

HYGELA INC. Project No. 5617

HYGELA INC.

AN INVESTIGATION INTO
AIRBORNE ASBESTOS FIBER CONCENTRATIONS
DURING THE REMOVAL OF ASBESTOS-CONTAINING
VALVE PACKING MATERIALS

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T A B L E O F C O N T E N T S

<u>CONTENTS</u>	<u>PAGE NO.</u>
1. INTRODUCTION.....	1
2. AIR SAMPLING PROCEDURES.....	1
3. ANALYTICAL METHODS AND RESULTS.....	7
4. DISCUSSION OF RESULT AND CONCLUSIONS.....	10
Appendix A: PCM Air and PLM Bulk Sample Results	
Appendix B: Analytical Transmission Electron Microscopy Results	
Appendix C: Pump Calibration Worksheets	
Appendix D: Letter from A.W. Chesterton Describing Sampling Location at the Woburn, Massachusetts Facility	
Appendix E: Analytical Transmission Electron Microscopy Photomicrographs of Air Samples	

1. INTRODUCTION

The objective of this investigation was to determine levels of airborne asbestos fiber generated during the removal of worn asbestos-containing valve packing materials. These packings are press-fit into the flanges between the valve and the connecting pipe. The packings manufactured by the A. W. Chesterton Company contain woven chrysotile asbestos fiber impregnated with a resin. The packing is cast into a rope having a more-or-less square cross section approximately 1/4- to 3/8-inch on a side.

Over time, the resin deteriorates and, as leaks occur at the flange, the packing must be replaced with a new one. This study focuses on the level of asbestos fiber released into the air during the removal of the dried asbestos woven fiber.

2. AIR SAMPLING PROCEDURES

Air samples were collected on November 23, 1983 at the A. W. Chesterton Woburn facility. These samples were collected in the boiler room containing two process steam boilers. Both boilers are insulated with asbestos lagging which appears to be completely intact and in good condition. The valve used in these tests was located on a pipe leading from the top of one of the boilers. This boiler had not been operated for several years and the packing in the valve needed replacement.

In this test, a six-inch hot water valve (see Appendix D) located at the top of the boiler was removed for packing replacement. The bolts attaching the valve to the pipe were loosened and removed and the valve was pried off the packing material that was sticking to the two flanges. The valve was then lowered to the floor with an assist from a rope sling. Air monitoring was carried out, as described below, during the removal of the packing material. It was noted that the packing was compressed flat to approximately 1/2-inch by 1/8-inch. The packing was remarkably dry and a dust was visible during the first attempt at removal. The packing was very solidly adhering to the metal flange and had to be removed using a cold chisel and hammer.

Air samples were collected for both phase contrast microscopic (PCM) and analytical transmission electron microscopic (ATEM) analysis. A 25 mm mixed-cellulose ester (MCE) membrane filter having a nominal pore size of 0.80 micrometers (um) was used for the PCM sample and a 25 mm MCE filter with a nominal pore size of 0.45 um was used for the ATEM analysis. These cassettes and pore sizes are those required for the NIOSH 7400 PCM and U.S. EPA TEM methods.

Two 117 VAC pumps were used to draw the air through the filters. Air flow was controlled through critical orifices, one orifice for each filter type. The critical orifices were calibrated for air flow both before and after the samples were collected using a Buck bubble meter, a primary calibration standard. (see Appendix C).

Air samples collected included a PCM/ATEM background sample, a PCM/ATEM sample collected during the valve disassembly and the actual scraping of the gasket from the valve. A PCM/ATEM sample pair was collected during the packing removal (see Figure 1). and another pair representing the airborne fiber concentration within the worker's breathing zone were collected throughout the entire removal process (Figures 2 to 5).

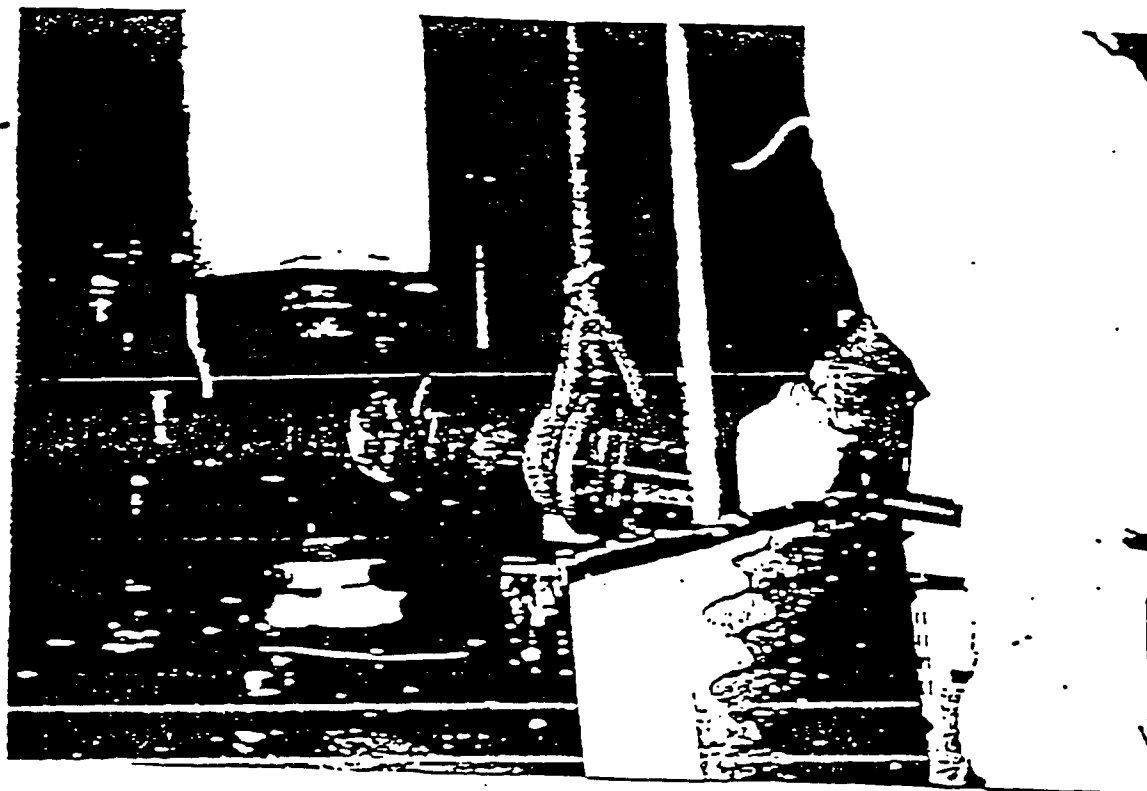


Figure 1. Removal of valve from pipe flange.

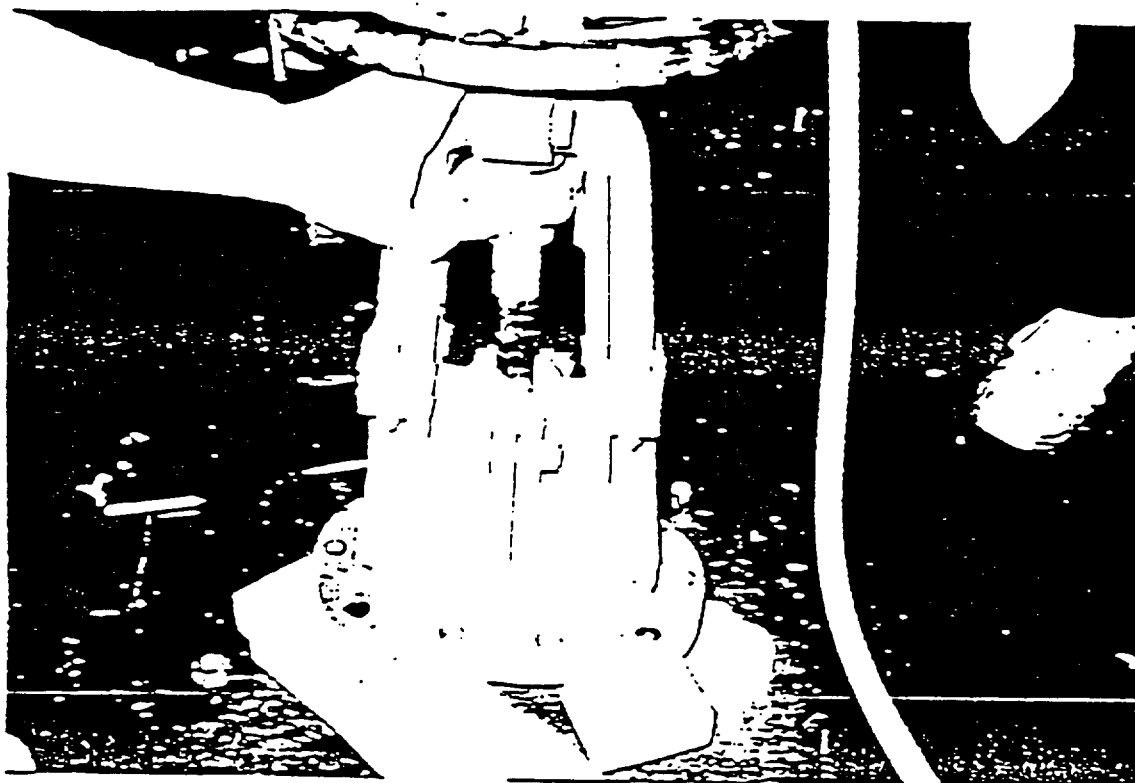


Figure 2. Valve removed from pipe flange prior to removal of asbestos-containing packing.

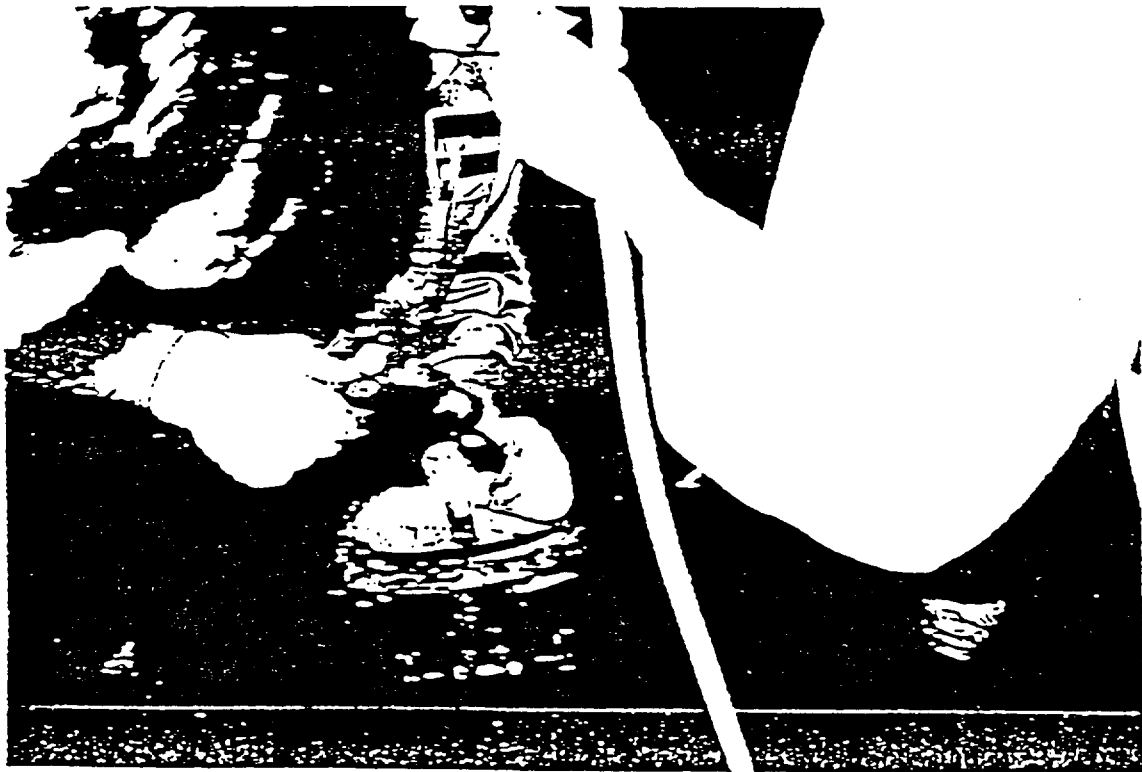


Figure 3. Air sampling during removal of packing.



Figure 4. Removal of packing material with hammer and cold chisel. Note air sampling cassettes within breathing zone of mechanic.

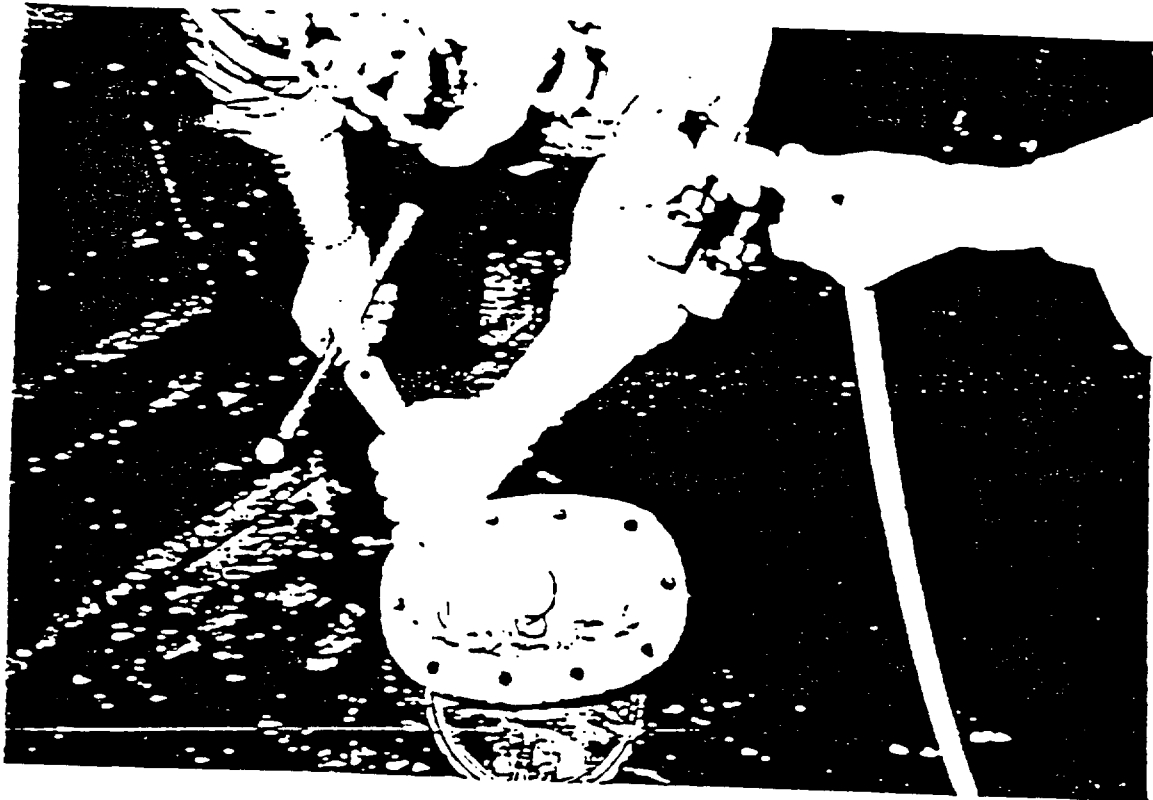


Figure 5. Air sampling within breathing zone during removal of asbestos-containing valve packing.

Prior to any activities in the boiler room, two blank (or background) air samples were collected for PCM/ATEM analysis. Figures 1 through 5 illustrate the air sampling procedure and the relationship of the breathing zone sample to the packing removal operation.

3. ANALYTICAL METHODS AND RESULTS

Bulk Analysis of Packing Material:

Samples of the actual gasket and packing material were collected after the removal process. These samples were analyzed by the HYGELA INC. Laboratory. The bulk samples were analyzed by polarized light microscopy (EPA Interim Method: Appendix A to Subpart F-40 CFR Part 763) at magnifications ranging from 10x to 400x. The estimated phase abundances are provided in weight percent and are accurate to within 10 to 15 percent of the amount reported. This method is sensitive to the presence of asbestos to less than one percent by weight. The HYGELA INC. laboratory is accredited by the U.S. EPA for asbestos in bulk sample analysis (#1386) and by the State of Massachusetts for asbestos analysis. This laboratory is also accredited under the National Voluntary Laboratory Accreditation Program (NVLAP), number 1011.00, administered by the National Institute of Standards and Technology (formerly the National Bureau of Standards).

The results of the bulk analyses are shown in Table 1; the laboratory worksheets are contained in Appendix A.

TABLE 1

BULK ASBESTOS ANALYSIS OF PACKING AND GASKET MATERIALS

<u>Sample No.</u>	<u>Material Type</u>	<u>Results</u>
610	Gasket	Asbestos (Chrysotile) 45% Cellulose Fiber 35% Opagues 20%
P11	Packing	Asbestos (Chrysotile) 50% Vermiculite 5% Opagues 45%

Phase Contrast Microscopic Analysis of Air Samples:

The air samples were analyzed by a combined phase contrast-polarized light microscopic technique. The total fiber count corresponds to the National Institute of Occupational Safety and Health (NIOSH) Method 7400 for determination of asbestos fibers and should be used solely when assessing overall air quality according to the appropriate OSHA or EPA standards. The asbestos fiber percentage refers to those larger fibers (on the filter wedge sample) which could be positively identified as asbestos by polarized light microscopy. The asbestos fiber percentage given is qualitative only and represents an estimated percentage of the total fibers on the filter wedge which could be identified as asbestos. This value should be used as supplementary information for assessing current air quality and is not to be used above for determining compliance with regulatory air quality standards.

Results for the analysis of the four PCM/PLM air samples are shown in Table 2.

TABLE 2

ANALYSIS OF AIR SAMPLES BY COMBINED
PHASE CONTRAST/POLARIZED LIGHT MICROSCOPY

Sample No. 02: Boiler Room Background

Total Fiber Count <0.01 f/cc (Fiber per cubic centimeter);
No Asbestos Fiber Detected

Sample No. 04: Gasket Removal

Total Fiber Count <0.01 f/cc; Asbestos, 30% (Chrysotile)

Sample No. 06: Packing Removal

Total Fiber Count <0.01 f/cc; No Asbestos Fiber Detected

Sample No. 08: Personal

Total Fiber Count <0.01 f/cc; Asbestos, 25% (Chrysotile,
Amosite)

Analytical Transmission Electron Microscopic Analysis of Air Samples:

A Philips Model 300 Analytical Transmission Electron Microscope (ATEM) equipped with a non-dispersive X-ray spectrometer and having electron diffraction capability was used for the analysis. The analytical method used was a modified version of the United State Environmental Protection Agency (U.S. EPA) "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy", Level III, Contract No. 68-02-3256. The modifications involved counting an area of the filter to achieve analytical sensitivity of 0.005 structures per cubic centimeter as required by the "Asbestos-Containing Materials in Schools; Final Rule and Notice" 40 CFR Part 763 (Appendix A to Subpart E). According to this regulation a building space is deemed to be free of asbestos if there are fewer than 70 structures per square millimeter (s/mm^2). Asbestos fibers are identified by their morphology, chemical composition and selected Electron Diffraction (SAED) patterns. Photos of the morphology were taken for each sample containing asbestos structures for documentation. The results expressed in units of fibers per cubic centimeter (f/cc) and nanograms per cubic meter (ng/m^3) of air are reported in Table 3 and the complete computer printout of the analysis is contained in Appendix B.

TABLE 3

RESULTS OF AIR SAMPLE ANALYSIS BY
ANALYTICAL TRANSMISSION ELECTRON MICROSCOPY

<u>Sample No.</u>	<u>Location</u>	<u>Asbestos f/cc</u>	<u>Asbestos ng/m³</u>
01	Boiler Room, Background	None Detected	None Detected
03	Gasket Removal	0.050	0.414
05	Packing Removal	0.050	25.04
07	Breathing Zone during whole operation	0.035	174.12

4. DISCUSSION OF RESULT AND CONCLUSIONS

The bulk sample analyses indicate there to be approximately 45 to 50 percent by weight chrysotile asbestos present in the packing material. The packing material, when new, is encapsulated in a resin; however, as the packing ages in place some resin is removed to expose a braided asbestos rope when the valve is dismantled.

The air testing during this disassembly at the A. W. Chesterton Company was conducted during extremely aggressive removal of the gasket from the flange. The boiler unit had not been operated for several months and the leaking gasket, which was the subject of this test, had dried and hardened in the flange. To part the valve flange from the mating pipe flange, considerable force was applied to disconnect the two. There was a visible dust when the two parts were separated. A cold chisel and hammer had to be used to peel the dried gasket from the groove of the flange. This last operation represents the greatest proportion of the sampling time.

The personal sample was collected from the breathing zone of the mechanic who removed the gasket from the flange. The dual sampling unit, collecting both phase contrast and ATEM samples was hand held within a few inches of the mechanic's nose and mouth. The duration of this work was less than 15 minutes.

An area sample was collected in the vicinity of the valve as it was being removed from the pipe flange. The cassette was placed at a distance of about one foot from the flange itself.

Both phase contrast and an ATEM background air samples were collected in the boiler room before any testing activities began in that space. Filter blanks, (i.e., unexposed filters) yielded no fibers on microscopic analysis.

The phase contrast analytical results are at the limit of detection for the volume of air that was collected. The total airborne fiber concentration was exceedingly low and well below the Permissible Exposure Limit (PEL) of 0.2 f/cc currently enforced by the Occupational Safety and Health Administration (OSHA). The low airborne fiber concentration and the short duration of the work combine to give an even lower time-weighted average exposure.

The ATEM results are a more "absolute" in the assessment of actual airborne asbestos fiber concentrations. Unlike the phase contrast method, used for enforcement of the occupational standard, which is based on the total fiber count, the ATEM results are based on actual asbestos fibers. Here again the airborne fiber concentrations are exceedingly low and, in fact, the asbestos structures seen were non respirable.

All the asbestos-containing artifacts that were observed on the filters are shown in the Figures in Appendix E.

Four filters were analyzed using phase contrast microscopy according to the NIOSH 7400 method. The results are as follows. A background sample taken before any activity took place gave a fiber count of less than 0.01 fiber per cubic centimeter (f/cc). No asbestos fiber could be detected. During gasket removal the fiber count was 0.01 f/cc. During packing removal the fiber count was less than 0.01 f/cc. Finally, a personal sample collected during the whole operation gave a fiber count of 0.01 f/cc. This operation included pulling the gate valve away from the flange, and the removal of both packing and gasket materials using a cold chisel. The total elapsed time for this operation was about 20 minutes.

Four air samples were collected for analysis by analytical transmission electron microscopy (ATEM), with the following result. A background sample collected over a period of 50 minutes gave an asbestos structure count of less than 0.005 structures per cc. That is, no asbestos fiber was found at the limit of detection.

During packing removal, an asbestos structure count of 0.05 structures per cc was found. During gasket removal, the asbestos structure count was 0.005 structures per cc. These samples represent airborne fiber concentrations in the area adjacent to the operation. A personal sample collected in the breathing zone of the operator gave a result of 0.035 structures per cc for the duration of the operation.

By way of explanation, we provide the following comments. The term "structures per cubic centimeter" includes individual fibers, fiber bundles, clusters and matrices. Referring to the photographs, we see that the majority of asbestos-containing artifacts found were matrices. Very few single unattached asbestos fibers were found on any of the samples. We were unable to obtain selected area electron diffraction (SAED) patterns on the fibers because they were coated with resin. Fiber identification was made on the basis of morphology and chemistry.

The short duration of the dismantling operation made it necessary to collect the personal samples at a higher volumetric flow rate than is normally used. Also, a far greater number of TEM grids had to be examined in order to attain the detection limit of 0.005 structures per cc. The computer printout attached provides individual measurements of the asbestos fiber matrices. The photographs, we believe, are a good representation of the structures observed (keeping in mind that there were very few of them).

In our opinion, the airborne asbestos fiber concentration created during the aggressive removal of dried, spent valve packing/gasket of the type used here is exceedingly low. The short duration of packing/gasket replacement work (i.e., less than 15 minutes duration) also has an important effect in reducing already low total dose to the worker.

In conclusion, the results demonstrate that the asbestos fiber level is well below even the current OSHA Standard of 0.2 f/cc or the 0.1 f/cc action level. The short duration of the work procedure, approximately 20 minutes, further reduces the level exposure when based on an 8-hour time-weighted average.

In more "absolute" terms, the actual asbestos fiber content in the air at the workers' breathing zone is also very small indeed. The photomicrographs included in this report depict all asbestos-containing bodies observed on the filters. Without exception, the fibers were enclosed within larger bodies of resin or the individual fibers were encapsulated with resin. We believe that these fibers could not be respired deeply into the respiratory tract. Rather, they would be trapped in the upper bronchial tree to be removed by mucociliary action. We also infer that the one single asbestos fiber encountered was coated with resin, a fact that may affect the fiber potency.

HYGELA INC. Project No. 5617

HYGELA INC.

APPENDIX A
LABORATORY WORKSHEETS
FOR
SOLID ANALYSIS BY POLARIZED LIGHT MICROSCOPY
AND
AIR SAMPLE ANALYSIS BY PHASE CONTRAST MICROSCOPY (NIOSE 7400)

HYGELA INC.

Asbestos Analysis Worksheet

Client Name <i>Richard L. Kirby</i>		HYGELA JOB# <i>5617</i>
Client Identification <i>P-11</i>	HYGELA HB- <i>2787 B</i>	Date Collected <i>11/23/88</i>

Sample Location

Back

Gross Sample Description

Green metal

By: *HW*

Date: *11/23*

Friable?

☐ Yes ☒ No

Homogeneous?

☐ Yes ☒ No

Microscopically Estimated Fiber Percentages:

Magnification: ☐ 10X ☐ 20X ☐ 40X

Extinction parallel?	S i g n	Color	Birefr.	Pleochroic?	RI n =	Asbestos Type	Weight Percent Present:				Average Weight %
							1	2	3	4	
yes/no	<i>S</i>	<i>L</i>	<i>L</i>	☐ yes ☒ no	<i>1.55</i>	Chrysotile	<i>51%</i>				<i>50%</i>
yes/no				☐ yes ☒ no	1.630	Amosite					
yes/no				☐ yes ☒ no	1.700	Crocidolite					
yes/no				☐ yes ☒ no	1.605	Anthophyllite					
yes/no				☐ yes ☒ no	1.605	Tremolite					
yes/no				☐ yes ☒ no	1.605	Actinolite					
Cellulose Fiber ☐ non-uniform extinction ☐ fiber twisted											
Mineral Wool ☐ isotropic ☐ n > 1.55											
Glass Fiber ☐ isotropic ☐ n < 1.55											
Perlite											
Calcite											
Gypsum /Anhydrite							<i>TR</i>				<i>TR</i>
Vermiculite							<i>5%</i>				<i>5%</i>
Quartz											
Organic Binder											
Opakes							<i>4%</i>				<i>4%</i>
Other											

Comments

Date of Analysis

11-24-88

Analyst

H. Kirby

HYGELA INC.

Asbestos Analysis Worksheet

Client Name

Richard L. Lohr

HYGELA JOB# 5617

Client Identification

G16

HYGELA HB- 1786B

Date

11/23/88

Collected

Sample Location

Geocat

Gross Sample Description

Crystalline / metal

By: WLR

Date: 11/22

Friable?

☒ Yes ☐ No

Homogeneous?

☐ Yes ☒ No

Stereoscopically Estimated Fiber Percentages:

Magnification: ☐ 10X ☐ 20X ☐ 40X

Extinction parallel?	S i g n	Color	Birefr.	Pleochroic?	RI n =	Asbestos Type	Weight Percent Present				Average Weight %
							1	2	3	4	
yes/no	S	C	1	yes/no	1.550	Crysotile	45%				45%
yes/no				yes/no	1.580	Amosite					1
yes/no				yes/no	1.700	Crocidolite					
yes/no				yes/no	1.605	Anthophyllite					
yes/no				yes/no	1.605	Tremolite					
yes/no				yes/no	1.605	Actinolite					
☒ Cellulose Fiber				☐ non-uniform extinction			35%				35%
				☒ fiber twisted							
☐ Mineral Wool				☐ isotropic							
				☐ n > 1.53							
☐ Glass Fiber				☐ isotropic							
				☐ n < 1.53							
☐ Perlite											
☐ Calcite											
☐ Gypsum /Anhydrite											
☐ Vermiculite											
☐ Quartz											
☐ Organic Binder											
☒ Opacques							75%				75%
☐ Other											

Comments

Date of Analysis

11-24-88

Analyst:

WLR

HYGEIA INC.

AIR SAMPLE ANALYSIS - NIOSH ANALYTICAL METHOD NUMBER 7400

CLIENT: Richard S. Lirhy

HYGEIA JOB: 5617

DATE COLLECTED: 11/22/88

PHASE CONTRAST ☐

PHASE CONTRAST + P.L.M. ☒

CLIENT IDENTIFICATION	HYGEIA HA-	Time (min)	Rate (lpm)	Total Flow (l)	# Fields	Fibers Counted	Total fibers/cm ³	Asbestos fiber(%)	Asbestos fibers/cm ³	B.C.
1 07	2782B	50	9.7	485	100	0	<0.01	0%	—	
2 04	2783B	8.25	9.7	80.0	100	1.5	.01	30%	<0.1	
3 06	4B	11.30	9.5	107.4	100	1	<0.01	11%	1.1	
4 08	5B	17.25	9.75	190.6	100	5	.01	25%	<0.1	
5										
6										
7										
8										

SAMPLING DETAILS OF THE ABOVE (PROCESS, LOCATION OF PUMP, NAME OF INDIVIDUAL MONITORED)

1	Baker Room Back ground
2	Room asbestos removal
3	Room Packing removal
4	General filling hole operation
5	
6	
7	
8	

* percentage of asbestos fibers in entire sample wedge

$$C(F/cm^3) = \frac{(\text{Fibers Counted} - B.C.) \times 355 \text{ mm}^2}{(\# \text{ Fields}) \times 7.35 \times \text{Total Flow}(l)}$$

Filter Series: _____

Date of Analysis: 11/25/88

Analyst: Richard S. Lirhy

COMMENTS	Low sample volumes use standard routine method
	11/24 - 11/25/88
	2782B - 2783B - 4B - 5B

HYGZIA INC. Project No. 5617

HYGZIA INC.

APPENDIX B

ANALYTICAL TRANSMISSION ELECTRON MICROSCOPY RESULTS

Report Date: 03/06/89

Page 1

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 01
Sample Location: Boiler Room Background

HYGEIA Project #S617
HYGEIA Batch 88 Nov 01
HYGEIA ID ET98-3279

DATA SUMMARY

Sample Volume (liters): 480.0	Date of Collection: 11/23/88
Sample Collected by: C. Spooner	
Filter Type: Millipore	Filter Diameter: 25 mm.
TEM Analyst: W. Cranton	Date of Analysis: 03/03/89
Number of Structures: 1	
Grid Openings: 22	Grid Opening Area (mm ²): 0.007139
	Total Grid Area
	Analyzed (mm ²): 0.158158

SUMMARY OF ANALYSIS

Total Structure Count (s/cc)	0.005
Total Structure Count (s/mm ²)	6.323
Asbestos Structure Count (s/cc)*	ND
Asbestos Structure Count (s/mm ²)*	ND
Asbestos Structure Mass (ng/m ³)*	ND
Asbestos Structure Concentration (s/cc)*	ND
for all structures greater than 5 microns in length with an aspect ratio of 5:1 or greater.	
Analytical Sensitivity (s/cc)	0.005

*Includes Ambiguous Structures
Ref: TEM/Form1

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 01
Sample Location: Boiler Room Background

HYGZLA Project #5617
HYGZLA Batch 88 Nov 01
HYGZLA ID HT38-1279

STRUCTURE LISTING

----- Microns -----				Mass	Aspect		EDAX					
Length	Width	Thickness	Ident	Form	(Picoqm)	Ratio	SAED	MG	SI	CA	FE	NA
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mid #1: No Structures Encountered												
Mid #2: No Structures Encountered												
Mid #3: No Structures Encountered												
Mid #4: No Structures Encountered												
Mid #5:												
1.653	0.127	0.000	Calc. Fiber		2.10E-2	13						
Mid #6												
through												
Mid #22: No Structures Encountered												

Report Date: 03/06/89

Page 1

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 03
Sample Location: Gasket Removal

HYGZIA Project #5617
HYGZIA Batch 88 Nov 01
HYGZIA ID HT88-3280

DATA SUMMARY

Sample Volume (liters): 80.8	Data of Collection: 11/23/88
Sample Collected by: C. Spooner	
Filter Type: Millipore	Filter Diameter: 25 mm.
TEM Analyst: M. O'Halloran	Date of Analysis: 03/01/89
Number of Structures: 17	
Grid Openings: 135	Grid Opening Area (mm ²): 0.007189
	Total Grid
	Analyzed (mm ²): 0.970515

SUMMARY OF ANALYSIS

Total Structure Count (s/cc)	0.083
Total Structure Count (s/mm ²)	17.517
Asbestos Structure Count (s/cc)*	0.005
Asbestos Structure Count (s/mm ²)*	1.030
Asbestos Structure Mass (ng/m ³)*	0.414
Asbestos Structure Concentration (s/cc)*	ND
for all structures greater than 5 microns in length with an aspect ratio of 5:1 or greater.	
Analytical Sensitivity (s/cc)	0.005

*Includes Ambiguous Structures
Ref: TEM/FORM1

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 03
Sample Location: Gasket Removal

HYGELA Project #5617
HYGELA Batch 88 Nov 01
HYGELA ID ET38-3280

STRUCTURE LISTING

----- Microns -----						Mass	Aspect		EDAX
No	Length	Width	Thickness	Ident	Form	(Picogram)	Ratio	SAED	MG SI CA FE NA
---	---	---	---	---	---	---	---	---	-----
Grid #1	No Structures Encountered								
Grid #2:	No Structures Encountered								
Grid #3:	No Structures Encountered								
1	2.263	0.151	0.000	Callu	Fiber	4.04E-2	15	None	Non Asbestos
Grid #4 through Grid #14:	No Structures Encountered								
Grid #15:	No Structures Encountered								
1	2.369	0.113	0.000	Callu	Fiber	2.61E-2	20	None	Non Asbestos
Grid #16:	No Structures Encountered								
Grid #17:	No Structures Encountered								
0.888	0.059	0.000	NonAsb	Fiber	4.92E-3	15	None	Non Asbestos	
Grid #18 through Grid #22:	No Structures Encountered								
Grid #23:	No Structures Encountered								
2.665	0.059	0.000	Callu	Fiber	7.34E-3	45	None	Non Asbestos	
Grid #24:	No Structures Encountered								
Grid #25:	No Structures Encountered								
2.258	0.217	0.000	NonAsb	Fiber	2.89E-1	14		Non Asbestos	
Grid #26 through Grid #28:	No Structures Encountered								

microns -----		Ident	Form	Mass (Pico gm)	Aspect Ratio	SAED	EDAX				
h	Width Thkness						MG	SI	CA	FE	NA
---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	
2:											
5	0.059	0.000	Unknown Fiber	8.20E-3	25	None	Non Asbestos				
3:											
5	0.059	0.000	NonAsb Fiber	1.05E-2	32	None	Non Asbestos				
3	0.237	0.000	Callu Fiber	1.17E-1	11						
1:											
0	0.592	0.000	Callu Fiber	1.47E00	9						
2:			No Structures Encountered								
3:											
10	0.118	0.000	Callu Fiber	5.94E-2	46						
14											
152											
18:			No Structures Encountered								
19:											
30	0.176	0.000	NonAsb Fiber	1.92E-1	22		Non Asbestos				
40:			No Structures Encountered								
42:											
77	0.118	0.000	NonAsb Fiber	3.94E-2	15		Non Asbestos				
142											
ough											
167:			No Structures Encountered								
168:											
836	0.118	0.000	NonAsb Fiber	4.07E-2	15		Non Asbestos				
169											
ough											
174:			No Structures Encountered								
175:											
317	0.118	0.000	NonAsb Fiber	7.35E-2	26		Non Asbestos				
176											
ough											
100:			No Structures Encountered								
101:											
672	0.592	0.000	NonAsb 1/2Fibr	2.03E00	6						

----- Microns -----			Ident	Form	Mass (Picogram)	Aspect Ratio	SAED	EDAX				
Length	Width	Thickness						MG	SI	CA	FE	NA

rid #102:												
6	4.738	0.118	0.059	Chrysoc Bundle	8.44E-2	40	Faint	5	10	0	1	0

rid #103:				No Structures Encountered								
-----------	--	--	--	---------------------------	--	--	--	--	--	--	--	--

rid #104:				No Structures Encountered								
-----------	--	--	--	---------------------------	--	--	--	--	--	--	--	--

rid #105:												
7	3.554	0.592	0.000	NonAsb Fiber	1.97E00	6		Non Asbestos				

rid #106.												
-----------	--	--	--	--	--	--	--	--	--	--	--	--

through												
---------	--	--	--	--	--	--	--	--	--	--	--	--

rid #108:				No Structures Encountered								
-----------	--	--	--	---------------------------	--	--	--	--	--	--	--	--

ref: TEM/Form2												
----------------	--	--	--	--	--	--	--	--	--	--	--	--

Report Date: 03/06/89

Page 1

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 05
Sample Location: Packing Removal

HYGELA Project #5617
HYGELA Batch 88 Nov 01
HYGELA ID HT88-3281

ATA SUMMARY

Sample Volume (liters): 108.1	Date of Collection: 11/23/88
Sample Collected by: C. Spooner	
Filter Type: Millipore	Filter Diameter: 25 mm.
TEM Analyst: W. Cranton	Date of Analysis: 03/02/89
Number of Structures: 19	
Grid Openings: 99	Grid Opening Area (mm ²): 0.007189
	Total Grid Area
	Analyzed (mm ²): 0.711711

SUMMARY OF ANALYSIS

Total Structure Count (s/cc)	0.095
Total Structure Count (s/mm ²)	26.696
Asbestos Structure Count (s/cc)*	0.050
Asbestos Structure Count (s/mm ²)*	14.051
Asbestos Structure Mass (ng/m ³)*	25.042
Asbestos Structure Concentration (s/cc)*	0.005
for all structures greater than 5 microns in length with an aspect ratio of 5:1 or greater.	
Analytical Sensitivity (s/cc)	0.005

*Includes Ambiguous Structures
Ref: TEM/Form1.

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 05
Sample Location: Packing Removal

HYGELA Project #5617
HYGELA Batch 88 Nov 01
HYGELA ID HT38-J281

STRUCTURE LISTING

----- Microns -----					Mass	Aspect		EDAX					
No	Length	Width	Thickness	Ident	Form	(Picogram)	Ratio	SAED	MG	SI	CA	FE	Na
Grid #1 through Grid #6: No Structures Encountered													
Grid #7:													
1	6.358	0.636	0.064	Ambigu Clump		5.17E-1	10	None	8	10	0	12	1
Grid #8 through Grid #16: No Structures Encountered													
Grid #17:													
3	1.006	0.084	0.000	NonAsb Fiber		1.12E-2	12	None	Non Asbestos				
Grid #18: No Structures Encountered													
Grid #19:													
4	9.921	5.669	0.142	Unknown Matrix		1.60E01	2	None	Non Asbestos				
Grid #20 through Grid #23: No Structures Encountered													
Grid #24:													
5	3.135	0.838	0.084	Ambigu Matrix		4.50E-1	4	None					
Grid #25: No Structures Encountered													
Grid #26:													
6	1.844	0.084	0.000	NonAsb Fiber		2.04E-2	22	None	Non Asbestos				
Grid #27 through Grid #38: No Structures Encountered													
Grid #39:													
7	3.406	0.163	0.000	Cellul. Fiber		7.58E-2	21	None	Non Asbestos				

----- Microns -----			Ident	Form	Mass (Picogram)	Aspect Ratio	SAED	EDAX				
Length	Width	Thickness						MG	SI	CA	FE	NA
rid #83:												
2.444	0.136	0.000	Unknown Fiber		7.12E-2	16	None	Non Asbestos				
rid #84: No Structures Encountered												
rid #85:												
5.432	2.716	0.068	Unknown Fiber		2.01E00	2	None	9	10	0	1	0
rid #86 through												
rid #99: No Structures Encountered												

Asbestos Analysis by
Transmission Electron Microscopy

Client Name: Richard Kirby
Client Sample I.D.: 07
Sample Location: Breathing Zone
during whole operation

HYGEMA Project #5617
HYGEMA Batch 88 Nov 01
HYGEMA ID HT88-3282

DATA SUMMARY

Sample Volume (liters): 190.2	Date of Collection: 11/23/88
Sample Collected by: C. Spooner	
Filter Type: Millipore	Filter Diameter: 25 mm.
TEM Analyst: W. Cranton	Date of Analysis: 03/01/89
Number of Structures: 11	
Grid Openings: 56	Grid Opening Area (mm ²): 0.007139
	Total Grid Area
	Analyzed (mm ²): 0.402584

SUMMARY OF ANALYSIS

Total Structure Count (s/cc)	0.053
Total Structure Count (s/mm ²)	27.324
Asbestos Structure Count (s/cc)*	0.035
Asbestos Structure Count (s/mm ²)*	17.388
Asbestos Structure Mass (ng/m ³)*	174.127
Asbestos Structure Concentration (s/cc)*	0.025
for all structures greater than 5 microns in length with an aspect ratio of 5:1 or greater.	
Analytical Sensitivity (s/cc)	0.005

Includes Ambiguous Structures
as: TEM/Total

Asbestos Analysis by Transmission Electron Microscopy

Client Name: Richard Kirby

HYGELA Project #5617

Client Sample I.D.: 07

HYGELA Batch 88 Nov 01

Sample Location: Breathing Zone
during hole operations

HYGELA ID HT88-3282

***** STRUCTURE LISTING

----- Microns -----				Ident	Form	Mass (Picogram)	Aspect Ratio	SAED	EDAX				
No	Length	Width	Thickness						MG	SI	CA	FE	NA
Grid #1:	No Structures Encountered												
Grid #2:	No Structures Encountered												
Grid #3:	1.584	0.151	0.000	Callu	Fiber	2.63E-2	11	None					
Grid #4:	No Structures Encountered												
Grid #5:	No Structures Encountered												
Grid #6:	No Structures Encountered												
Grid #7:	3.017	0.377	0.075	Chryso	Bundle	2.18E-1	8	Faint	7	10	1	1	2
Grid #8:	9.805	2.263	0.075	Chryso	Clump	4.25E00	4	Faint	8	10	1	3	2
Grid #9:	8.296	0.151	0.000	Callu	Fiber	1.46E-1	55	None					
Grid #10:	5.279	0.225	0.000	Callu	Fiber	2.12E-1	23	None					
Grid #11:	No Structures Encountered												
Grid #12:	No Structures Encountered												
Grid #13:	5.759	5.759	0.096	Chryso	Matrix	8.09E00	1	None	5	10	0	2	2
Grid #14:	No Structures Encountered												
Grid #15:	No Structures Encountered												

HYGELA INC. Project No. 5617

HYGELA INC.

APPENDIX C
PUMP CALIBRATION WORKSHEETS

----- Microns -----			Ident	Form	Mass (Picogram)	Aspect Ratio	SAED	EDAX				
Length	Width	Thickness						MG	SI	CA	FE	NA
id #20												
10.538	1.440	0.000	NonAsb	Fiber	3.45E01	7	None	Non Asbestos				
id #21												
through												
id #39: No Structures Encountered												
id #40:												
9.642	6.026	0.121	Chryso	Matrix	1.78E01	2	None	6	10	0	2	0
id #41												
through												
id #43: No Structures Encountered												
id #44:												
48.758	0.480	0.048	Chryso	Bundle	2.85E00	102	Faint	8	10	0	1	0
9.118	0.960	0.048	Chryso	Bundle	1.07E00	10	None	8	10	0	1	0
4.799	0.768	0.048	Ambigu	Matrix	3.55E-1	6	None					
id #45												
through												
id #56: No Structures Encountered												

PUMP CALIBRATION SHEET

Name (Person Calibrating): M. J. Carter

Calibration Equipment: Buck
(Name, Model and Serial #)

6m-30

Serial # 8046

Calibration Location: Local

Temperature: _____

Atm. Pressure: 7.5

Pump No.: _____

Pump Manufacturer: BGT

M. J. Carter

Date/Time

Calculated Flow Rate

Initials

27	1.	11:30am 11/23/84	1 9.6 45 MCE	M. J. Carter
	2.		2 9.8 .8 MCE	
	3.			
32	4.		9.5 Tpm .8 MCE	
	5.		9.6 Tpm .45 MCE	
	6.			
28	7.		9.5 Tpm .45 MCE	
	8.		9.6 Tpm .8 MCE	
	9.			
	10.			

PUMP CALIBRATION SHEET

Name (Person Calibrating): J. H. K. Smith

Calibration Equipment: R. v. C.
(Name, Model and Serial #)

.4-30
Serial # 8041

Calibration Location: W. D. R.

Temperature: 70°F

Atm. Pressure: 1013

Pump No.: _____

Pump Manufacturer: BGE

M. H. P. & S.
Calculated Flow Rate

Date/Time

Initials

17	<	1. 4-30 11/22/00 9.65 US MCE		W. D. R.
		2. 9.1 8. MCE		
		3.		
28	<	4. 9.3 8. US MCE		
		5. 9.4 8. MCE		
		6.		
32	<	7. 9.7 8. MCE		
		8. 9.5 8. MCE		
		9.		
		10.		

HYGELA INC. Project No. 5617

HYGELA INC.

APPENDIX D

LETTER FROM A.W. CHESTERTON DESCRIBING
SAMPLING LOCATION AT THE WCBURN MASSACHUSETTS FACILITY

JAN 6 1989

A.W. CHESTERTON CO. SEALING DEVICES PUMP SYSTEMS TECHNICAL PRODUCTS
MIDDLESEX INDUSTRIAL PARK ROUTE 92 STONEHAM, MASS. 02180 U.S.A. TEL: 517-428-7000 TELEX: 24-3477 FAX: 517-428-8971 CABLE: CHESTERTON STONEHAM MASS

525-411

January 4, 1989

Mr. Richard B. Kirby, P.C.
20 Ashburton Place
Boston, MA 02108

Dear Sir:

Following is the information concerning the valve and boiler at our Woburn location, that air quality testing was done on:

Boiler - Cyclotherm Steam Generator
Serial No. - 14115
National Board - 10575
Maximum W.P. lbs. - 150
Type - CS-2100 CL-5-43
Heating Surface - 3.33
Steam lbs. per hour - 2070
Year - 1962

Valve - Walworth
Type - Gate, Main Stop
125 lb., 6" (pipe)

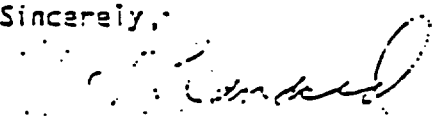
Packing - We believe the packing is Chesterton
Style 1722, size 3/8" c.s.

The boiler was taken out of service approximately July, 1985.

If you have further questions, please feel free to contact me.

Thank you.

Sincerely,


Neil Leonard
Manager of Plant Engineering

NL/yt

APPENDIX 2

ANALYTICAL TRANSMISSION ELECTRON MICROSCOPY

PHOTOMICROGRAPHS OF AIR SAMPLES



Figure 1. Sample of the mineralized zone, sample of
mineralized zone.



Figure 1. Chrysotile Bundle
Packing Removal

Sample 05



Figure 3. Chrysotile Matrix Sample of
Coastal Zone During Hole Operation

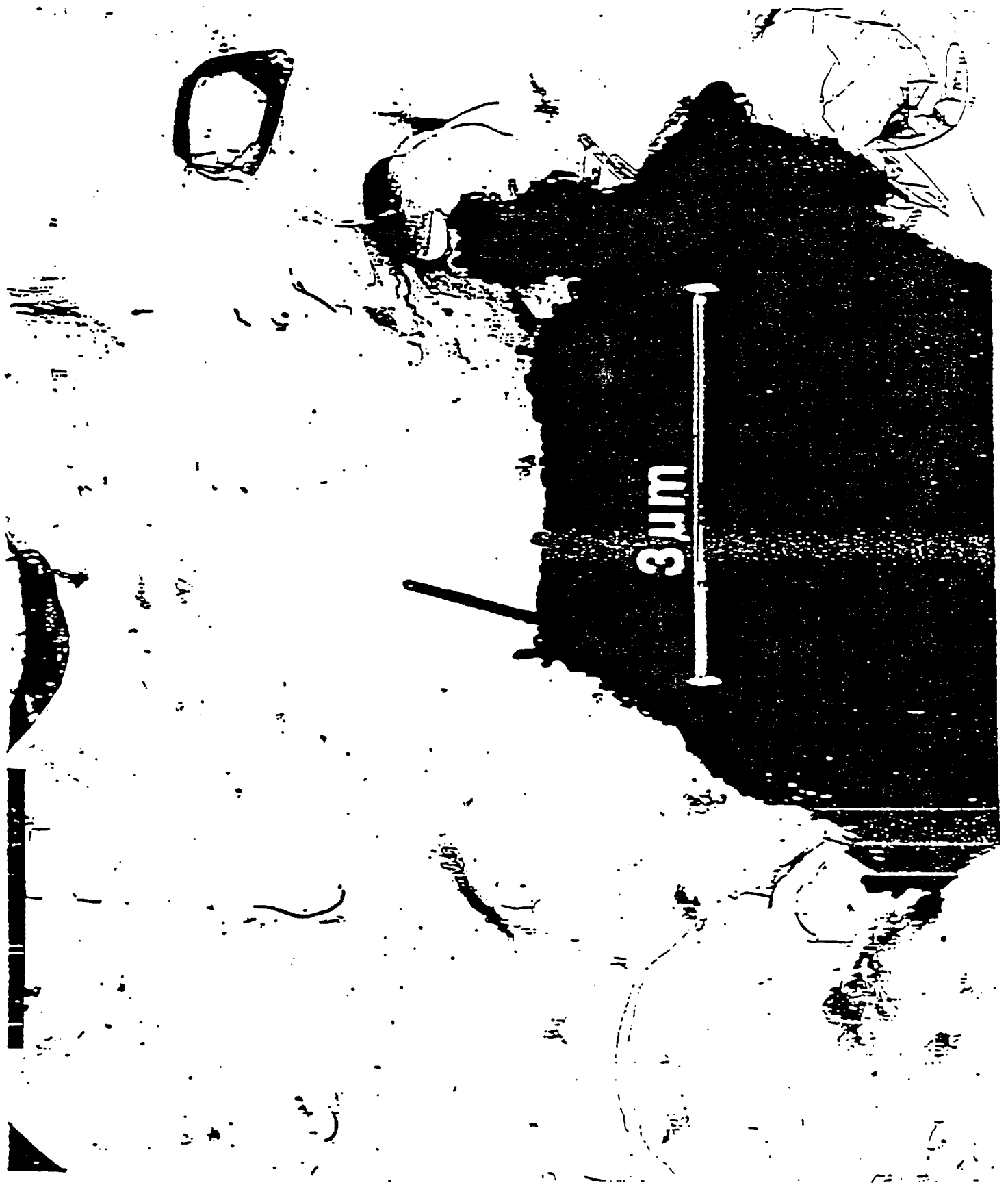


Figure 4. Chrysotile Matrix Sample 07
Breaching Zone During Hole Operation



Figure 5. Chrysotile Matrix Sample 37
Breathing Zone During Hole Operation

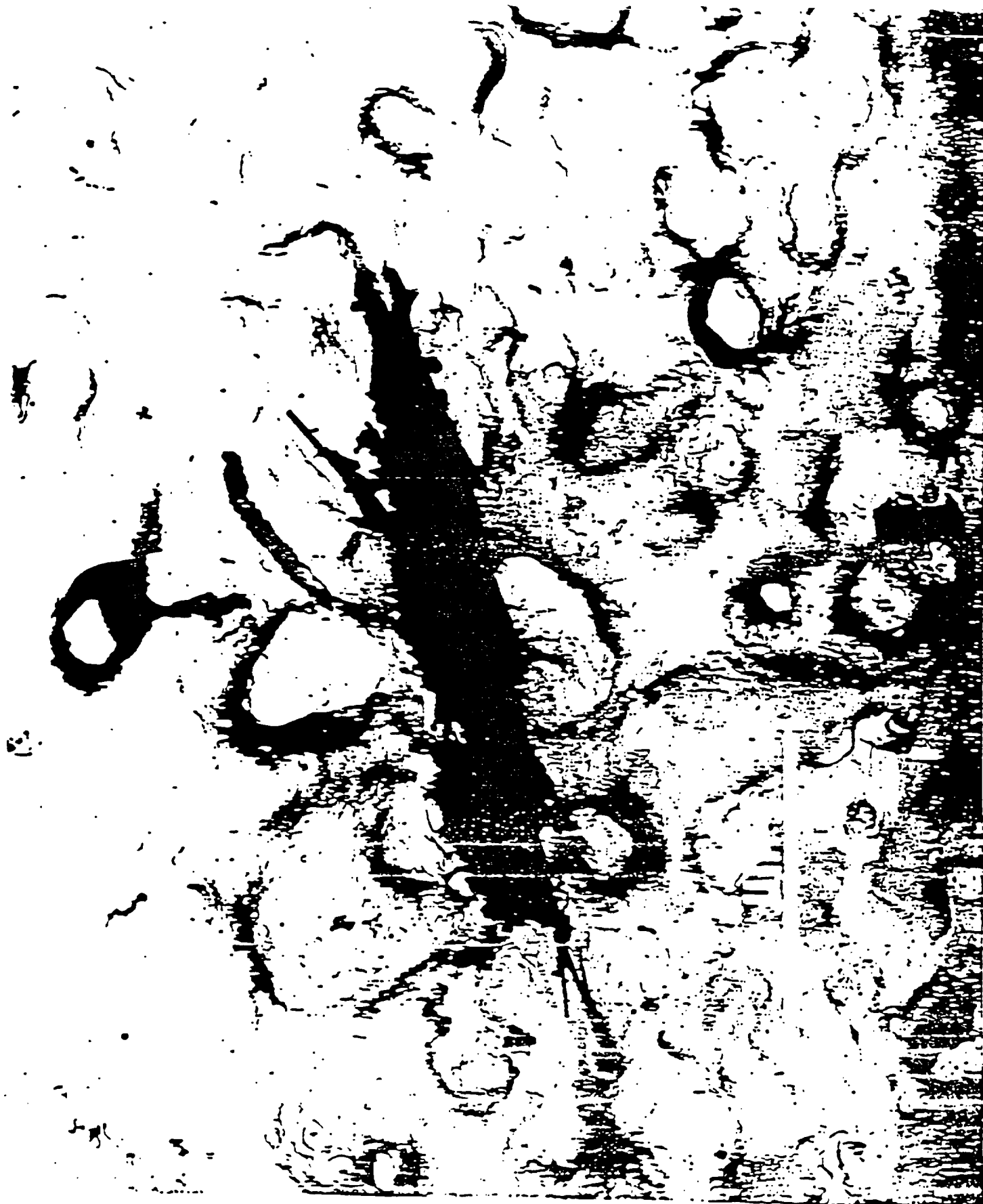


Figure 6. Chrysotile Matrix, Sample 07
Erosion Zone During Hole Operation