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Dust Control

ASBESTOS EXPOSURES DURING THE CUTTING AND MACHINING OF ASBESTOS CEMENT PIPE

Prepared for

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PRODUCED
JM - 83

ASBESTOS EXPOSURES DURING THE CUTTING AND MACHINING OF ASBESTOS CEMENT PIPE

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Equitable Environmental Health, Inc.
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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 incor-

PRODUCED
JM - 83

porated 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

PRODUCED
JM - 83

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

PRODUCED
JM - 83

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 suffici

PRODUCED
JM - 83

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

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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 8-12P) 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

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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,

PRODUCED
JM - 83

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

PRODUCED
JM - 83

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

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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

*A special tool not included in main survey protocol.

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

PRODUCED
JM - 83

Table 2

Operator'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	19	11	21.9	0.22	72	13	24.2	0.72
	20	11	21.9	0.14	75	12	22.3	0.64
	23	9	17.9	0.09	76	20	37.2	0.17
				av. 0.15				av. 0.51
Power lathe	5	13	25.6	0.12	55	20	37.2	0.34
	8	14	27.9	<.06	59	17	31.6	0.09
	11	14	27.9	.06	61	15	27.9	0.57
				av. 0.08				av. 0.33
Power hole cutter	13	11	21.9	0.51	63	18	33.5	1.47
	15	15	29.8	0.69	65	14	26.0	1.82
	17	14	27.6	0.11	68	18	33.5	1.66
				av. 0.44				av. 1.65
Abrasive disc	36	4	8.0	16.7	41	7	13.9	19.8
	38	5	9.9	40.4	43	5	9.9	23.9
	40	4	8.0	49.3	45	7	13.9	17.1
				av. 35.5				av. 20.3
Chisel and rasp	27	14	27.9	0.23	47	12	23.9	3.71
	30	11	21.9	0.22	49	14	27.9	1.70
	34	9	17.9	0.44	51	10	19.9	0.56
				av..30				av. 1.99
Wheeler pipe cutter	24	14	27.9	<.06	70	4	7.4	0.85

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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	12	23.9	0.13	73	16	29.0	0.55
	21	12	23.9	0.07	74	12	21.7	<0.07
	22	10	19.9	0.20	77	20	36.2	0.04
				av. 0.13				av. 0.22
Power lathe	2	14	27.9	0.06	57	18	32.6	0.55
	7	15	29.8	0.16	60	18	32.6	0.39
	10	16	31.8	<0.05	62	14	25.3	0.75
				av. 0.09				av. 0.56
Power hole cutter	12	11	21.9	0.29	64	18	32.6	0.29
	14	14	27.9	0.28	66	14	25.3	0.44
	16	13	25.9	0.12	69	19	34.4	0.41
				av. 0.23				av. 0.38
Abrasive disc	35	4	8.0	58.2	42	5	9.9	62.0
	37	5	9.9	52.6	44	5	9.9	62.0
	39	5	9.9	81.2	46	7	13.9	55.2
				av. 64.0				av. 59.7
Chisel and rasp	26	14	27.9	<0.06	48	11	21.9	1.37
	28	12	23.9	0.13	50	14	27.9	0.40
	33	10	19.9	0.56	52	11	21.9	0.94
				av. 0.25				av. 0.90
Wheeler pipe cutter	25	13	25.9	<0.06	71	5	9.0	0.87

PRODUCED
JM - 83

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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
Feb. 8, a.m. Sewer pipe: power lathe, hole cutter, manual lathe, chisel and rasp.	4	184	366	0.09	3	181	246	0.10	6	184	342	0.04
Feb. 8, p.m. Sewer pipe: chisel and rasp, abrasive disc Pressure pipe: abrasive disc chisel and rasp.	31	112	221	3.94	29	113	154	7.07	32	115	214	4.90
Feb. 9, a.m. Pressure pipe: power lathe, hole cutter, manual lathe.	54	182	248	0.75	56	185	368	0.17	58	194	386	0.44
Background, Feb. 8, a.m.	1	97	175	0.01								
Background, Feb. 8, p.m.	53	83	150	0.02								
Background, Feb. 9, a.m.	67	68	135	0.01								
Background, Feb. 9, p.m.	78	130	259	<0.01								

PRODUCED
JM - 83

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.

PRODUCED
JM - 83

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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	
Pressure 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

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

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JM - 83

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	SET UP	HOLE CUTTER sewer pipe	SET UP	MANUAL LATHE sewer pipe	SET UP	WHEELER CUTTER sewer pipe	SET UP	CHISEL & RASP sewer pipe
Average of 3 peak samples		Average of 3 peak samples		Average of 3 peak samples		Single Sample		Single Sample
operator 0.08 f/cc		operator 0.44 f/cc		operator 0.15 f/cc		operator 0.15 f/cc		operator 0.23 f/cc
helper 0.09 f/cc		helper 0.23 f/cc		helper 0.13 f/cc		helper 0.13 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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JM - 83

TAL /B

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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JM - 83

Table 7C

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	SET UP	HOLE CUTTER pressure pipe	SET UP	WHEELER CUTTER	SET UP	MANUAL LATHE pressure pipe
Average of 3 peak samples		Average of 3 peak samples				Average of 3 peak samples
operator 0.33 f/cc		operator 1.65 f/cc				operator 0.51 f/cc
helper 0.56 f/cc		helper 0.38 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

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FIGURE 1. Changing filters on personal samplers.

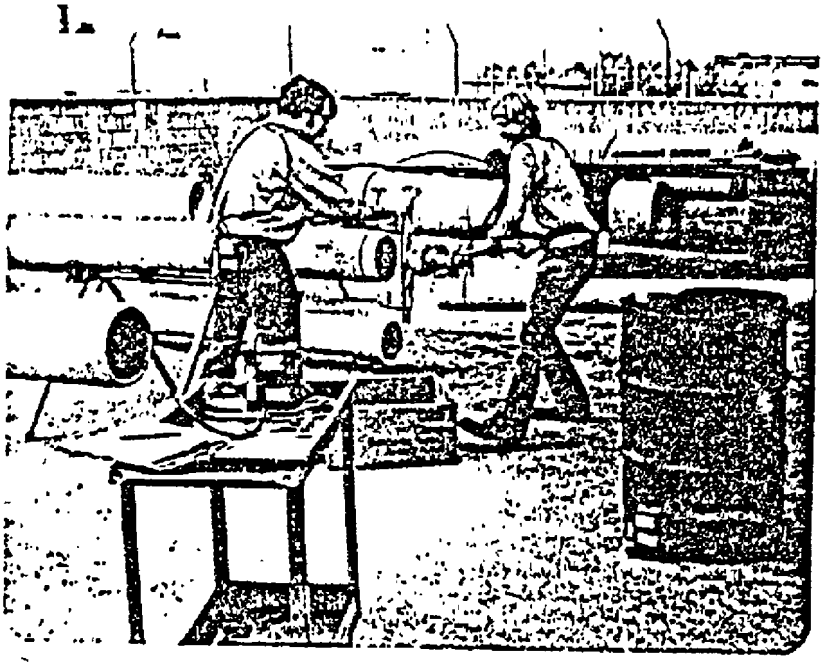


FIGURE 2. Conducting a typical test. Area sampler for fiber concentrations on cart, area sampler for total dust on drum.

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JM - 83

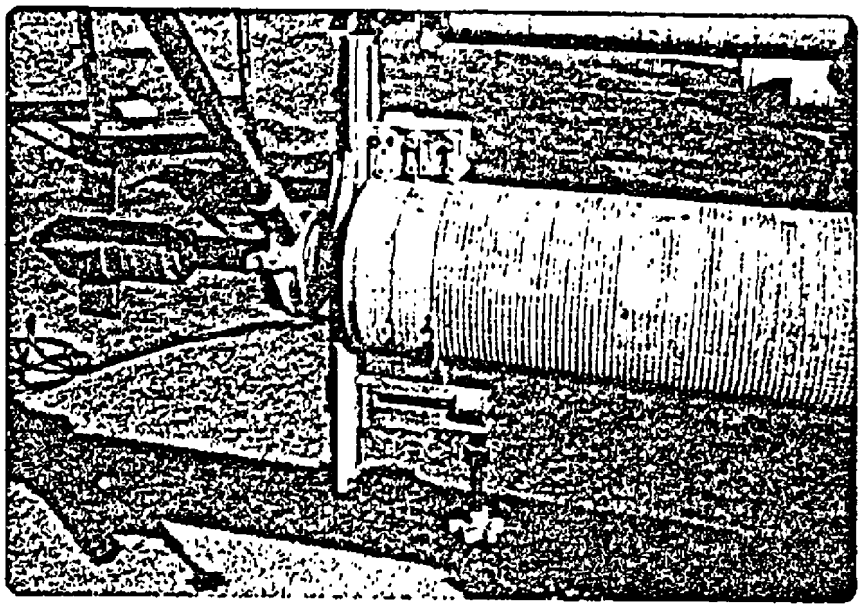


FIGURE 3. Manual field lathe.

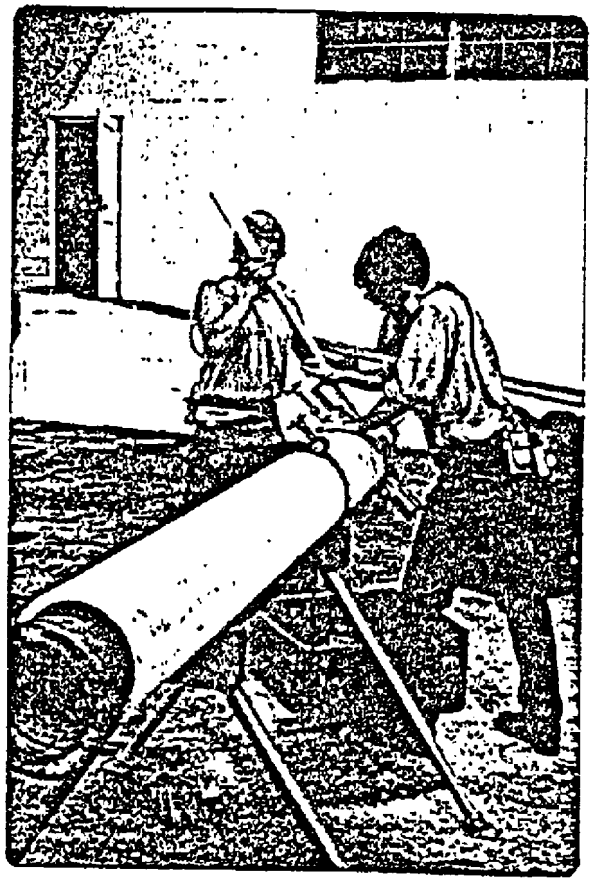


FIGURE 4. Operating manual field lathe.

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JM - 83

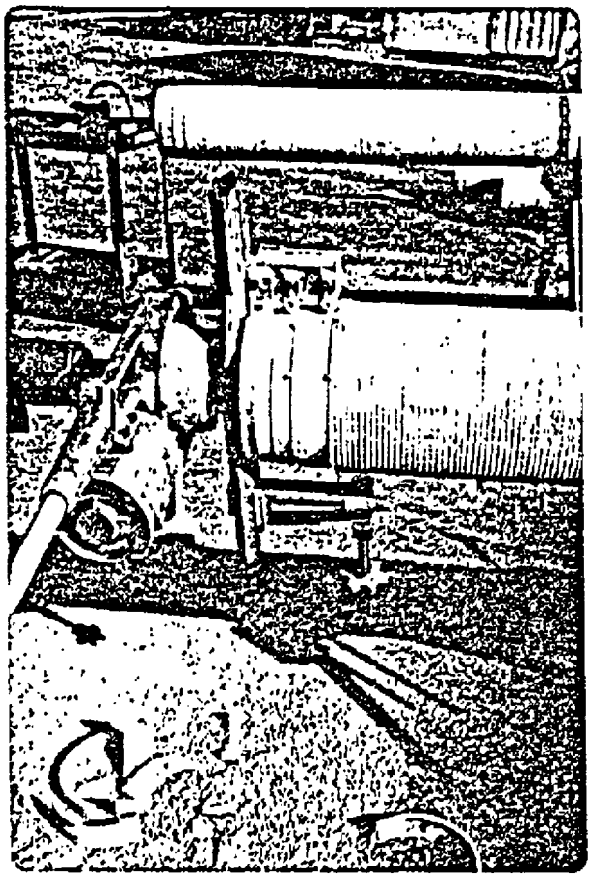


FIGURE 5. Powered field lathe.

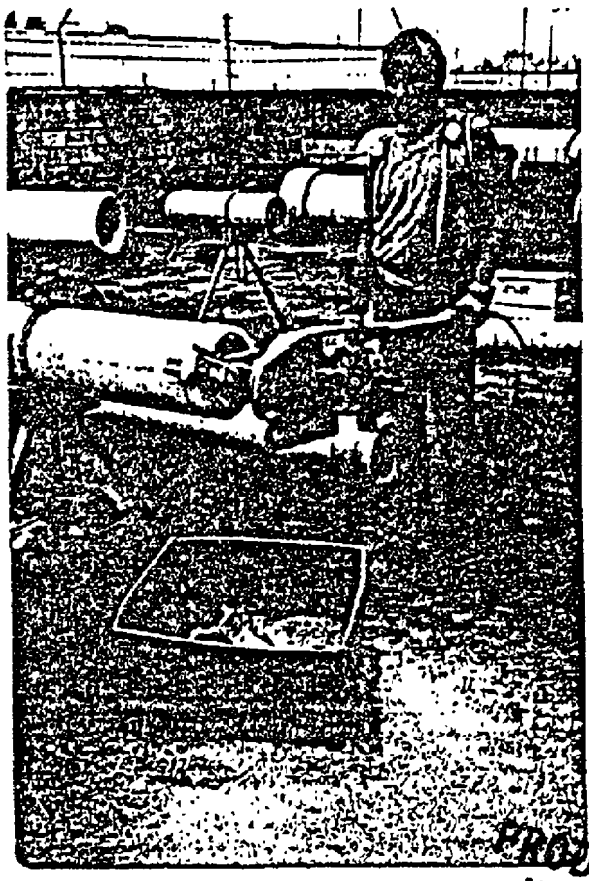


FIGURE 6. Operating powered field lathe.

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JM - 83



FIGURE 7. Operating abrasive disc saw.



FIGURE 8. Power hole cutter.

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83



FIGURE 9. Cutting pipe with hammer and chisel.



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JM - 83

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.

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IN - 83



FIGURE 13. Pilot pipe cutter in operation.

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JM - 83

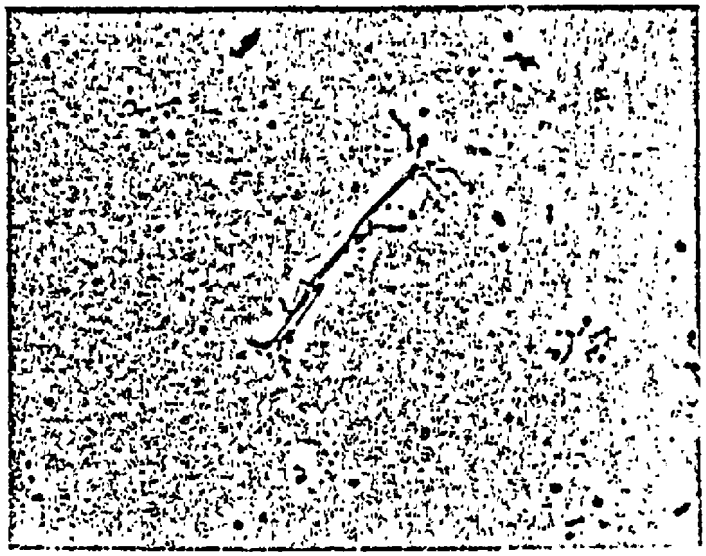


FIGURE 14. Chrysotile fiber bundle, abrasive disc cutting of pressure pipe.

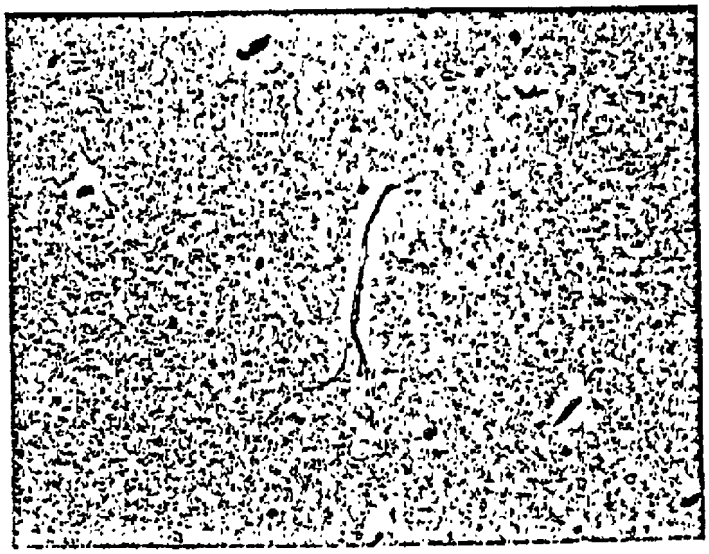


FIGURE 15. Chrysotile fiber, power lathe operation pressure pipe.

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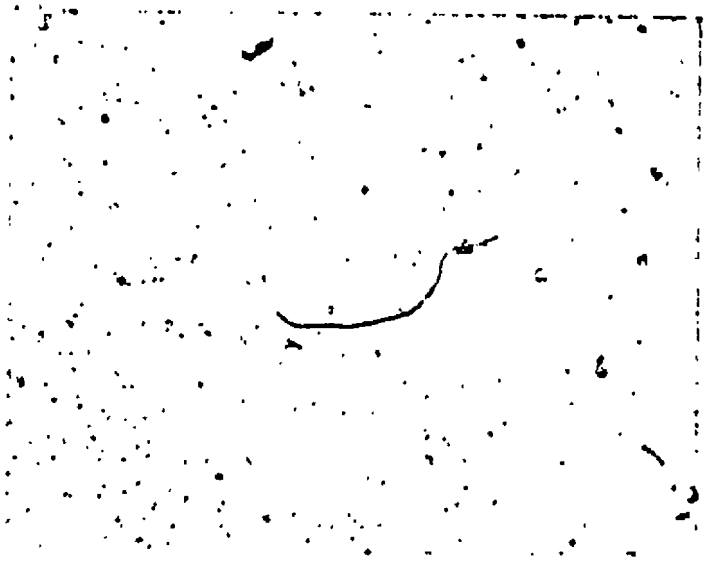


FIGURE 16. Chrysotile fiber from area integrated sample, pressure pipe.

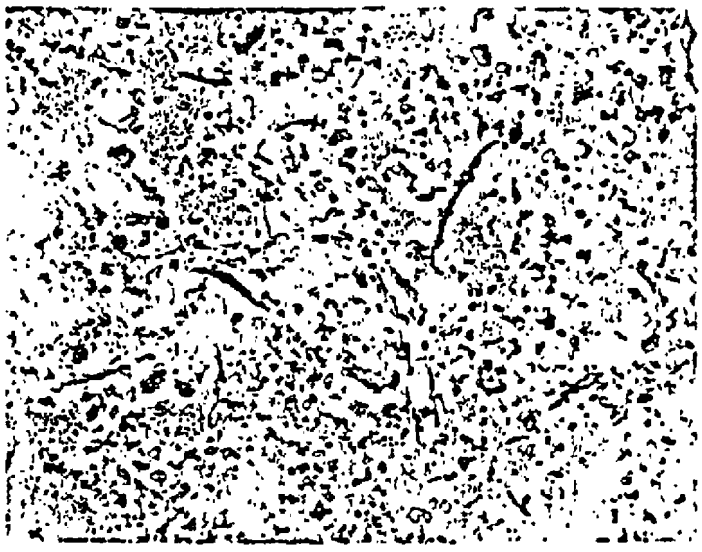


FIGURE 17. Field from helper's integrated sample, [illegible] types of pipe.

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JM - 83

Dust Control
S. Tape

DUST EXPOSURES DURING THE CUTTING AND MACHINING OF ASBESTOS/CEMENT PIPE ADDITIONAL STUDIES

Prepared for

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Prepared by

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December 15, 1977

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JM - 83

INTRODUCTION

On March 16, 1977, Equitable Environmental Health, Inc., submitted a draft report to the A/C Pipe Producers Association which provided quantitative data on dust exposures during field operations in which sewer and pressure pipe were subjected to a number of typical field cutting and machining operations. A final report on the above was completed in July 1977, and the results have been incorporated in recommendations for work practices in the handling of A/C pipe.

On July 12, 1977, the Association requested additional studies of dust exposures involving other field operations. These also included a quantitative estimation of potential exposures to quartz.

STUDY DESIGN & OPERATIONAL PLAN

Determination of airborne asbestos fiber concentrations. Airborne fiber concentrations were determined during the following operations:

(1) Unloading pressure pipe at work site

(2) Laying pressure pipe in trench

(3) Cutting operations

   a. Cutting with manual saw (pressure pipe)

   b. Cutting with snap cutting equipment (pressure and sewer pipe)

   c. Cutting with abrasive disc wet (pressure and sewer pipe)

(4) Machining operations

   a. Cutting and machining with Doty tool (pressure and sewer pipe)

   b. Use of tapering tool (air duct pipe)

   c. Machining differing sizes of pressure pipe (4", 8", and 16") with manual lathe

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JM - 83

(5) Hole cutting

a. Use of drill and rasp (pressure and sewer pipe)

(6) Tapping operations

a. Dry tap with Mueller J (pressure and sewer pipe)

b. Wet tap with Mueller B-100 (pressure and sewer pipe)

(7) Coupling removal (i.e. removing pipe from line)

a. Hammer and chisel (pressure and sewer pipe)

It was not possible to set up a cutting operation with a water-cooled masonry (radial arm) saw, or to remove pipe from a line with a sabre saw.

Determination of quartz. Samples of total and respirable dust integrated over a number of operations were collected and analyzed for quartz.

METHODS

Each operation, when performed in the field, is of short duration compared to an 8-hour workday. Consequently, the OSHA ceiling standard, intended to cover short periods of relatively intense exposure, would be more likely to be exceeded than would be the 8-hour time weighted average (TWA) standard. A sampling period of 15 minutes is regarded as suitable for determining "peak" or ceiling exposures while at the same time obtaining an adequate sample for analysis.

Most of the cutting and machining operations took less than 15 minutes; some required less than a minute. In these cases it was decided to perform the same operation several times during the sampling period. The times will be indicated.

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JM - 83

For each operation, except as otherwise indicated, three replicate short-term breathing zone samples were collected for the operator and for his helper.

Simultaneously, longer-term personal samples were collected on the operator and his helper, over a period of two to three hours and covering more than one type of field operation. Also, integrated area samples were collected at a site approximately 15 feet away and downwind (if there was air movement). Other area samplers located 1 to 5 feet from the field operations were used to collect total dust and respirable dust by weight. Samples used for total dust were changed every 4 hours; those for respirable dust every 8 hours. Three such samples were used to determine quartz content. Background samples were collected before and after each day's operations.

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 in the July, 1977 Report illustrates worker and helper with samplers in place. Figure 2 in the same report shows the test site with area samplers located near the operation.

Asbestos fiber counts were done by an experienced and accredited technician, following OSHA and NIOSH methods. The same technician was employed who had worked in the earlier A/C pipe study. Briefly, the analytic procedure consisted of rendering the filter transparent with a high viscosity solution of membrane filter material in a mixture of diethyloxalate and dimethyl phthalate. The

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JM - 83

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. Fibers which appeared not to be asbestos were noted when seen. 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 wide margin of error, often being based on the observation of very few fibers. For example, in a 15 minute sample, one fiber observed per 100 fields is equivalent to 0.05-0.07 fibers/cc, which is the approximate lower limit of detection for this sampling period. Although counts are reported as calculated, to two decimal places, small differences in counts in these ranges should not be overinterpreted. A zero count merely means that the count was too low for any fibers to be seen in 100 fields and is consistent with a very low concentration of airborne fibers. Samples for gravimetric dust concentrations were weighed in the laboratory of EEH. Quartz analyses were performed by George Clayton Associates.

Performance of study. As in the previous study, all of the operations were carried out on the premises of Pilot Mfg. Co., a manufacturer of A/C pipe equip-

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JM - 83

ment in Torrance, California, except for unloading and placing in trench which were done on a job site in Alameda County, California. A workman experienced in the use of the tools performed the individual operations, with a helper provided by EEH. EEH independently purchased the necessary sewer pipe and pressure pipe for cutting and machining from a local supply house. All pipe was 8 inches in diameter unless otherwise specified. As before, no engineering dust control or local ventilation was utilized, except when this was built into the equipment being used (as was true for some of the tests using the Doty tool, and when wetting was added to the use of the abrasive disc).

GENERAL DESCRIPTION OF OPERATIONS

The study, except for unloading and pipe-laying operations, was carried out during the period October 1-15, 1977. Mrs. Barbara Kawahara was the industrial hygienist, and she was assisted by Mr. Jerry Flanery of the EEH staff. The weather during the period was in general overcast, with clearing skies in mid-morning. Temperatures during the test periods ranged from 16-21° C (60 to 70° F). There was relatively little breeze in the mornings, with gusty breezes up to 5 or 10 mph in the afternoons.

Housekeeping. In order to minimize contamination of the test area with dust and scrap, a commercial vacuum cleaner was brought in to maintain a clean work area. Unfortunately, it was ineffective because of a worn gasket, and blew visible dust from its exhaust. It was necessary to wet down the area periodically and sweep up loose scraps and dust.

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JM - 83

DETAILED DESCRIPTION OF OPERATIONS AND SAMPLING TIMES

(1) Unloading. This was done with a palletized load, using a fork-lift (Figures 1 & 2). The pipe was arranged on 4 foot pallets, 8 per bed, plus miscellaneous short lengths and couplings. It took approximately 15 minutes to unload a two-bed truck. Up until three or four years ago, it had been customary for the pipes to be loaded individually by being rolled down skids. To unload a two-bed truck in this manner took about 2 hours.

For this operation a single 24-minute personal sample was collected on the fork-lift operator while pressure pipe was being unloaded.

(2) Laying pipe in trench. The operation which was studied involved trenching, laying pipe, and filling simultaneously (Figures 3-5). One worker remained in the trench at the forward end of the pipe. The second worker worked both topside and in the trench. He attached a clamp to the pipe, lubricated the end, then got into the trench to help guide it into place for coupling. Two 1-1/2 hour samples were collected by personal samplers placed on the two workers.

(3a) Cutting with manual saw. (Figure 6). Due to the inability to procure an appropriate bow saw blade, a standard hack saw was used with a hardened steel blade. The blade was changed before each run. Sampling times ranged from 12 to 15 minutes, during which time it was possible to cut about one-half way through the 8" pressure pipe. This tool was not used with sewer pipe.

(3b) Cutting with snap cutting equipment. For this portion of the study a Wheeler Chain Cutter (Model 2990) was used. It has cutting discs mounted on a chain which is wrapped around the pipe (Figures 7 & 8). The action is controlled hydraulically by an operator who can stand as far as 10 to 15 feet from the pipe being cut. The set-up between cuts took about two minutes. Pumping to build up pressure required about 15 seconds. Five to 8 cuts were

PRODUCED
JM - 83

made during each sampling period; the average ranged from 14 to 16 minutes for sewer pipe and 13 to 16 minutes for pressure pipe.

(3c) Cutting with abrasive disc, wet. A gasoline-powered abrasive disc saw (Stihl) with a 10-inch carbide blade was used (Figures 9-11). Four 1/4 inch diameter plastic hoses were mounted on the housing of the saw, two on a side as shown in Figure 10, in accordance with TAC Ltd. blueprints provided by AACPP. These were connected to a manifold to which was attached a hose delivering water at a rate of 2 to 3 gallons per minute.

A preliminary run was with a saw that proved to be underpowered, requiring 18 minutes for two cuts. With a more powerful saw (1-1/2 hp motor) a cut could be completed in approximately 1-1/2 minutes. Two to 3 cuts were taken per sample, the sampling periods having been reduced to 3 to 6 minutes after an initial test sampling period of 17 minutes had led to overloading of the filter with dust. This test was run on pressure pipe only.

(4a) Cutting and machining with Doty tool. The Doty tool (Figures 12-15) has two operating stations, one for cutting, and one for machining. It has three operating modes: dry, dry with shroud, and wet with shroud. The last two modifications were to reduce dust generation and dispersion. During tests of the tool in the dry mode with shroud and wet mode with shroud, a plastic bag was placed over the blade to reduce dust (Figure 13).

All cuts were made wet, because a diamond blade is used. A fine spray of water is directed across the blade during operations. About one-half minute is required for a single cut.

Machining was done dry with no shroud, dry with shroud, and wet with shroud. Again for the wet mode, a fine spray was used. Machining took about 1 minute. Most of the sampling time involved moving pipe. Use of the Doty tool is essentially a one-man operation, a helper being needed only to move large pipes.

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JM - 83

Two to four cuts and two to four machine operations were completed per sample cycle. Sampling time was reduced from approximately 15 minutes to approximately 10 minutes for the dry mode because it raised visible dust. It was observed that on the dry mode with shroud tests, visible dust was released during bevelling. It is suggested that a gasket or some other seal would be helpful in preventing this.

Sampling times recorded for the use of the Doty tool, wet, for pressure pipe were 10 to 11 minutes and for sewer pipe 9 to 15 minutes. For use of Doty tool, dry with shroud, with pressure pipe the sampling times were 13 to 17 minutes, and for the sewer pipe 12 to 14 minutes. For the use wet with shroud, 13 to 18 minute sampling times were employed for pressure pipe, 12 to 16 minutes for sewer pipe.

(4b) Use of tapering tool with A/C air duct pipe. Test of the tapering tool (Figure 16) was limited to 10-inch A/C air duct pipe, which has a thickness of approximately 1/4 inch. Its operating principle is similar to that of the manual field lathe. Sampling times ranged from 14 to 22 minutes which included one cut and one tapering operation.

(4c) Machining with manual lathe on differing sizes of pipe. In order to determine whether or not the size of pipe had a detectable influence on dust production, a manual lathing operation was carried out on pressure pipe of 4-inch, 8-inch, and 16-inch diameter (Figures 17 & 18). For the 4-inch pipe there was one cut and one machining for each sample, set-up requiring about 3 minutes, cut requiring about 3 minutes, second set-up about 4 minutes, and machining about 8 minutes, the sampling times for the three replications being 13 to 21 minutes.

For 8-inch pipe, again one cut and one machining was carried out for each sample, the set-up requiring about 3-1/2 minutes, the cut about 2 minutes, second set-up requiring about 2 minutes and machining about 10 minutes. The

PRODUCED
JM - 83

replicate samples ranged from 19 to 21 minutes. For the 16-inch pipe there was one partial cut per sample; each sample included some machining and some cutting. The set-up required 3 minutes, the cutting about 12 minutes, the second set-up about 2 minutes, and machining about 20 minutes.

(5a) Hole cutting with drill and rasp. For this operation (Figures 19-21) 5/8-inch holes were drilled on the pipe in a circular pattern of about 6 inches in diameter, after which the central portion was knocked out with a hammer and the rough edges smoothed with a rasp. The operator used the exhaust air from the drill to blow off excess dust (Figure 22). Although the practice of "blowing" asbestos-cement dust is not recommended, it was used in this instance to duplicate "worst possible" work practices or tool performance characteristics. The drilling took a long time to complete, so that only about 3/4 of the circumference was finished in one sampling period. Therefore, some samples did not include the hammer and file steps. Sampling times for pressure pipe ranged from 16 to 24 minutes, for sewer pipe from 17 to 21 minutes.

(6a) Tapping operations with Mueller J tool. (Figure 23). The Mueller J tool is used for tapping pipes, not pressurized, at the trench top or in the trench. In the latter case, a hole is dug to expose the pipe, but for the test, a pipe which had not been installed was employed. A manually operated tool was used, which cuts a hole and threads it. Two one-inch holes were cut per sampling period. Sampling periods for pressure pipe were 14 to 19 minutes.

(6b) Tapping operations with Mueller B-100 tool. The Mueller B-100 tool (Figure 24) is used for tapping pipes already in line, usually those under pressure. It has a pressure chamber to keep the water from flowing out during the tests. At the recommendation of the local Mueller representative, this chamber was filled with water to simulate "wet" conditions during the tests. There were two holes cut per sampling period; the sampling times were 14 to 19 minutes.

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JM - 83

(7a) Removal of coupling with hammer and chisel. For pressure pipe, a hammer and chisel were used to make a longitudinal trough in the coupling (Figure 25). When this had been completed, a crowbar was used to separate the coupling. For pressure pipe this took about 22 minutes, one coupling being removed per sample. With sewer pipe, the same procedure took about 10 minutes per sample. It was soon found that by placing the chisel midline on the coupling, one or two sharp hits would split the coupling, a procedure which took only 10-30 seconds per coupling. For sewer pipe, 3 to 4 couplings were cut per sample, the major portion of the sampling time being during moving pipe and securing it to supports.

Order of tests. Availability of equipment and efficient use of pipe and manpower led to the actual tests being carried out in an order different from that summarized in the foregoing outline. The order of testing was as follows:

Monday, October 10, 1977

Cutting with snap cutting equipment, pressure pipe (3b)
Cutting with hack saw, pressure pipe (3a)
Machining with manual lathe, 8-inch pressure pipe (5c)
Machining with manual lathe, 4-inch pressure pipe (5c)
Machining with manual lathe, 16-inch pressure pipe (5c)
Hole cutting with drill and rasp, pressure pipe (5a)

Tuesday, October 11, 1977

Coupling removal, hammer and chisel, pressure pipe (7a)
Tap with Mueller J, pressure pipe (6a)
Tap with Mueller B-100, pressure pipe (6b)
Tap with Mueller B-100, sewer pipe (6b)
Tap with Mueller J, sewer pipe (6a)
Use of tapering tool on A/C air duct (4b)
Cutting with snap cutting equipment, sewer pipe (3b)

PRODUCED
JM - 83

Wednesday, October 12, 1977

Cutting with hack saw, sewer pipe (3a)
Hole cutting with drill and rasp, sewer pipe (5a)
Cutting with abrasive disc, wet, pressure pipe (3c)
Removal of coupling with hammer and chisel, sewer pipe (7a)

Thursday, October 14, 1977

Cutting and machining with Doty tool, dry, pressure pipe (4a)
Cutting and machining with Doty tool, dry, shroud, pressure pipe(4a)
Cutting and machining with Doty tool, wet, shroud, pressure pipe (4a)
Cutting and machining with Doty tool, dry, sewer pipe (4a)
Cutting and machining with Doty tool, dry, shroud, sewer pipe (4a)
Cutting and machining with Doty tool, wet, shroud, sewer pipe (4a)

Friday, October 15, 1977

Cutting with abrasive disc, wet, pressure pipe (3c)
Cutting with abrasive disc, wet, sewer pipe (3c)

Testing at Bay Area site

Unloading pipe at site (1)
Laying pipe in trench (2)

Integrated long-term samples were taken as shown in the tables of results.

RESULTS

The short-term or peak exposures during the operations studied are shown in Tables 1-6. Integrated personal samples analyzed for asbestos fiber concentrations are shown in Table 7. Table 8 summarizes integrated area samples, which were studied for asbestos fiber concentrations, total dust, respirable dust, and quartz content, as shown. None of the respirable samples, i.e. samples collected with a pre-filter cyclone to remove large non-respirable

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JM - 83

particles, showed a measurable amount of dust sufficient for quartz analysis. Table 9 summarizes background levels.

DISCUSSION

Background levels, as in the previous study, were at the limit of sensitivity for the volumes of air and the methods employed. Ranging from below the level of detection to 0.07 fibers/ml, they indicate low concentrations, similar to those found in many earlier studies.

Short-term or peak exposures. All operations that were studied produced airborne concentrations far below the current short-term standard of 10 fibers/ml or the proposed short-term standard of 5 fibers/ml, except for some operations using the Doty tool and operations using the abrasive disc saw. Some operations using the Doty tool, particularly when used dry, although below the permissible concentrations for short-term exposures, would if continued over an 8-hour day, exceed the permissible time weighted average of 2.0 fibers/ml. It is, of course, unlikely that use would be continuous.

The abrasive disc saw, even when used wet, produced unacceptably high concentrations of airborne fibers, averages ranging from 10 to 65 fibers/ml. It is believed that use of water to cut down dust with this machine could be improved upon. Because the hose was attached to the housing and the latter could be rotated with respect to the handle of the saw, the water was not invariably directed to the cutting area. It was observed also that dust was generated within the pipe during the cutting and would exhaust from the ends of the pipe, and this could not be reduced by water applied to the outside of the pipe. Also, although the outside of the pipe was thoroughly wet, as the cut proceeded, the disc would generate heat and dry an area on either side of the blade. It is

PRODUCED
JM - 83

recommended that water be applied through a fine spray, spread over a wide field, so that nozzle placement would not be critical. We do not feel that the wet-cutting modification employed in our tests was designed to cover all conditions of tool positioning and usage, therefore the possibility of effective dust reduction with a proper method of wetting should not be ruled out.

The quartz analyses, which employed x-ray diffraction methods which would be used by OSHA and most industrial hygienists, showed more than 5% quartz in each of the total dust samples that were analyzed, specifically 5.7%, 9.0%, and 15.4%. The threshold limit value, i.e., the permissible time-weighted average for total quartz-containing dust, is $\frac{30 \text{ mg/m}^3}{\% \text{ quartz} + 3}$. Therefore, in the three samples measured, the range of TWA's would have been from 1.6 to 2.6 mg/m^3. No concentrations this high were reported in the integrated samples collected during the current studies. The high levels reported in the previous survey were peak, not integrated samples.

PRODUCED
JM - 83

SUMMARY AND CONCLUSIONS

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JM - 83

Summary and Conclusions

Determinations were made of airborne asbestos fiber concentrations, total dust and respirable dust concentrations, and crystalline silica concentrations during a number of field operations used in the cutting, machining and installation of asbestos-cement pipe. These were designed to supplement studies reported in 1977, which showed that potential asbestos exposures during most operations were well below current occupational health standards, but that one tool, the abrasive disc saw, resulted in unacceptably high concentrations of fibers. In addition, short term concentrations of total dust suggested that if crystalline silica content was high, permissible levels might be exceeded.

The additional studies included a test of the abrasive disc saw with an attachment for wetting the area being cut, tests in which concentrations of crystalline silica were determined, as well as tests of several operations not previously studied. Specifically, the following operations were included: (1) unloading of pressure pipe at the work site; (2) laying pressure pipe in a trench; (3) cutting pressure pipe with a manual saw; cutting pressure and sewer pipe with snap cutting equipment; cutting pressure and sewer pipe with an abrasive disc, wet; (4) cutting and machining pressure and sewer pipe with a Doty tool, with various modifications, wet and dry; use of tapering tool on air duct pipe; machining differing sizes of pressure pipe (4-, 8-, and 16-inch), with a manual lathe; (5) hole cutting pressure and sewer pipe with drill and rasp; (6) dry tapping pressure and sewer pipe with a Mueller J tool, wet tapping pressure and sewer pipe with a Mueller B-100 tool; and (7) removing coupling from pressure and sewer pipe with hammer and chisel.

All operations that were studied produced airborne concentrations of asbestos far below the current short term OSHA standard of 10 fibers/ml (> 5um in length) and none would have exceeded a time-weighted average of 2 f/ml or even 0.5 f/ml

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JM - 83

if continued for a full working day except for (1) the abrasive disc saw and (2) some operations with the Doty tool when used dry. The abrasive disc, even when used wet, resulted in fiber concentrations ranging from 10 to 65 f/ml. It was concluded that better design of the wetting method was essential. The concentrations observed with the Doty tool, dry, were below short-term standards, and would have exceeded the time weighted average of 2 f/ml only in the unlikely event of being used continuously over a full work day.

Integrated total dust samples contained 5.7%, 9.0% and 15.4% quartz. This meant that permissible time-weighted averages would have ranged from 1.6 to 2.6 mg/cubic meter. The only integrated sample that exceeded the current OSHA standard was that collected during use of the abrasive disc saw.

These additional studies confirm that asbestos-cement pipe can be cut, machined, and installed without exceeding current and proposed OSHA standards, but that use of proper tools and adherance to recommended work practices are essential.

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JM - 83

Table 1

Airborne Fiber Concentrations During
Unloading of Pressure Pipe and Laying Pipe in Trench

Operation	Duration (min)	Fibers/ ml
Unloading pipe	24	0.03
Laying pipe	92	0 *
Laying pipe	90	0.02
Background	32	0 *

*Below detectable limit.

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Table 2

Airborne Fiber Concentrations During Cutting Operations with Hack Saw, Snap Cutting, and Use of Abrasive Disc (Wet)

	A/C Pressure Pipe				A/C Sewer Pipe			
	Operator		Helper		Operator		Helper	
	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Hack saw	15	0.06	15	0.05	18	0.11	16	0
	15	0	15	0.21	17	0.23	16	0.17
	12	0	12	0.07	15	0.19	15	0.06
Mean		0.01		0.11		0.18		0.08
Snap cutting	16	0	16	0	15	0	15	0.05
	14	0	13	0	15	0.07	14	0.06
	15	0.07	16	0	16	0.06	16	0.05
Mean		0.02		0		0.04		0.05
Abrasive disc	17	30.4*	17	30.9*				
(Wet)	6	60.1	5	54	5	95.3	5	14.4
	3	25.8	4	46	5	19.8	5	8.4
	4	109.1	5	47.5	6	11.3	6	7.8
Mean		65.0		49.2		42.1		10.2

*Filter overloaded, not used in calculating mean.

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Table 3

Airborne Fiber Concentrations During Machining Operations

Operation	A/C Pressure Pipe				A/C Sewer Pipe			
	Operator		Helper		Operator		Helper	
	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Cutting & Machining with Doty Tool								
Dry	11	3.75	11	1.37	15	1.13	15	0.32
	10	1.62	10	2.15	10	8.91	10	0.48
	10	0.32	10	3.18	9	1.44	9	0.08
Mean		1.9		2.23		3.83		0.29
Dry, Shroud	16	0.3	17	0.19	14	0.23	14	0
	13	1.56	13	0.24	13	0.25	13	0.06
	14	2.02	14	0.11	12	0.20	12	0.20
Mean		1.29		0.18		0.23		0.09
Wet, Shroud	18	0.18	17	0.47	14	0.17	14	0
	14	0.29	13	0.18	12	0.14	12	0
	16	0.15	16	0.15	16	0.30	15	0.11
Mean		0.21		0.27		0.20		0.04

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Table 4

Effect of Size of Pipe Upon Airborne Fiber Concentrations
During Machining With Manual Lathe

Operation	Operator		Helper	
	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Manual lathe				
4-inch pipe	18	0	18	0
	19	0	19	0
	20	0	21	0.05
Mean		0		0.02
8-inch pipe	22	0.04	22	0.07
	19	0	20	0.24
	21	0.05	21	0.07
Mean		0.03		0.13
16-inch pipe	18	0	18	0.05
	15	0	15	0.07
	19	0.05	20	0.05
Mean		0.02		0.06

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Table 5

Airborne Fiber Concentrations During Use of Tapering Tool with A/C Air Duct Pipe

		Operator		Helper	
		Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Tapering tool with air duct pipe		14	0.28	14	0.06
		23	0.13	22	0
		14	0.14	15	0
	Mean		0.18		0.02

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Table 6

Airborne Fiber Concentrations During Hole Cutting, Tapping Operations, and Coupling Removal

	Pressure Pipe				Sewer Pipe			
	Operator		Helper		Operator		Helper	
Operation	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Hole Cutting with Drill and Rasp	24	0.18	24	0.08	21	0.28	21	0.25
	19	0.14	18	0.11	17	0.17	17	0.15
	16	0.33	17	0	17	0.23	18	0 *
Mean		0.22		0.06		0.23		0.13
Dry Tap with Mueller J	14	0.06	15	0.06	18	0.07	15	0.05
	17	0.09	17	0.10	16	0.12	16	0
	19	0	19	0.05	15	0	15	0.05
Mean		0.05		0.07		0.06		0.03
Wet Tap with Mueller B-100	19	0.17	19	0.14	14	0.17	14	0
	13	0	18	0.20	18	0	16	0
	14	0.17	14	0.06	15	0	19	0
Mean		0.11		0.13		0.06		0
Coupling Removal Hammer and Chisel	22	0.29	24	0.11	12	0.12	13	0.12
	16	0.30	15	0.12	12	0.07	13	0
	15	0.32	16	0.06	9	0	9	0.18
Mean		0.30		0.10		0.06		0.10

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* Plus One (1) Glass Fiber

Table 7

Integrated Personal Samples Covering Successive Operations

Operation	Average Peak Counts		Integrated Sample Counts			
	Operator	Helper	Operator		Helper	
	Fibers/ ml	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
Snap cutting pressure	0.02	0	250	0.02	250	0.11
Hack saw, pressure	0.01	0.11				
Manual field lathe 8"	0.03	0.13				
Manual field lathe 4"	0	0.02	228	0.08	229	0.02
Manual field lathe 16"	0.02	0.06				
Hole drilling	0.22	0.06				
Coupling, hammer and chisel	0.3	0.1	275	0.05	279	0.04
Mueller J, pressure	0.05	0.07				
Mueller, B-100, pressure	0.11	0.13				
Mueller, B-100, sewer	0.06	0.0				
Mueller-J, sewer	0.06	0.03	226	0.06	226	0.02
Tapering tool, air-duct	0.18	0.02				
Cutting, snap-cutting	0.04	0.05				
Cutting, hack saw, sewer	0.18	0.08	264	0.34	263	0.14
Hole drilling, sewer	0.23	0.13				
Abrasive disc, wet, pressure*	4.30	0.79				
Coupling removal, sewer	0.06	0.10	132	0.05	178	0.03
Doty tool, dry, pressure	1.90	2.23	237	0.35	237	0.26
Doty tool, dry, shroud, pressure	1.29	0.18				
Doty tool, wet, shroud, pressure	0.21	0.27				
Doty tool, dry, sewer	3.83	0.29				
Doty tool, dry, shroud, sewer	0.23	0.09				
Doty tool, wet, shroud, sewer	0.20	0.05				
Abrasive disc, wet, pressure	65.02	49.15	69	5.84	74	5.80
Abrasive disc, wet, sewer	42.1	10.22				

*Motor underpowered, only one test tried.

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Table 8

Integrated Area Samples Covering Successive Operations

Operations	Area Samples: Asbestos Fibers Duration (min)	Asbestos Fibers ml	Total Dust Duration (min)	Total Dust mg/m^3	Quartz Content
Snap cutting pressure pipe Hack saw cutting, pressure pipe Manual field lathe 8" pressure	251	0.57	252	0.33	11.1%
Manual field lathe 4" pressure Manual field lathe 16" pressure Hole drilling	234	0.04	235	0.31	
Coupling removal, hammer and chisel Dry tap, Mueller J, pressure Wet tap, Mueller B-100, pressure Dry tap, Mueller B-100, sewer	286	0.02	290	0.34	
Dry tap Mueller J, sewerpipe Tapering tool with A/C air duct pipe Snap cutting sewer pipe	225	0.02	233	0.00	
Hack saw cutting, sewer pipe Hole drilling, sewer pipe Wet abrasive disc, pressure pipe	272	0.08	272	0.12	5.7%
Coupling removal, sewer pipe	17	0.02	191	0.79	

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Table 8 Cont'd

Integrated Area Samples Covering Successive Operations

Operations	Area Samples				Quartz Content
	Asbestos Fibers		Total Dust		
	Duration (min)	Fibers ml	Duration (min)	mg/m^3	
Cutting and machining, Doty dry pressure Cutting and machining, dry, shroud, pressure Cutting and machining, wet, shroud, pressure Cutting and machining wet, shroud, pressure Cutting and machining dry, sewer Cutting and machining dry, shroud, sewer Cutting and machining wet, shroud, pressure	238	0.03	240	0.20	Not Determined
Abrasive disc wet, pressure pipe Abrasive disc wet, sewer pipe	80	3.83	82	1.66	15.4%

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Table 9

Airborne Fiber Concentrations Before and After Operations
(Background Levels)

Date and Time	Duration (min)	Fibers/ ml
October 10, 1977 am	55	0*
October 10, 1977 pm	67	0.02
October 11, 1977 am	72	0.07
October 11, 1977 pm	85	0.0
October 12, 1977 am	72	0.01
October 12, 1977 pm	75	0
October 14, 1977 am	129	0.002
October 14, 1977 pm	51	0
October 15, 1977 am	72	0.01
October 15, 1977 pm	32	0

*Below detectable limit.

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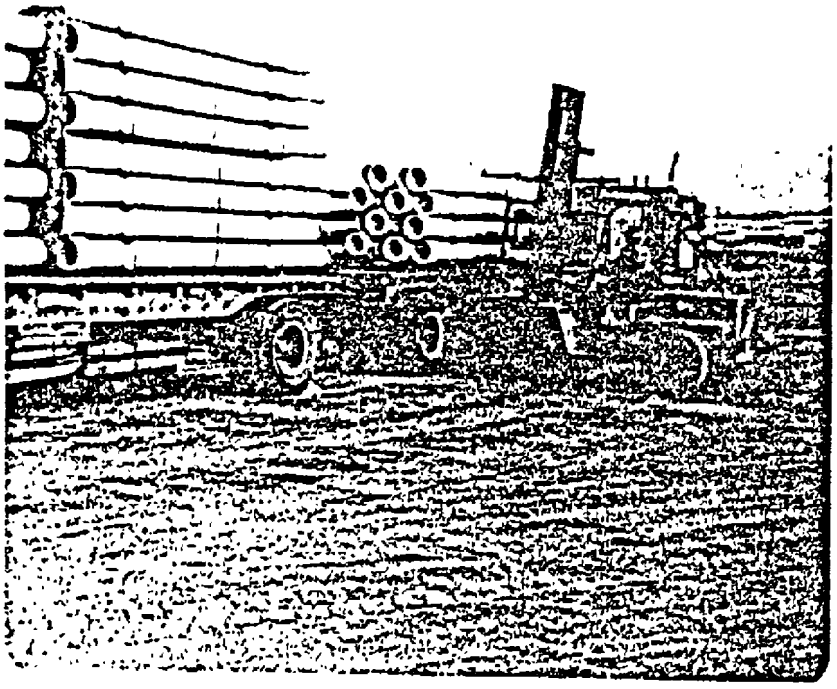


FIGURE 1. Unloading 8-inch pressure pipe at work site.

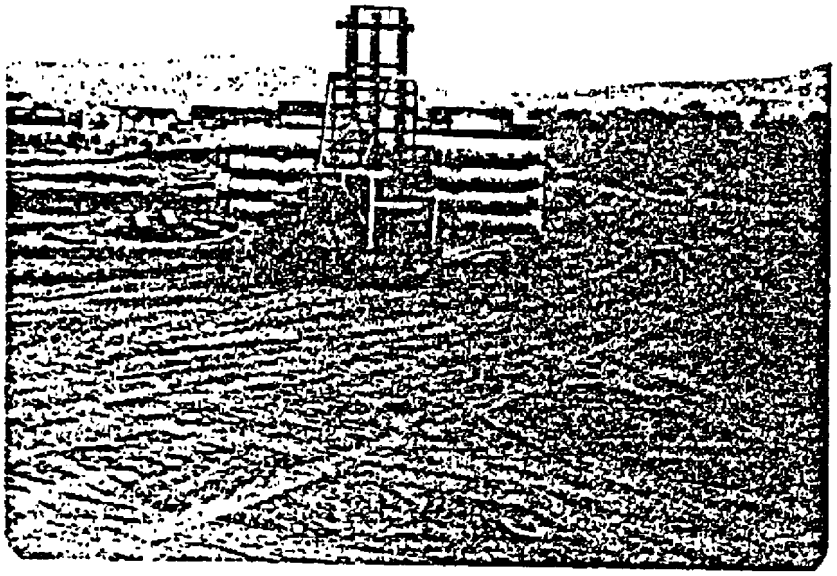


FIGURE 2. Transporting 8-inch pressure pipe from truck to trench.

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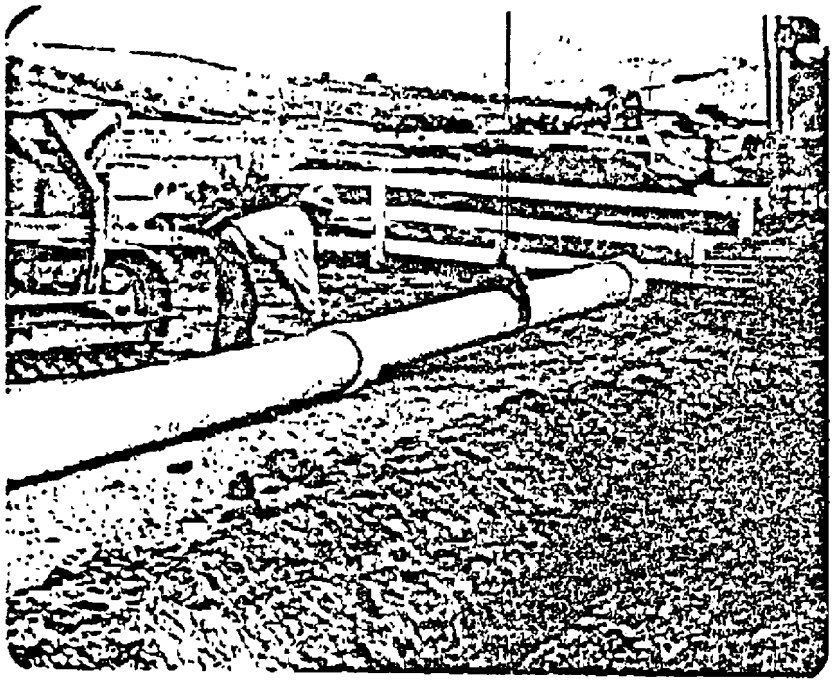


FIGURE 3. Placing pipe at side of trench.

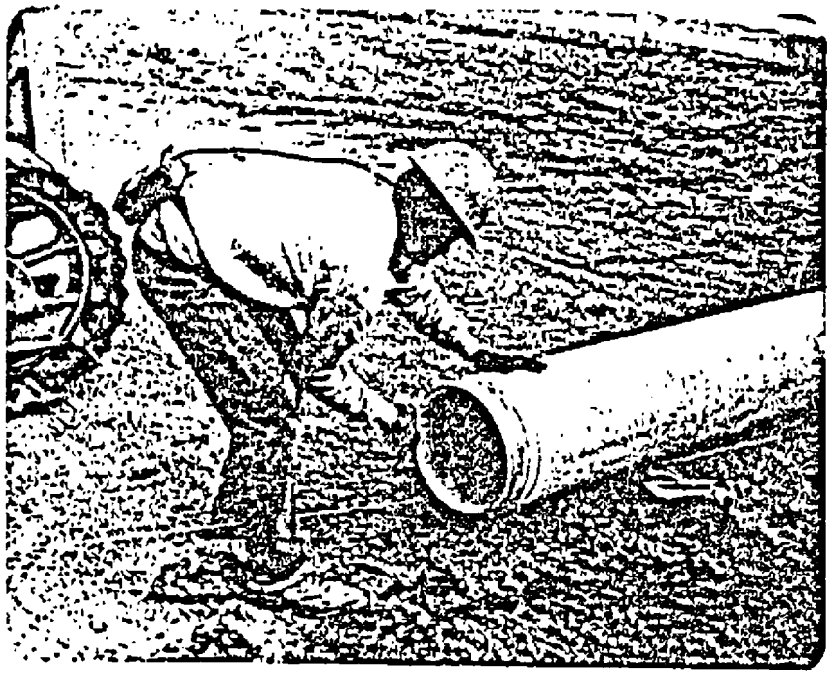


FIGURE 4. Lubricating pipe at trench.

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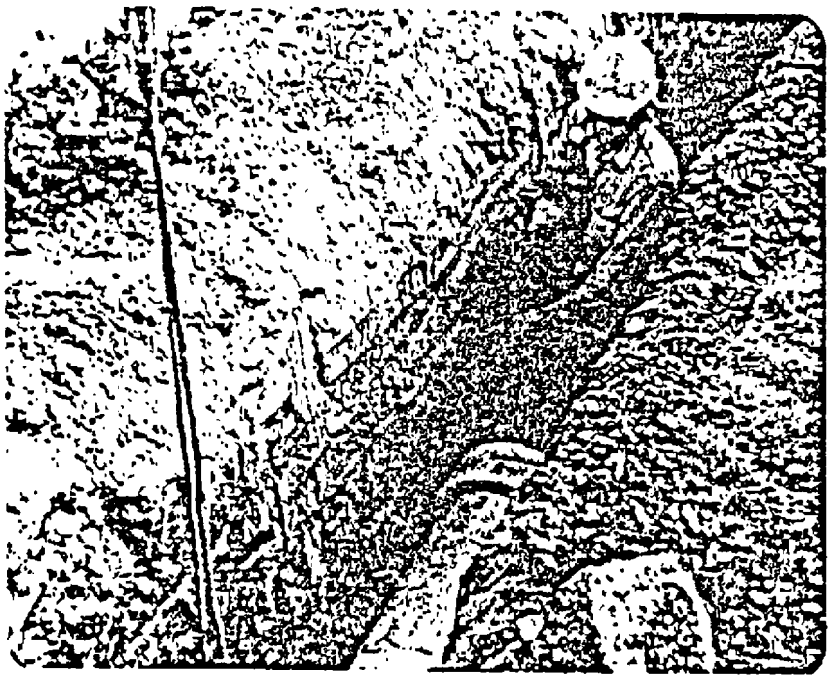


FIGURE 5. Positioning in trench.

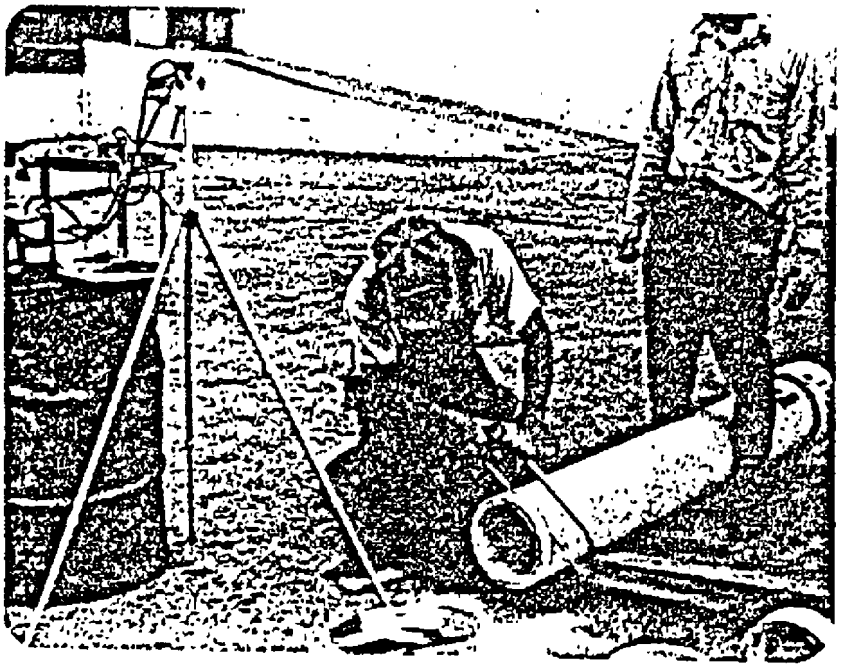


FIGURE 6. Cutting with hack saw.

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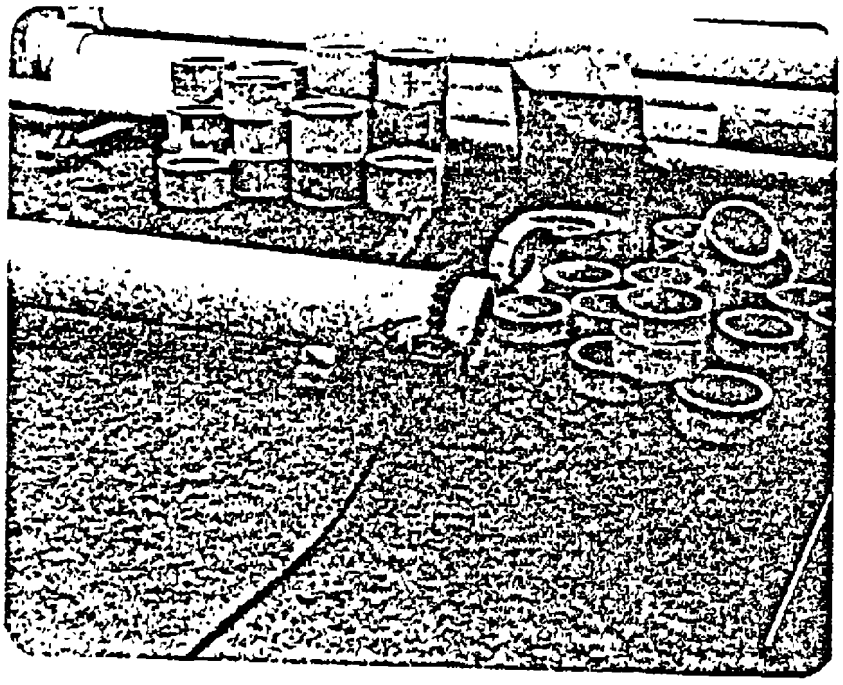


FIGURE 7. Snap cutting tool.



FIGURE 8. Hydraulic control of snap cutting equipment.

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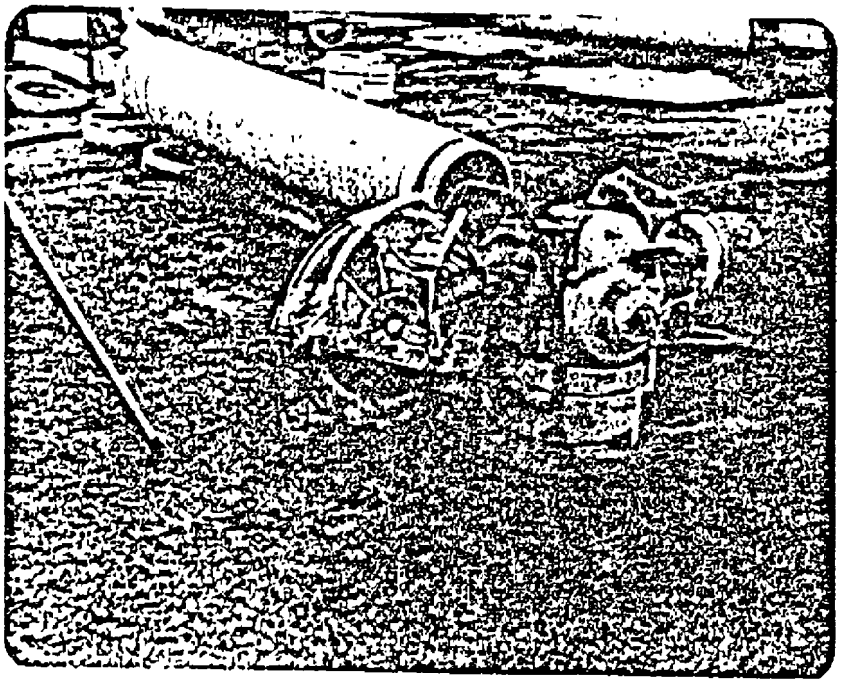


FIGURE 9. Abrasive disc saw with hoses for wet cutting.

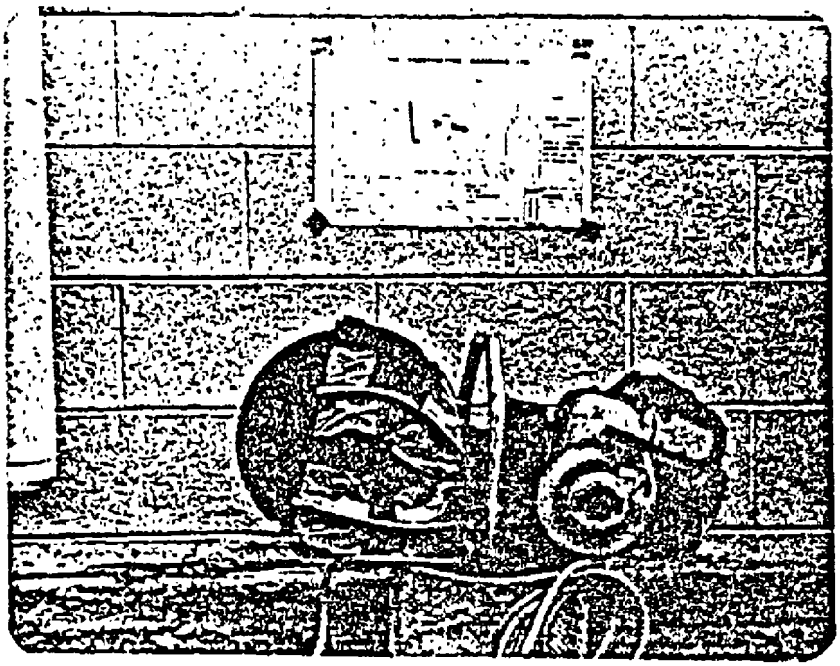


FIGURE 10. Abrasive disc saw with hoses for wet cutting.

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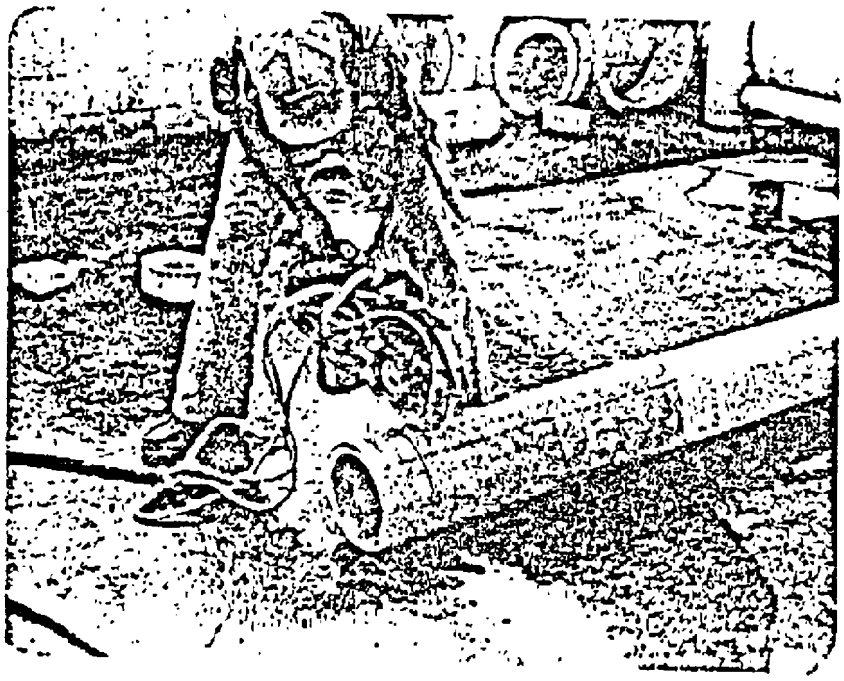


FIGURE 11. Use of abrasive disc saw, wet.

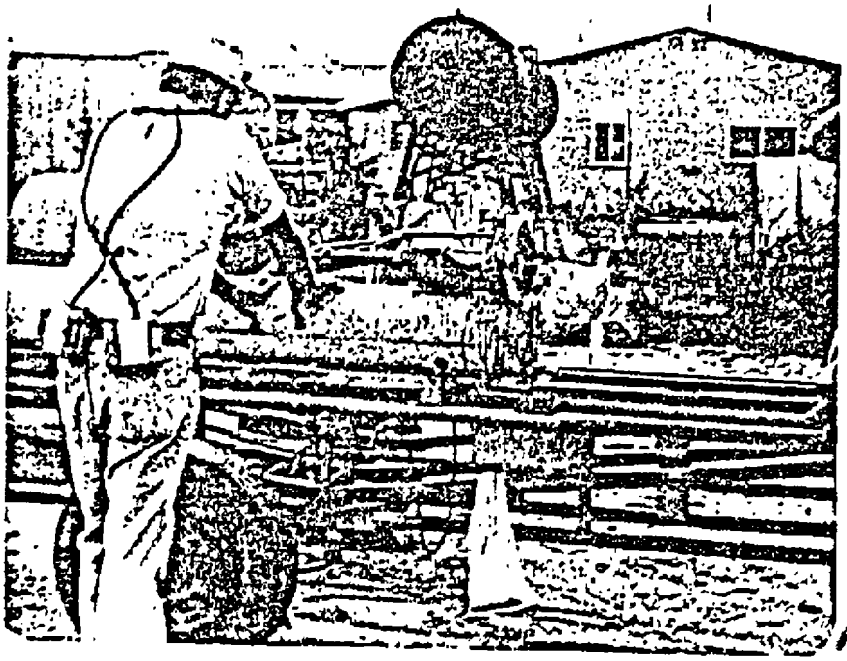


FIGURE 12. Doty tool, cutting.

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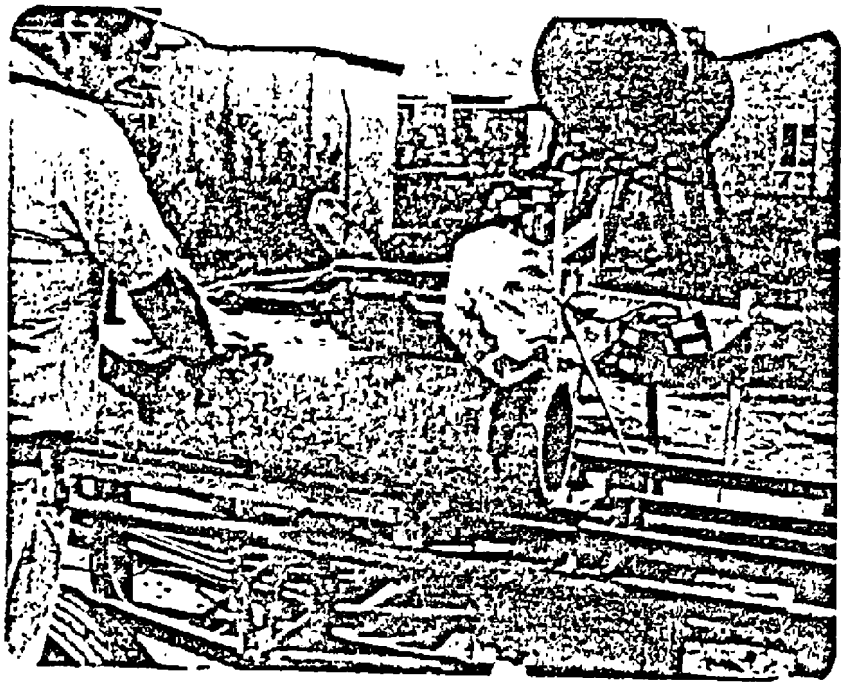


FIGURE 13. Doty tool, cutting, with bag around blade.

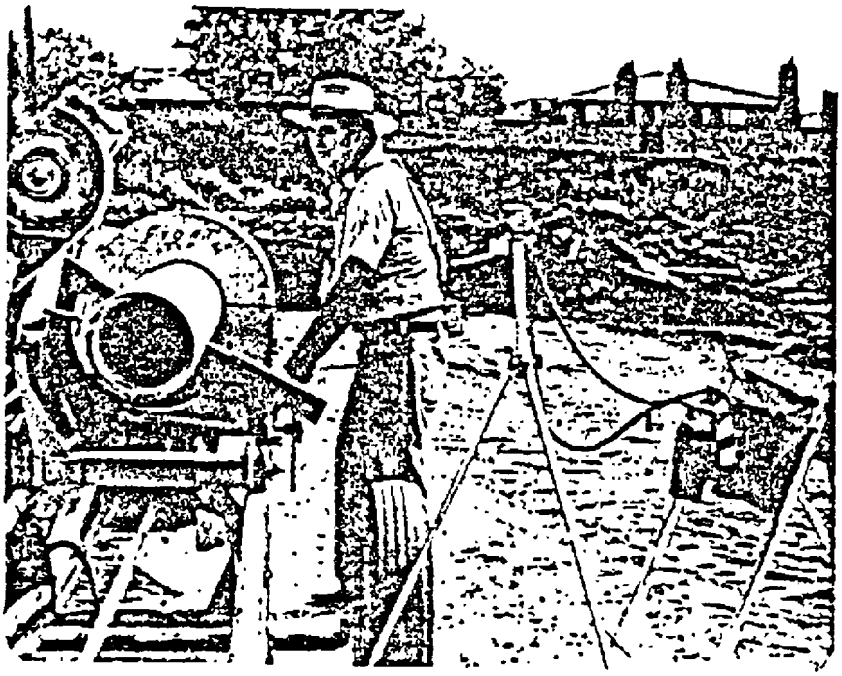


FIGURE 14. Doty tool, machining with shroud.

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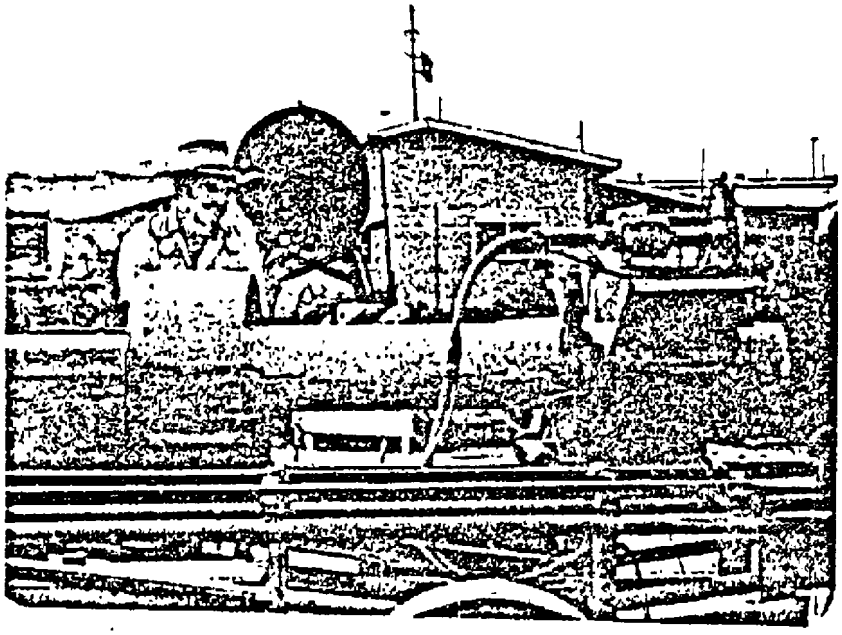


FIGURE 15. Doty tool, machining dry without shroud.

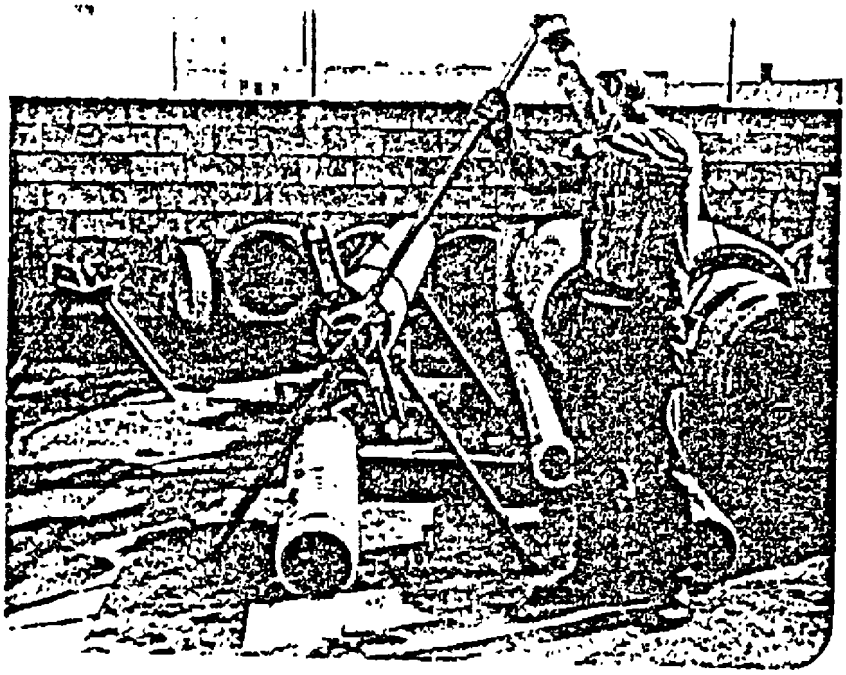


FIGURE 16. Tapering A/C air duct.

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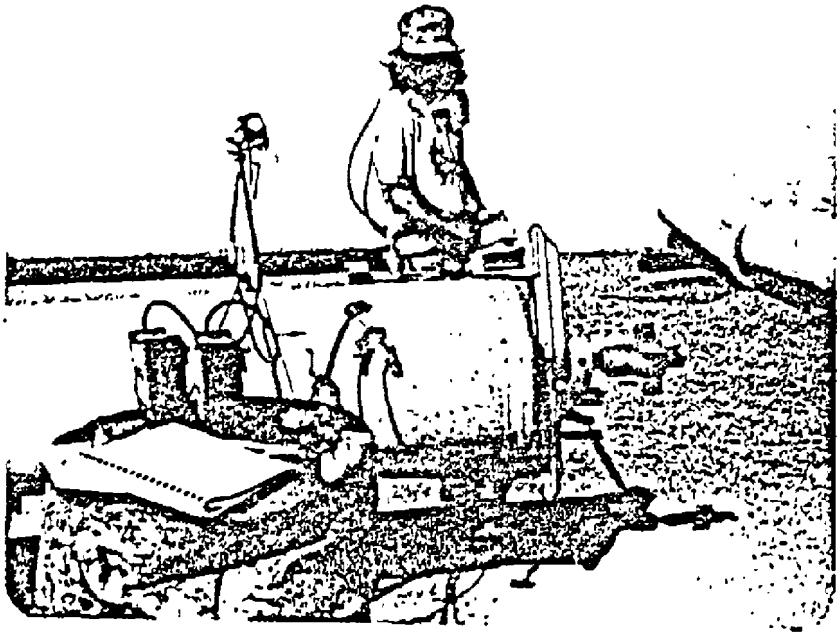


FIGURE 17. Use of manual lathe on 16-inch pressure pipe.

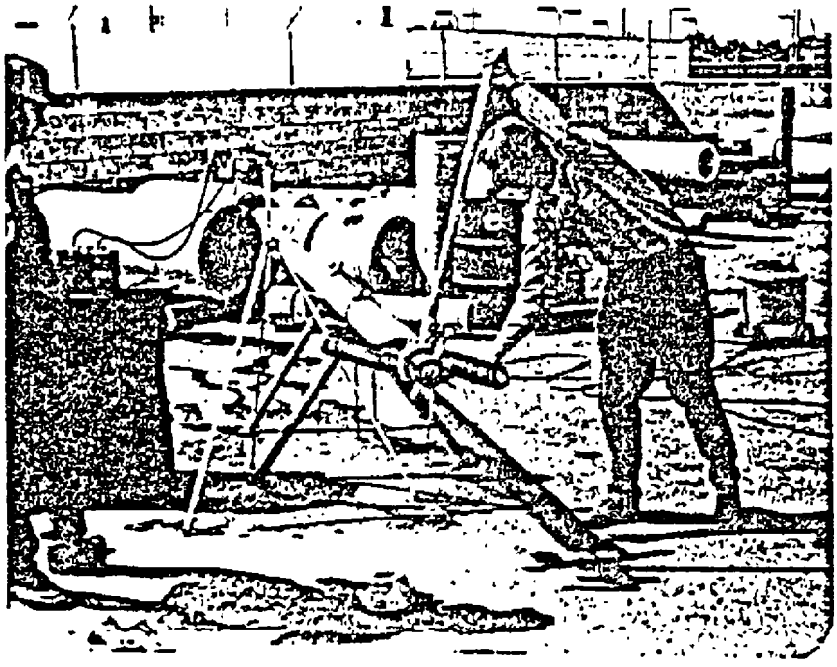


FIGURE 18. Use of manual lathe on 4-inch pressure pipe.

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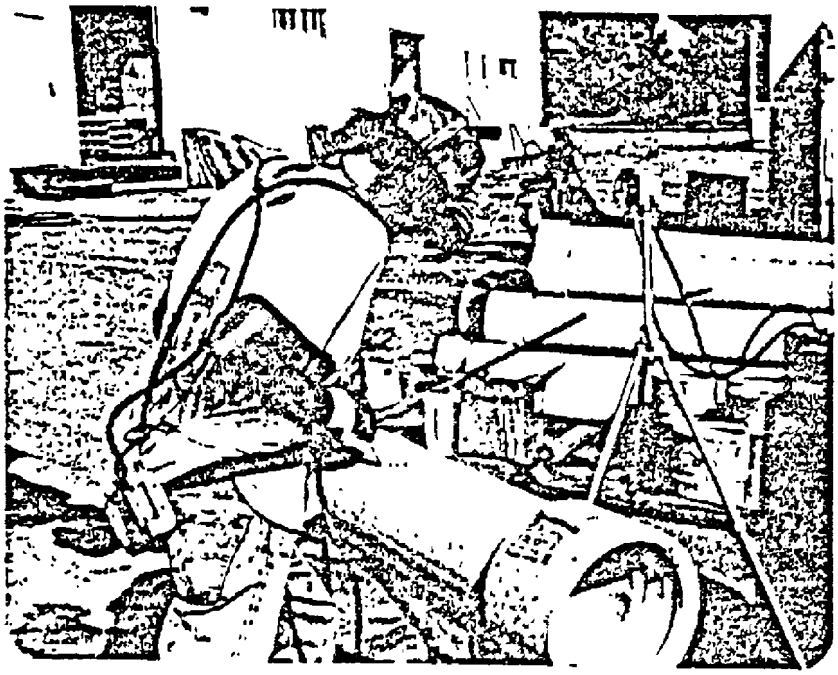


FIGURE 19. Cutting hole with drill.

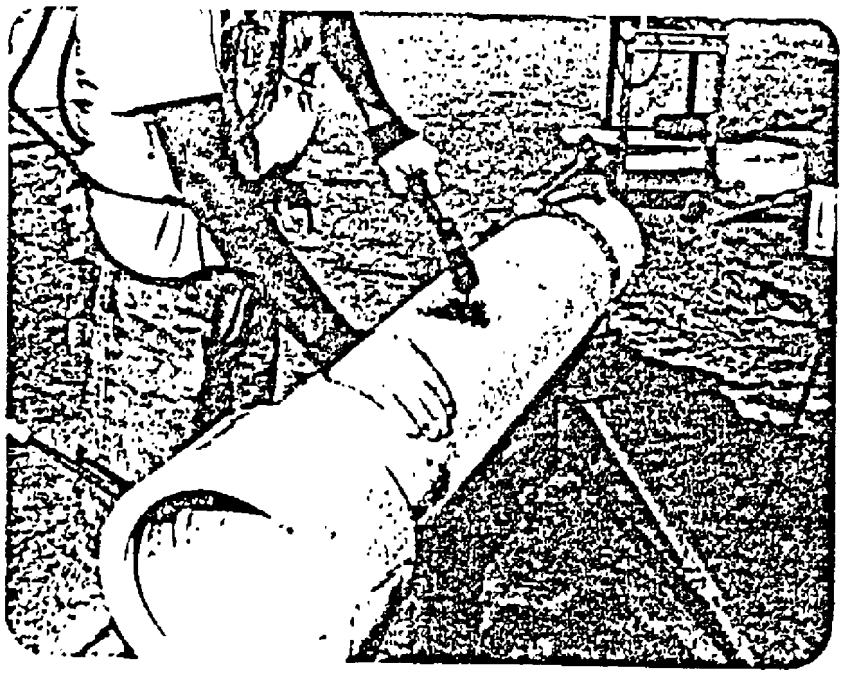


FIGURE 20. Knocking central portion with hammer.

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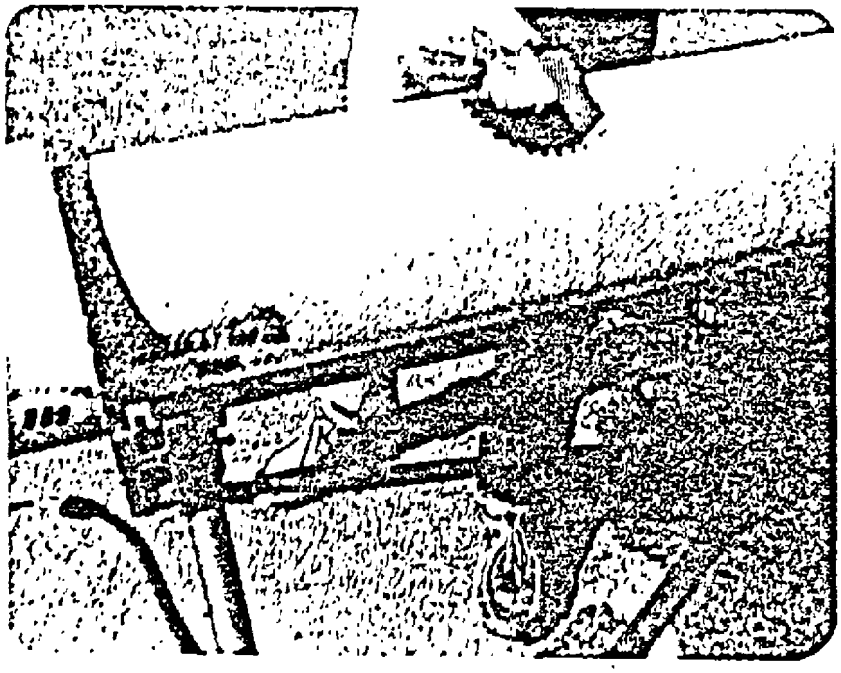


FIGURE 21. Smoothing rough edges with rasp.

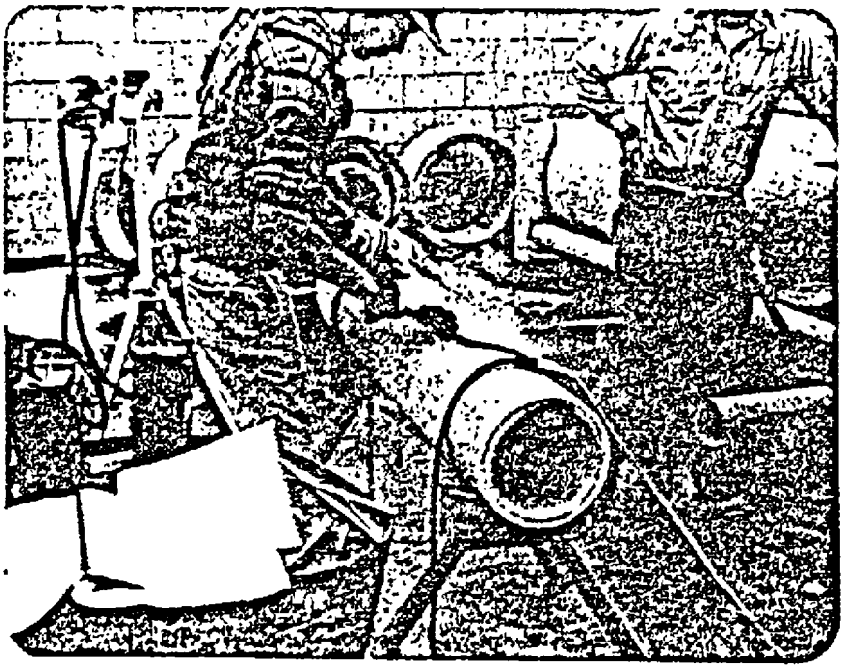


FIGURE 22. Blowing dust with exhaust.

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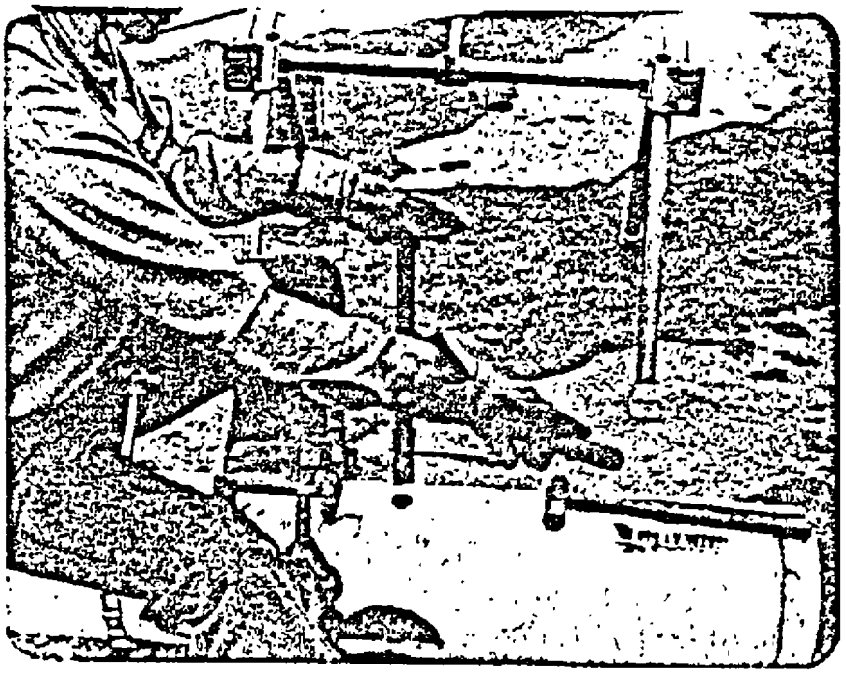


FIGURE 23. Use of Mueller J tool.

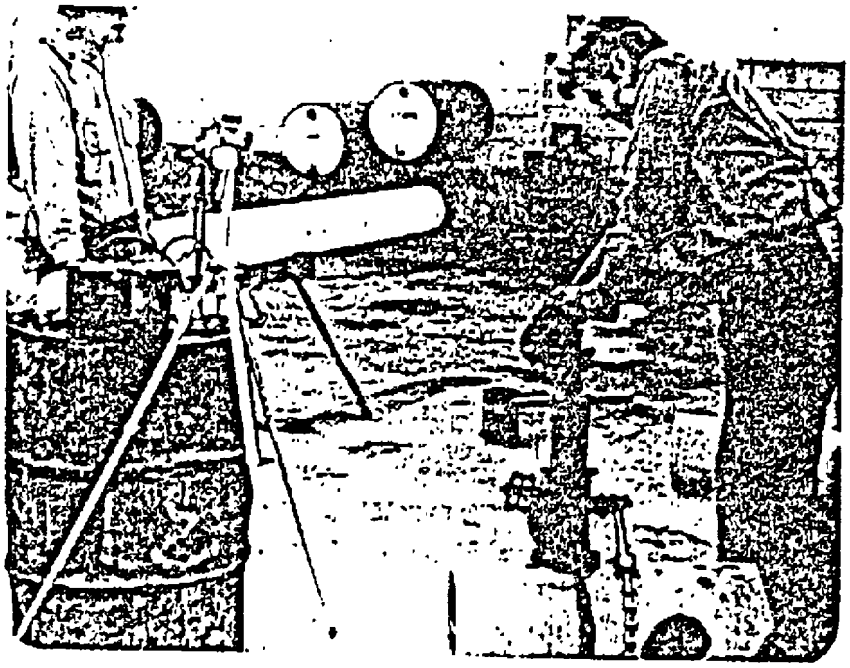


FIGURE 24. Mueller B-100 tool.

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FIGURE 25. Removal of coupling with chisel.

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