av.38	0.17	0.44	0.21	
	Wheeler cutter	0.85		0.87			<0.1	
	Manual lathe	av.51		av.22			8.13	<0.1

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er concentrations in these ~~rasps~~ tests are only approximate and indicate only that the background was extremely low.

Table 7A

Distribution of Time for Successive Operations
During Integrated Samples

-February 8, A.M.-

Operator Integrated Sample	184 minutes	0.09 fibers/cc
Helper Integrated Sample	181 minutes	0.10 fibers/cc
Area Integrated Sample	184 minutes	0.04 fibers/cc

POWER LATHE sewer pipe Average of 3 peak samples operator 0.08 f/cc helper 0.09 f/cc	SET UP	HOLE CUTTER sewer pipe Average of 3 peak samples operator 0.44 f/cc helper 0.23 f/cc	SET UP	MANUAL LATHE sewer pipe Average of 3 peak samples operator 0.15 f/cc helper 0.13 f/cc	SET UP	WHEELER CUTTER sewer pipe Single Sample operator 0.15 f/cc helper 0.13 f/cc	SET UP	CHISEL & RASP sewer pipe Single Sample operator 0.23 f/cc helper <0.06 f/cc
← 52 min →	5 min	← 42 min →	5 min	← 36 min →	7 min	←14 min→	8 min	←14 min→

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TABLE 7B

Distribution of Time for Successive Operations
During Integrated Samples

-February 8, P.M.-

Operator Integrated Sample	112 minutes	3.94 fibers/cc
Helper Integrated Sample	113 minutes	7.07 fibers/cc
Area Integrated Sample	115 minutes	4.90 fibers/cc

CHISEL & RASP sewer pipe	SET UP	ABRASIVE DISC sewer pipe	SET UP	ABRASIVE DISC pressure pipe	SET UP	CHISEL & RASP pressure pipe
Average of 2 peak samples		Average of 3 peak samples		Average of 3 peak samples		Average of 3 peak samples
operator 0.33 f/cc		operator 35.5 f/cc		operator 20.3 f/cc		operator 1.99 f/cc
helper 0.35 f/cc		helper 64.0 f/cc		helper 59.7 f/cc		helper 0.90 f/cc
23 min	5 min	17 min	7 min	21 min	4 min	38 min

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Distribution of Time for Successive Operations
During Integrated Samples
-February 9, A.M.-

Operator Integrated Sample		182 minutes				0.75 fibers/cc
Helper Integrated Sample		185 minutes				0.17 fibers/cc
Area Integrated Sample		194 minutes				0.44 fibers/cc
POWER LATHE pressure pipe Average of 3 peak samples operator 0.33 f/cc helper 0.56 f/cc	SET UP	HOLE CUTTER pressure pipe Average of 3 peak samples operator 1.65 f/cc helper 0.38 f/cc	SET UP	WHEELER CUTTER	SET UP	MANUAL LATHE pressure pipe Average of 3 peak samples operator 0.51 f/cc helper 0.22 f/cc single sample operator 0.85 f/cc helper 0.87 f/cc
58 min	3 min	51 min	5 min	5 min	9 min	49 min

FIGURE 1. Changing filters on personal samplers.

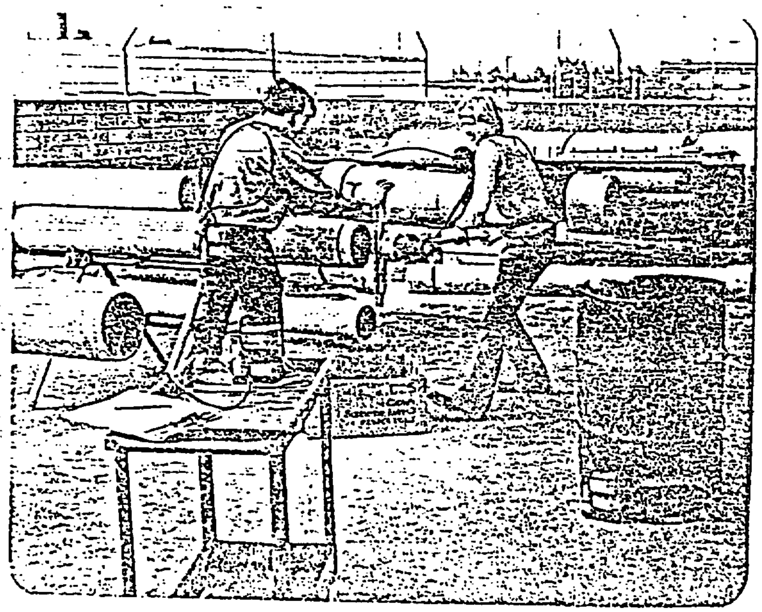

FIGURE 2. Conducting a typical test. Area sampler for fiber concentrations on cart, area sampler for total dust on drum.

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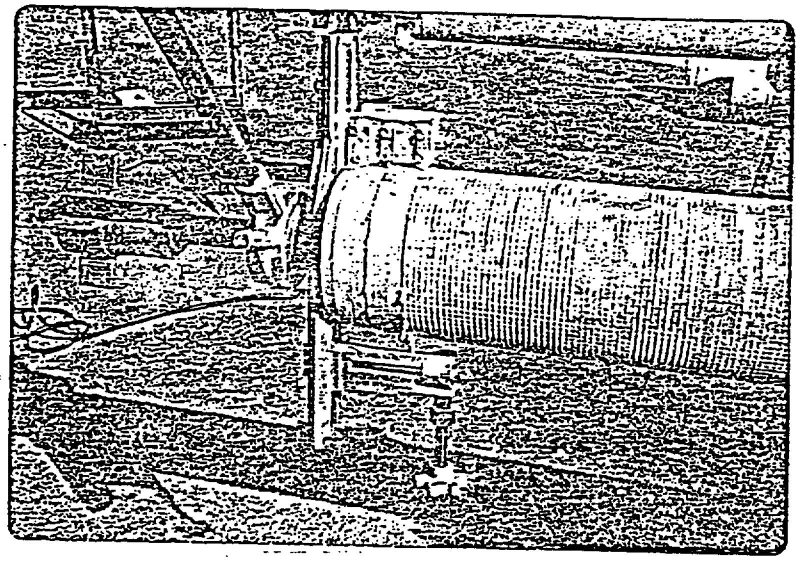


FIGURE 3. Manual field lathe.

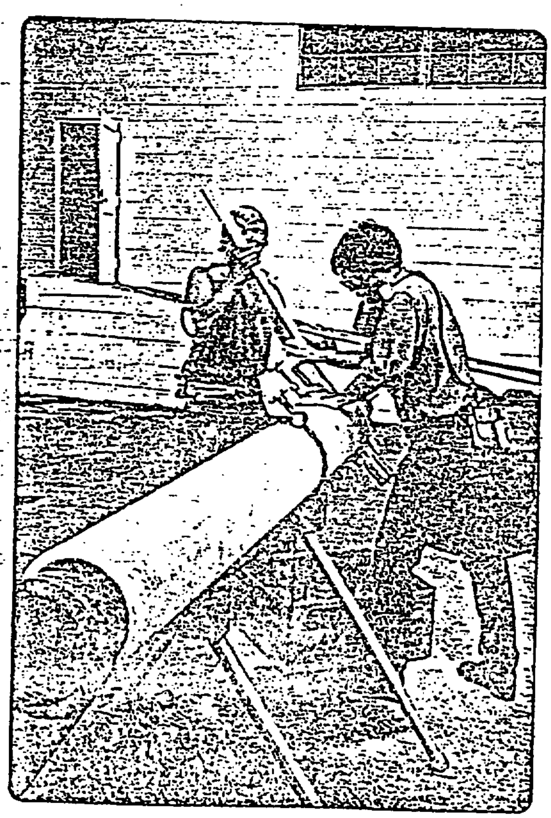


FIGURE 4. Operating manual field lathe.

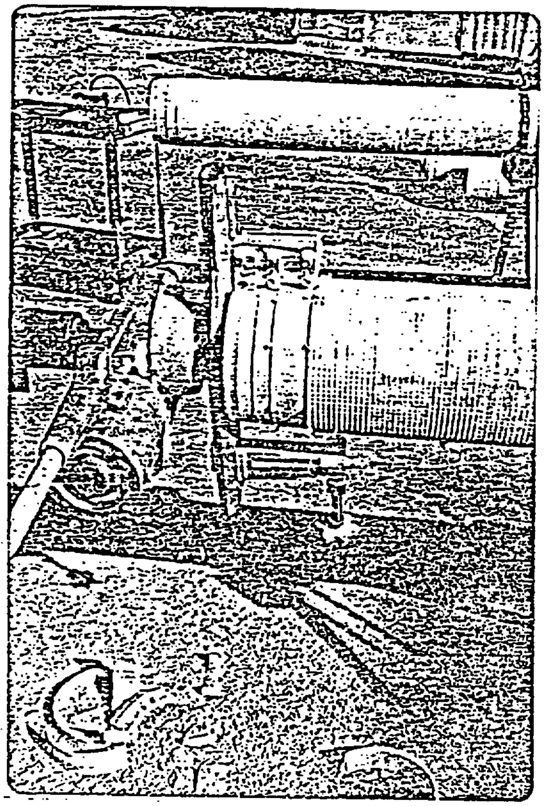


FIGURE 5. Powered field lathe.

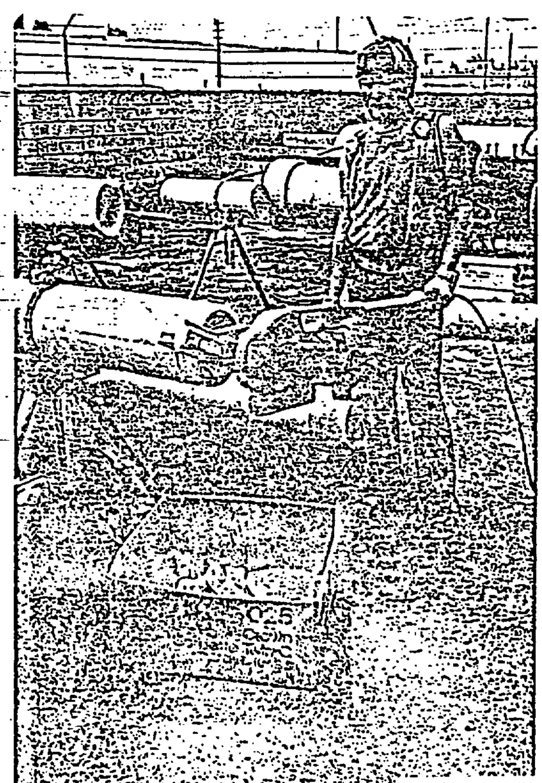
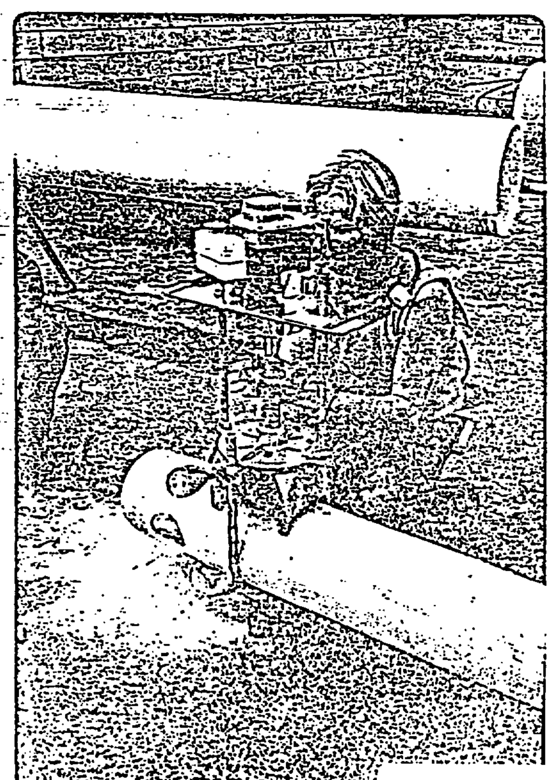


FIGURE 6. Operating powered field lathe.

FIGURE 7. Operating abrasive disc saw.

FIGURE 8. Power hole cutter.



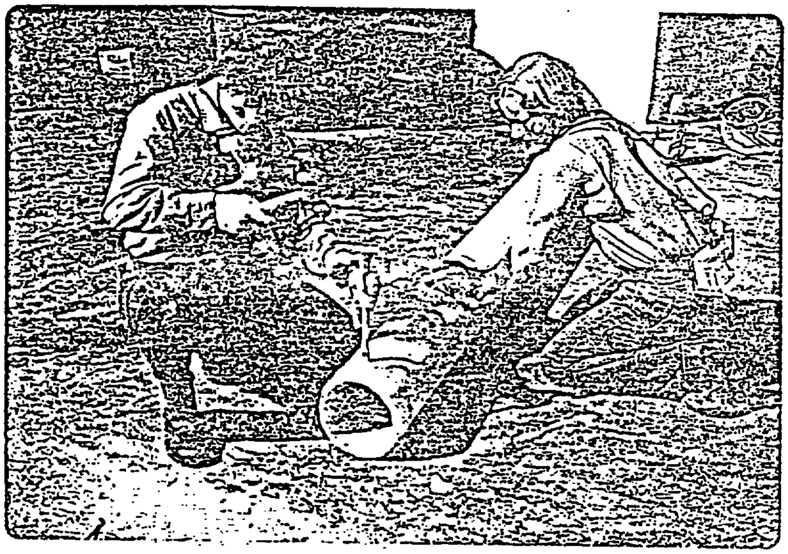


FIGURE 9. Cutting pipe with hammer and chisel.

FIGURE 10. Rasping end of cut pipe.

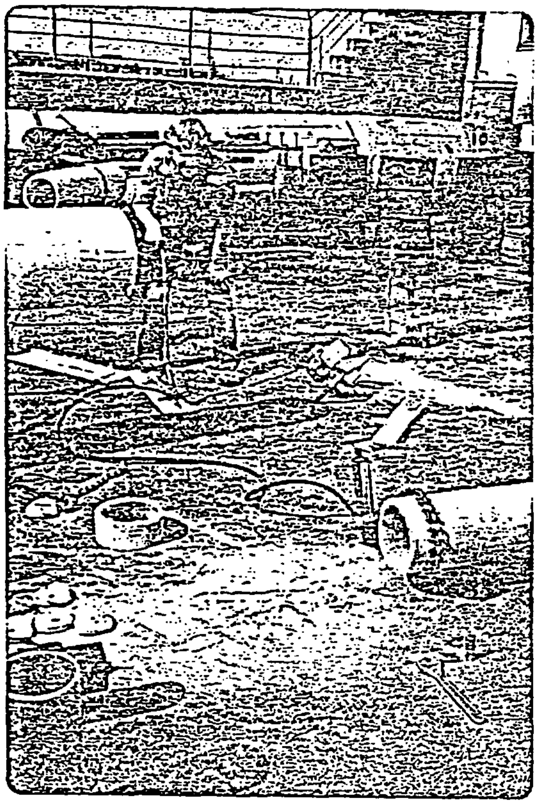


FIGURE 11. Operating Wheeler pipe cutter, beginning of cut.

FIGURE 12. Operating Wheeler pipe cutter, end of cut.

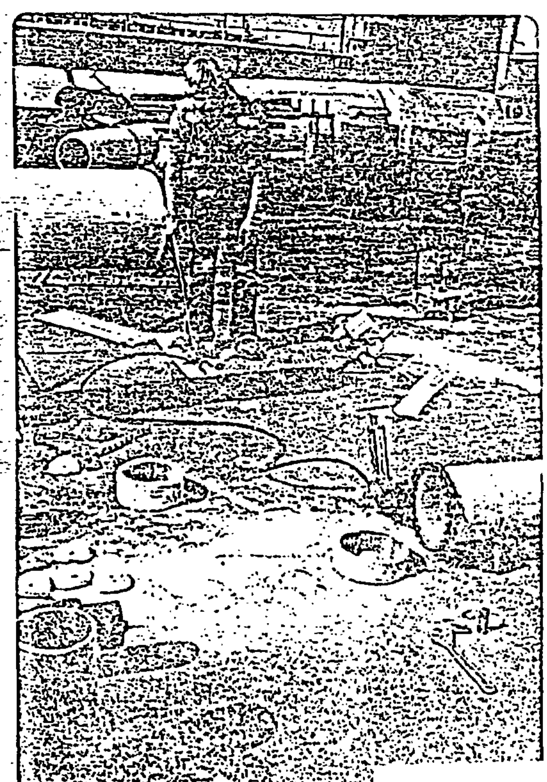


FIGURE 13. Pilot pipe cutter in operation.

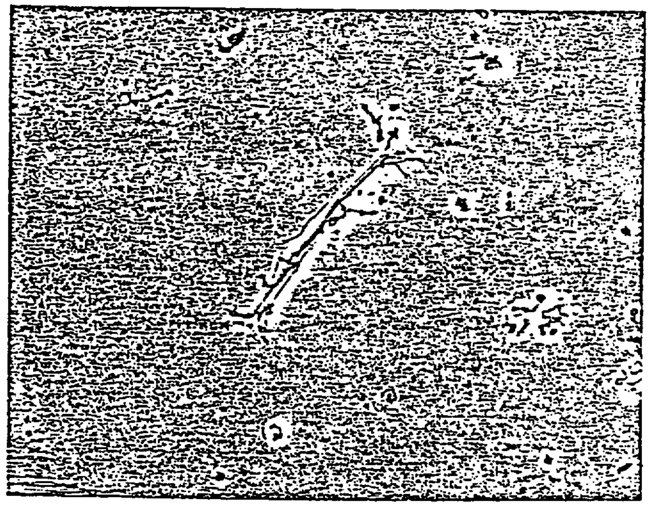


FIGURE 14. Chrysotile fiber bundle, abrasive disc cutting of pressure pipe.

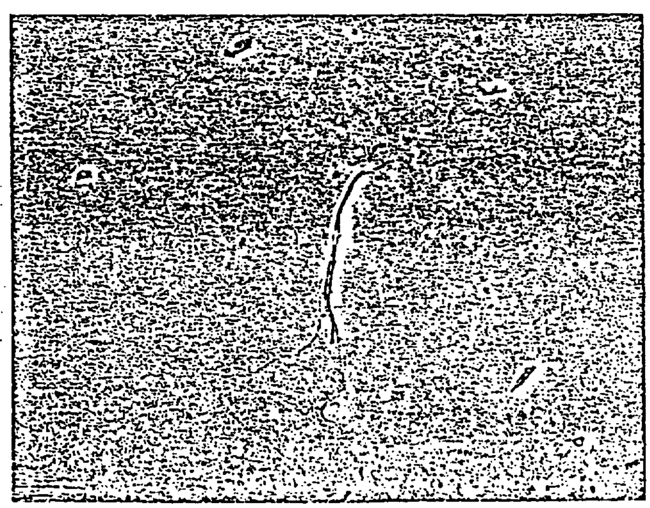


FIGURE 15. Chrysotile fiber, power lathe operation, pressure pipe.

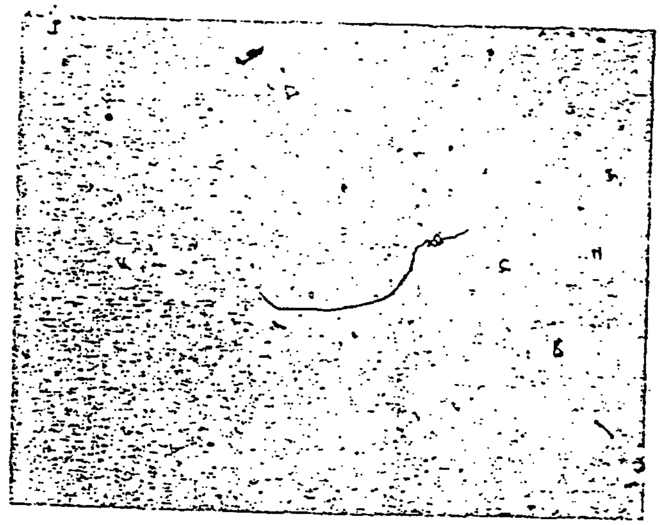


FIGURE 16. Chrysotile fiber from area integrated sample, pressure pipe.

FIGURE 17. Field from helper's integrated sample, both types of pipe.