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DATE: 1976 TCA002

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DOCUMENT DESCRIPTION: Consultant Inspection Test Report #1481

REPORT

of

INDUSTRIAL HYGIENE TESTS

for

ASBESTOS FIBERS

conducted at

TILE COUNCIL OF AMERICA

PRINCETON, N.J.

on

July 29, 1976

TEST REPORT #1481

Prepared by:

ET

ROSSNAGEL & ASSOCIATES

Engineering & Technical Consultants

1999 Rt. 70 · Cherry Hill, N. J. 08034

Distribution:

Mr. Frank Bernett, Mgr. of Research (2 copies)
Mr. Bob Kleinans, Mgr. Technical Service

Report Issued: August 13, 1976

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APPENDIX

Paper entitled "O.S.H.A. Fiber & Mineral Dust Tests"
O.S.H.A. Standard, FEDERAL REGISTER, Vol. 40, October 9, 1975

I

INTRODUCTION

Tile Council of America requested ROSSNAGEL & ASSOCIATES to conduct industrial hygiene tests specifically for asbestos fibers at its plant in Princeton, N.J., as per Proposal #76-139, dated June 25, 1976.

The sampling was conducted on Thursday, July 29, 1976. Samples were taken, by means of approved Personal Air Samplers, from an employee working in the mixing room to simulate mixing conditions. The exposure to Johns-Manville asbestos fiber (Crysotile) occurs when a dry powder of silica and asbestos is mixed.

Mr. Bob Kleinans wore the Personal Sampling unit during the test.

The testing was done according to procedures established by O.S.H.A. as referenced in our paper entitled "O.S.H.A. Fiber & Mineral Dust Tests," which is included in the Appendix of this report.

The RESULTS & CONCLUSIONS are in Section II. Section III contains a DESCRIPTION OF TEST and Section IV, the DATA SHEETS, including an Events Log.

ROSSNAGEL & ASSOCIATES wishes to thank Mr. Frank Burnett and Mr. Bob Kleinans who willingly assisted whenever requested.

RESULTS & CONCLUSIONS

RESULTS

The results of the Asbestos Fiber Counting Test are shown in Table I below:

ASBESTOS FIBER COUNTING RESULTS

Sample No.	Personal Sample No.	Location/ Activity	FIBERS 5 μ or longer				Extrapolated TWA (3) 5 μ or longer fibers	Allowable Limit for TWA (4)
			Total Count	Avg. Count	Concentration Fibers/ ml (1)	Allowable Limit Fibers/ ml (2)		
1	P_1	Bob Kleinans Light Dust Conditions	24	1.20	6.84	Ceiling concentration is 10 fibers/ ml if 5 μ or longer	N/A*	Two fibers, ml if 5 μ or longer
2	P_2	Stationary Sample	28	1.40	1.00		1.00	
3	P_3	Bob Kleinans Heavy Dust Conditions	33	1.65	9.4		N/A*	

TABLE I

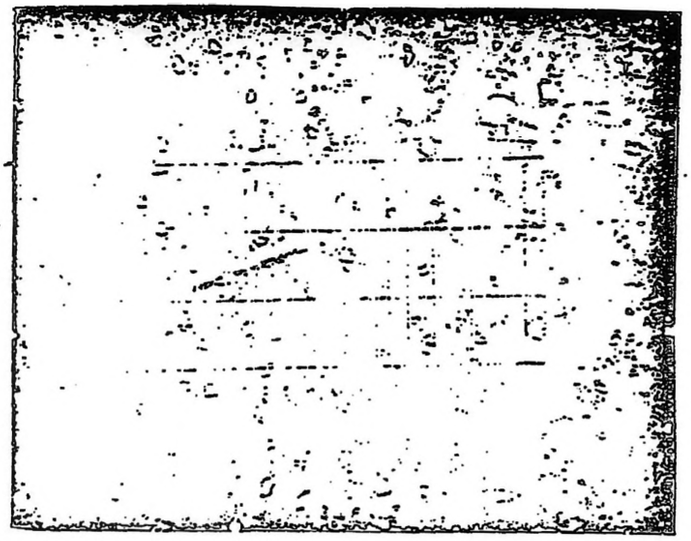
Notes: 1) Concentration of fibers/ml is calculated on basis of sample volume and area of membrane filter and microscope field area. Fibers counted are 5 microns or longer.

2) Allowable Limit is 10 fibers/ml ceiling limit in the size of 5 μ or longer, based on O.S.H.A. limit.

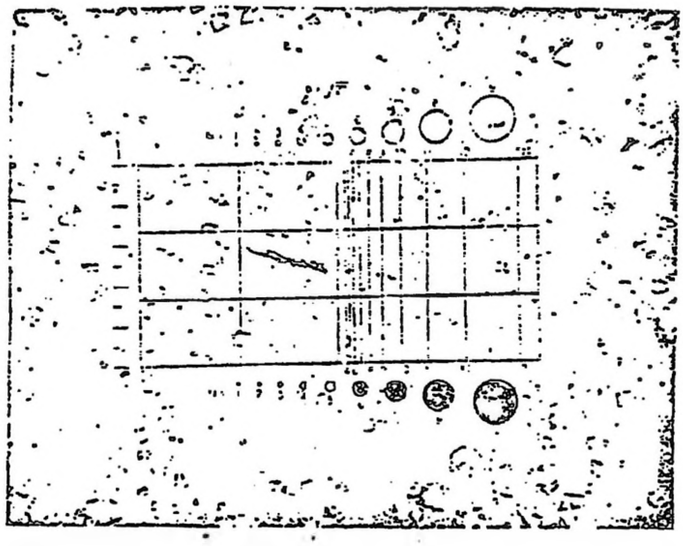
3) Extrapolated TWA is a mathematical calculation. TWA is Time Weighted Average. Fibers are 5 microns or longer.

4) Allowable limit for TWA is 2 fibers/ml in size of 5 μ or longer, based on O.S.H.A. limit as of July 1, 1976. See discussion on Page 6.

* Not applicable.



Photomicrograph showing large asbestos fiber in the size range of 35-37 microns. Note the split end characteristic of asbestos.



Photomicrograph view showing smaller asbestos bundle of fibers about in the size range of 15-25 microns.

Note: All photomicrographs are shown at a magnification of .520 X using phase contrast optics.

CONCLUSIONS

Table I shows that Samples #1, #2, and #3 for the day sampled, July 29, 1976, are within the allowable limit of exposure to asbestos dust concentrations of ten fibers (ceiling concentration) for a minimum of 15 minutes in any hour of any working day. It also shows that Sample #2 is within the allowable Time Weighted Average exposuse limit of 2 fibers/ml. The backup Time Weighted Average calculations are shown in Section IV for each run. It is based on asbestos exposure during the time sampled.

The previous national emission standard (effective June 7, 1972) for asbestos, published in FEDERAL REGISTER, Vol. 36, No. 235, Pages 2342-2343 by the E.P.A., and in FEDERAL REGISTER, Vol. 37, No. 110, Pages 11318-11322 by O.S.H.A., states: "The proposed standard would limit occupational exposure to 8-hour Time Weighted Average (TWA) airborne concentrations of asbestos dust not exceeding five fibers longer than five micrometers per milliliter. Concentrations above five fibers, but not to exceed ten fibers (ceiling concentration), would be permitted up to 15 minutes in an hour, but not for more than 5 hours in any one 8-hour day."

The new proposed national emission standards (effective July 1, 1976) for asbestos, published in FEDERAL REGISTER, Vol. 40, No. 197, Pages 47652-47665 by O.S.H.A., lowers the permissible exposure to two fibers for an 8-hour Time Weighted Average exposure. These standards are now in effect.

Under the O.S.H.A. limits effective as of July 1, 1976, only sample #2 is within the TWA limit of 2 fibers/ml.

O.S.H.A. presently requires periodic monitoring at intervals no longer than six months (membrane filter method). Medical surveillance

is required for all workers who are exposed to asbestos as part of their work environment. Required components of a medical surveillance program include periodic measurement of pulmonary function (forced vital capacity (FVC)), forced expiratory volume for 1 second (FEV_1) and periodic chest roentgenograms (posterior-anterior 14" x 17").

The use of respirators and protective clothing may vary depending on concentrations of asbestos dust at peak work intervals or based on Time Weighted Averages per testing interval. Recommendations for respirator types and protective clothing necessary when exposed to asbestos dust can be found in OCCUPATIONAL EXPOSURE TO ASBESTOS by NIOSH, 1972.

III

DESCRIPTION OF TEST

Miss Elizabeth Mahaffy, Chemist/Biologist, and Mr. Joseph Grella, Project Engineer, conducted the sampling. They arrived at the plant at 9:00 A.M. The sampling was completed by 12:00 P.M. After a brief discussion with Mr. Frank Burnett and Mr. Bob Kleinans, Miss Mahaffy and Mr. Grella left the plant.

Three-Millipore Membrane Filter Cassettes were utilized with the Bendix Personal Samplers to obtain the integrated samples. The membrane filter cassettes were returned to the lab for analysis. A representativ section of the filter was cut, properly mounted on a glass microscope slide using a 1:1 mixture of dimethyl phthalate and diethyl oxalate and examined at a magnification of 400X using phase contrast optics. The number and length range of the fibers observed in a given area under the microscope was recorded and this figure was used to calculate the number of fibers per cubic centimeter (or milliliter) of air sampled.

Photomicrographs of asbestos fibers found were made to illustrate how the concentration of asbestos is visually counted. Fibers having an aspect ratio of 3:1 and which were 5 microns or larger were counted. A minimum of 20 fields was examined and then the fiber count totaled.

This is an exceedingly skilled and painstaking operation requiring 2-3 hours for each filter under microscopic examination. See the additional words in Procedure #113 included in the "O.S.H.A. Fiber & Mineral Dust" paper which can be found in the Appendix.

IV

CALCULATIONS

Total Fiber Concentration

Daily Average Weighted Exposure

Job Name TILE COUNCIL OF AMERICA

Engineering & Technical Consultants
1999 Rt. 70 • Cherry Hill, N. J. 08003

Made by [illegible]

Checked by DJF

Description MILLIPORE MEMBRANE FILTER : PERSONAL SAMPLER P#1

FILTER AREA = 855 mm^2
FIELD AREA = .005 mm^2
$k = \frac{855\ mm^2}{.005\ mm^2}$
k = 171,000

FORMULA: $\frac{(\text{Average Net Count})(171{,}000)}{\text{Air Volume Sampled, ml.}} = \text{FIBERS/ml.}$

SAMPLING RATE: 2.0 LPM

SAMPLING TIME: 15.0 min.

SAMPLING VOLUME: RATE x TIME

2.0 LPM x 15.0 min. = 30 liters
30,000 mls.

TOTAL FIBERS COUNTED: 24

AVERAGE NET COUNT (20 FIELDS): 1.2

CALCULATION:

FIBER CONCENTRATION (5μ or Longer) $= \frac{(1.2)(171{,}000)}{30{,}000} = 6.84$ FIBERS/ml.

Southeastern Division
250 ARIZONA AVE., N. E.
ATLANTA, GA. 30307
(404) 577-2139

Form #RA-73

Job Name TILE COUNCIL OF AMERICA

Engineering & Technical Consultants
1999 Rt. 70 • Cherry Hill, N. J. 08003

Made by [illegible]

Checked by JFF

Description MILLIPORE MEMBRANE FILTER : PERSONAL SAMPLER P#2

FILTER AREA = 855 mm^2
FIELD AREA = .005 mm^2
$k = \frac{855\ mm^2}{.005\ mm^2}$
k = 171,000

FORMULA: $\frac{(\text{Average Net Count})(171{,}000)}{\text{Air Volume Sampled, ml.}} = \text{Fibers/ml.}$

SAMPLING RATE: 2.0 LPM

SAMPLING TIME: 120.0 min.

SAMPLING VOLUME: RATE x TIME
2.0 LPH x 120 min. = 240 liters
240,000 ml.

TOTAL FIBERS COUNTED: 28

AVERAGE NET COUNT (20 FIELDS): 1.4

CALCULATION:

FIBER CONCENTRATION (5μ or Longer) $= \frac{(1.4)(171{,}000)}{240{,}000} = 1.0$ Fibers/ml.

Southeastern Division
250 ARIZONA AVE., N. E.
ATLANTA, GA. 30307

Form #RA-73

Page 10

SALDIBAR-TCNA 1763

TILE COUNCIL OF AMERICA

Engineering & Technical Consultants

1999 Rt. 70 • Cherry Hill, N. J. 08003

Made by [illegible]

Checked by MF

Description MILLIPORE MEMBRANE FILTER : PERSONAL SAMPLER P#.7

FILTER AREA = 855 mm^2

FIELD AREA = .005 mm^2

$k = \frac{855\ mm^2}{.005\ mm^2}$

k = 171,000

FORMULA:

$$\frac{(\text{Average Net Count})(171{,}000)}{\text{Air Volume Sampled, ml.}} = \text{Fibers/ml.}$$

SAMPLING RATE: 2.0 LPM

SAMPLING TIME: 15.0 min.

SAMPLING VOLUME: RATE x TIME

2.0 LPM x 15.0 min. = 30 liters

30,000 mls.

TOTAL FIBERS COUNTED: 33

AVERAGE NET COUNT (20 FIELDS): 1.65

CALCULATION:

$$\text{FIBER CONCENTRATION (5}\mu\text{ or Longer)} = \frac{(1.65)(171{,}000)}{30{,}000} = 9.4 \text{ Fibers/ml.}$$

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(404) 377-4248

Form #RA-73

V

DATA SHEETS

Events Log

Lab Data Sheets

THE CORDAN CO. OF AMERICA JOB DAY [illegible]

PRINCETON, N.J. LOCATION DATE 7-29-74

EVENTS LOG

TIME	EVENT	ISOKINETIC PARAMET
9:03 AM	Arrived at Plant (E.M. & J.G.)	T_M = ____ $\%H_2O$ = ____ P_s/P_M = ____ C = ____
9:05 AM	Met with Mr. Frank Burnett and Mr. Bob Kleinans	
9:15 AM	Discussed sampling and conditions.	
9:36 AM	Set up Pump #5 using filter P1-Tile on Mr. Bob Kleinans - Mgr. Technical Service under minimum dust conditions - 2 LPM	T_S = ____ THEO. NOZZLE = ____ PITOT = ____
9:36 AM	Set up Stationary sampling pump #6 using filter P2-Tile on table near mixing operation to sample for 2 hours Rate = 2 LPM	T_M = ____ $\%H_2O$ = ____ P_s/P_M = ____ C = ____
9:51 AM	Stopped Pump #5 using filter P1-Tile	T_S = ____ THEO. NOZZLE = ____ PITOT = ____
10:06 AM	Started Pump #5 using filter P3-Tile on Mr. Bob Kleinans under maximum dusty conditions. Rate = 2 LPM	
10:21 AM	Stopped Pump #5 using filter P3-Tile	
11:00 AM	Met with Dr. J. V. Fitzgerald, Executive Director	
11:30 AM	Stopped Pump #6 - stationary sampling	
12:00 PM	After brief discussion with Mr. Bob Kleinans and Mr. Frank Burnett, E. Mahaffy and J. Grella left the plant. VISITORS LOG	

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ROSSNAGEL & ASSOCIATE
Engineering & Testing Consultants
1999 RT. 70
CHERRY HILL, N. J. 08003

1999 Rt. 70 • Cherry Hill, N.J. 08003

Lab # 535
Job # 1481
Job Name TILE COUNCIL OF AMERICA
Sample PERSONAL SAMPLE P-1

Date 5/6/76
Made by E.A. Mahaffey
Checked by DF Not

PARTICLE OR FIBER MICRON SIZE DISTRIBUTION BY COUNT

Magnification 400X
Classification ASBESTOS FIBER
Type Reticle PORTON
Operation MIXING
Sampling Method MEMBRANE FILTER
Sample Time 15.0 min.

Field No.	Lat.	Long.	PARTICLE SIZE OR FIBER LENGTH						
			<.5 μ	.5-5 μ	5-10 μ	10-20 μ	20-50 μ	50-100 μ	>100 μ
1	96	65			1		1		
2	97	64				1			
3	98	64			3				
4	99	63			1				
5	100	67							
6	101	66							
7	102	65			2				
8	103	64			1		1		
9	104	63			2	1			
10	105	62				1			
11	106	61							
12	107	60				1	1		
13	108	70				1			
14	109	69							
15	110	68			1	1			
16	107	67			1				
17	104	66					1		
18	105	65							
19	104	64			1				
20	103	63			1				
Totals			0	0	14	6	4	0	0
Percent			0	0	58.3	25.0	16.7	0	0

Note: 1. Must count at least 100 fibers or a minimum of 20 fields.
2. Count only fibers having an aspect ratio of at least 3:1 and a length of 5 microns or larger.
3. Latitude is left-to-right on filter. Longitude is in-and-out on filt
4. This distribution IS NOT on a weight basis.

Average Fiber Count 1.2
Total Fibers Counted 24

1999 Rt. 70 • Cherry Hill, N.J. 08003

Lab # 535
Job # 1481
Job Name TILE COUNCIL OF AMERICA
Sample PERSONAL SAMPLE P-2

Date 2/6/76
Made by E.A. Mahaffey
Checked by [illegible]

PARTICLE OR FIBER MICRON SIZE DISTRIBUTION BY COUNT

Magnification 400X
Type Reticle PORTON
Classification ASBESTOS FIBER
Operation MIXING
Sampling Method MEMBRANE FILTER
Sample Time [illegible] min.

Field No.	Lat.	Long.	PARTICLE SIZE OR FIBER LENGTH						
			<.5 μ	.5-5 μ	5-10 μ	10-20 μ	20-50 μ	50-100 μ	>100 μ
1	90	38							
2	91	37			2				
3	92	39			2	1			
4	93	40					1		
5	94	39				1			
6	95	37				1			
7	96	37			1				
8	97	36				1			
9	98	35				1			
10	99	34							
11	100	33				1			
12	101	33			2	1			
13	102	32			1	1			
14	103	31			1	2			
15	104	30							
16	105	30			2				
17	104	33				1			
18	105	33			1				
19	103	39				1	1		
20	101	40			2				
Totals			0	0	14	12	2	0	0
Percent			0	0	50.0	42.8	7.2	0	0

Note: 1. Must count at least 100 fibers or a minimum of 20 fields.
2. Count only fibers having an aspect ratio of at least 3:1 and a length of 5 microns or larger.
3. Latitude is left-to-right on filter. Longitude is in-and-out on fil
4. This distribution IS NOT on a weight basis.

Average Fiber Count 1.4

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Lab # 535
Job # 1481
Job Name TILE COUNCIL OF AMERICA
Sample PERSONAL SAMPLE P-3

Date 8/6/76
Made by E.A. Mahaffey
Checked by

PARTICLE OR FIBER MICRON SIZE DISTRIBUTION BY COUNT

Magnification 400X
Classification ASBESTOS FIBER
Type Reticle PORTON
Operation MIXING
Sampling Method MEMBRANE FILTER
Sample Time 15.0 min.

Field No.	Lat.	Long.	PARTICLE SIZE OR FIBER LENGTH						
			<.5 μ	.5-5 μ	5-10 μ	10-20 μ	20-50 μ	50-100 μ	>100 μ
1	160	13			1		1		
2	161	12			1				
3	162	14			1				
4	163	15				1			
5	164	14			1		1		
6	165	13			2				
7	166	12							
8	167	11							
9	168	10			1	2			
10	169	9							
11	110	8			3				
12	110	19			2	2			
13	111	18				3			
14	112	17			1		1		
15	113	16				1			
16	113	15			1	1			
17	112	14							
18	111	13			1		1		
19	110	12				1			
20	109	11			1	2			
Totals			0	0	16	13	4	0	0
Percent			0	0	48.5	39.4	12.1	0	0

Note: 1. Must count at least 100 fibers or a minimum of 20 fields.
2. Count only fibers having an aspect ratio of at least 3:1 and a length of 5 microns or larger.
3. Latitude is left-to-right on filter. Longitude is in-and-out on fil
4. This distribution IS NOT on a weight basis.

Form P# 1300 -16- Average Fiber Count 1.65
Total Fibers Counted 33

SALDIBAR-TCNA 1769

APPENDIX

Paper entitled "O.S.H.A. Fiber & Mineral Dust Tests"

O.S.H.A. Standard, FEDERAL REGISTER, Vol. 40, October 9, 1975

O.S.H.A FIBER & MINERAL DUST TESTS

by: Don Frost, Lab Manager &
Elizabeth Mahaffy, Chemist
ROSSNAGEL & ASSOCIATES
Cherry Hill, N. J. &
Atlanta, Georgia &
Painesville, Ohio

The Williams-Steiger Occupational Safety and Health Act of 1970, commonly known as O.S.H.A. regulations, contains over 7,000 codes. In this paper we will review three of the substances, asbestos, silica, and cotton dust, which N.I.O.S.H. (National Institute of Safety & Health a branch of O.S.H.A., placed emphasis upon when they initiated their Target Health Hazards Program in January of 1972. N.I.O.S.H. maintains a current list of criteria standards for exposure to more than twenty hazardous materials.

The O.S.H.A. codes require that effective August 27, 1971, (except for asbestos) all plants with employees exposed to dust or fibers be provided with protective equipment and the operation analyzed to determi if the contaminates can be eliminated or reduced at the source. This means that it is not enough just to give the operator a breathing mask - but rather definite steps must be taken to reduce the contaminate level. The similar effective date for asbestos was June 7, 1972.

A detail analysis of the requirements of these three materials follows:

Asbestos is a general term used to describe several fibrous mineral silicates that occur as white, gray/blue or green masses, either compact or of long silky fibers. The most important types are: Chrysolite - a simple magnesium silicate; amosite - a complex magnesium iron silicate; crocidolite - a complex sodium iron silicate. Some 95 percent of the world asbestos production comes from chrysolite. The principal danger o asbestos fibers is caused by inhaling. Prolonged inhalation of asbestos fibers between 5 and greater microns (one-millionth of a meter or 1/25,000 of an inch) long can produce a lung disease known as asbestosis The nasal pharangeal area and bronchial tubes tend to trap out the non respirable particulates and then dispel them by ciliary action. If this exposure continues for 10 to 20 years, the tissue reaction progresses until a generalized, diffuse fibrosis occurs, causing severe respiratory disability including lung cancer. The respirable dust may cause a mesotheloma (layer of the lung or gut lining) tumor to develop or even gastro-intestinal cancer.

The analysis of filters containing asbestos fibers is much more difficult. This requires at least a $3,000 trioctal microscope with phase contrast optics and an attached focusable Polaroid camera. The microscope should be located in a laminar flow booth or in a separate, clean room with temperature and humidity controls. Most important, it requires a skilled technician trained in the filter handling and optical procedures and with the patience to perform the required statistical sam pling techniques. Figures on Pg. 4 show asbestos fibers at various magn fications and with the Porton recticle as background. The statistical

counting plan requires counting fibers as described above in the Analysis section. Sometimes it is necessary to count the fibers in 100 or more "fields" in the Porton recticle. This has been compared with searching on your hands and knees to count four leaf clovers in a one acre field!

The O.S.H.A. codes currently require every employee exposed to asbestos fibers to be tested at least every six months and the records be maintained for review by O.S.H.A. representatives. O.S.H.A. codes state employers shall provide a medical examination within 30 days of the employees' first occupational exposure to asbestos and provide at least an annual examination thereafter. Also an examination is required within 30 days of termination of employment. These requirements are fully detailed in Reference (10).

Many plant engineers/hygienists are not aware that on July 1, 1976, the O.S.H.A. limits on airborne asbestos will become more restrictive as shown in Table A. The future proposed codes are also shown below.

SUMMARY OF ASBESTOS REQUIREMENTS

Primary Requirements	Present Code Since 6/7/72	Effective Code On 7/1/76	Proposed Code
1. Allowable Ceiling Limit	10 fibers*/ ml	10 fibers*/ ml	5 fibers* /ml
2. Allowable TWA (Time Weighted Average for 8 hours exposure)	5 fibers*/ ml	2 fibers*/ ml	.5 fibers* /ml
* fiber defined as larger than 5 microns in length and having an aspect ratio of at least 3:1.			

TABLE A

On the following page are the actual results of an asbestos test conducted by ROSSNAGEL & ASSOCIATES. The Table I results, listed in the column headed "Extropolated TWA 5 μ or longer fibers" shows one man's exposure above the 5 fiber limit (the limit allowed through July 1, 1976 and three men exposed to a level above 2 fibers (the planned new allowable limit effective after July 1, 1976).

These asbestos levels were reached in a process using asbestos pallets.

On Page 4 are photomicrographs showing the high density of asbestos fibers in this test. The photomicrographs show fibers of 5, 10 and 27 microns in size.

RESULTS & CONCLUSIONS

RESULTS

The results of the Asbestos Fiber Counting Test are shown in Table I below:

ASBESTOS FIBER COUNTING RESULTS

Sample No.	Personal Sample No.	Location/ Activity	FIBERS 5 μ or longer				Extrapolated TWA (3) 5 μ or longer fibers	Allowable Limit for TWA (4)
			Total Count	Avg. Count	Concentration Fibers/ ml (1)	Allowable Limit Fibers/ ml (2)		
1	P39	Mr. Caster Casting Dept.	121	6.05	2.22	Ceiling concentration is 10 fibers/ ml if 5 μ or longer.	2.22	Five fibers/ ml if 5 μ or longer
2	P40	Mr. General Helper Kiln Dept.	89	4.45	1.59		1.59	
3	P41	Mr. Hand Molder Mold Dept.	514	25.7	9.16		9.16	
4	P46	General Serviceman Mold Dept.	207	10.4	3.90		3.90	

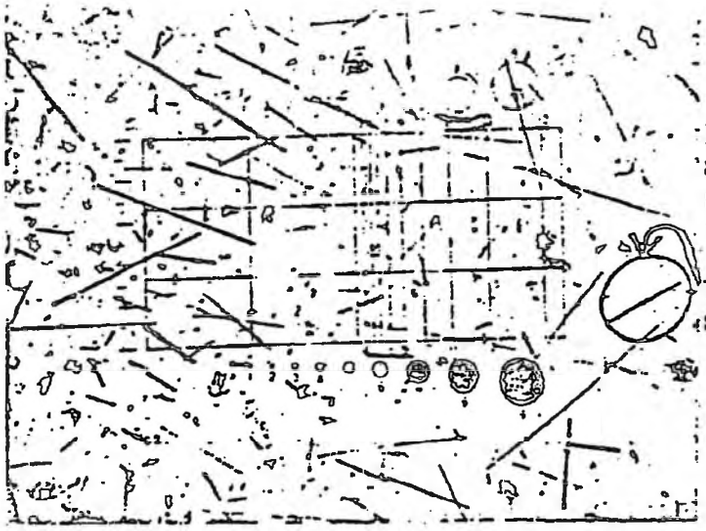
TABLE I

Notes: 1) Concentration of fibers/ml is calculated on basis of sample volume and area of membrane filter and microscope field area.

2) Allowable Limit is 10 fibers/ml ceiling limit in the size of 5 μ or longer, based on O.S.H.A. limit.

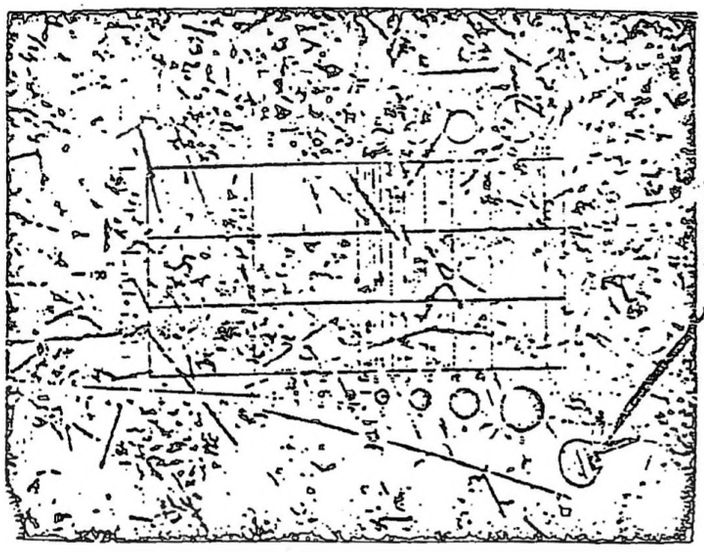
3) Extrapolated TWA is a mathematical calculation. TWA is Time Weighted Average.

4) Allowable limit for TWA is 5 fibers/ml in size of 5 μ or longer, based on O.S.H.A. limit. It is expected July 1, 1976, this limit will be changed to 2 fibers/ml. See discussion on Page 7.



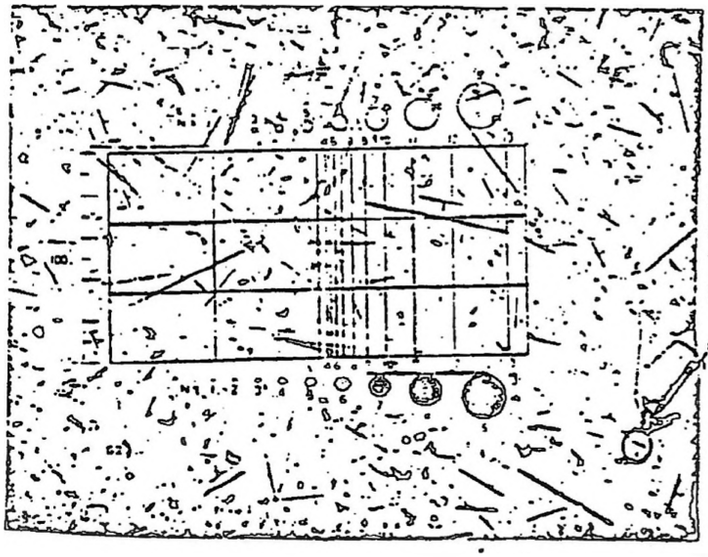
Photomicrograph showing numerous asbestos fibers of varying micron sizes found in the Personal Sampling.

This fiber is about 27 microns in size.



Photomicrograph showing asbestos fibers with particulate matter from the molding department.

This fiber is 10 microns in size.



Photomicrograph showing numerous small fibers as well as a few of the larger asbestos fibers. Notice fringed or split end of large fiber

This fiber is 5 microns in size.

All photomicrographs are taken at 520X magnification using phase contrast optics.

Silica is an oxide of silicon and is the characteristic ingredient of a great variety of minerals, including quartz, cristobalite, tridymite amethyst, and sand. It is widely used in cores for metal casting operations, ceramics, decorative materials, insulations, floor tile, building materials and glass. Inhalation of these particles can produce rapidly-developing (acute) or chronic silicosis - a disabling lung disease. Typically the lung tissue reacts to the presence of silica particles by forming fibrous matter around the particle. Evidence suggests that particles below one micron (one-millionth of a meter) in size may be the most dangerous since they may penetrate deeper into the lungs in high concentrations (See Figure I). In rapidly developing silicosis, symptoms appear 8 to 18 months after the first exposure. Chronic silicosis, the type usually encountered in industry, generally, is produced only after years of silica inhalation. The symptoms for either type are the same - slowly increasing difficulty in breathing under exertion. In some worker large masses of dense fibrous tissue develop in the upper portion of the lungs, leading to severe respiratory crippling. Tuberculosis is a freque complication of silicosis.

Listed below is a summary of the mineral dust (silica) limits. These requirements are fully detailed in Reference (11).

SUMMARY OF O.S.H.A. MINERAL DUST LIMITS

Silica:

Crystalline:

Quartz (respirable)---------- $\frac{10mg/M^3}{\%\text{ respirable quartz} + 2}$

Quartz (total dust)---------- $\frac{30mg/M^3}{\%\text{ quartz} + 2}$

Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz.

Tridymite: Use ½ the value calculated from the formulae for quartz

Amorphous, including natural diatomaceous earth. $\frac{80mg/M^3}{\%SiO_2}$

Coal dust (respirable fraction less than 5% quartz)---------- $2.0mg/M^3$

For more than 5% quartz---------- or $\frac{10mg/M^3}{\%\text{ respirable quartz} + 2}$

Inert or Nuisance Dust:

Respirable fraction---------- $5mg/M^3$

Total dust---------- $15mg/M^3$

Notes:

1) Respirable dust consists of particles which are .5 to 10 microns in diameter.
2) mg = milligram
3) M^3 = cubic meter

TABLE B

DUST PENETRATION INTO LUNGS

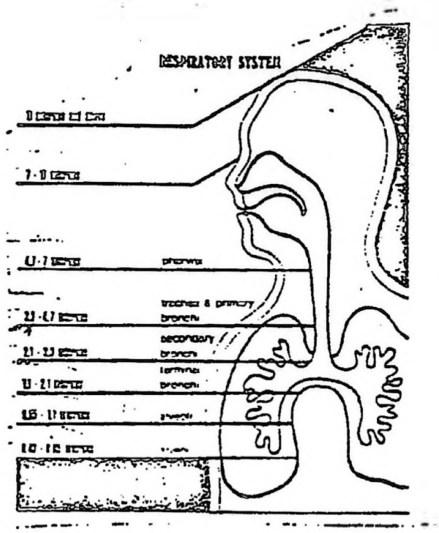


FIGURE I

On the following pages are the actual results of dust and silica tests conducted by ROSSNAGEL & ASSOCIATES. Remember, in testing for silica, one actually performs a normal dust level test and then analyzes the catch for the silica content.

The final results show on Table II that two of the operators' exposure to dust was over the TLV Threshold Limit of 10mg/M3 of air as listed in the last column. Note that three samples were taken on one man and two samples on each of the other two men. This was done to avoid too high a filter collection by using more than one filter. Note also the proportion of the dust loading caught in the cyclone or that caught in the filter (the respirable portion).

In Table III it is seen that all three operators' exposure to free silica ranged from 4.1 to 10% of the respirable dust catch. Each operator was within the calculated TLV. However, each of the three operator exceeded the TWA for free silica which is specified by N.I.O.S.H. as a maximum of .050mg/M3.

RESULTS, CONCLUSIONS & RECOMMENDATIONS

RESULTS

The data from the Personal Sampler tests is presented in Table II below:

PERSONAL SAMPLER DUST LOADING TEST DATA

	Personal Sampler Installed on and Job Description	Test Date	Sample #	Time Sampled, Minutes	Flow Rate, liters/min.	Sample Volume, m3	Dust loading mg.		Dust Concentration mg./m3 of air		Thr... of Lim... mg. of
							cyclone	filter	Total	Respirable#	
1	Mr. Cupola Operator	12/17	P30	43	1.86	.080	3.0	.3	14.3	8.26	1
			P34	120	1.86	.223		1.0			
			P37	104	1.86	.193		2.8			
2	Mr. Grinder/Ladle	12/17	P31	100	2.0	.200	6.4	1.0	28.9	13.7	1
			P36	111	2.0	.222		4.8			
3	Mr. Line Miscellaneous	12/17	P32	97	2.0	.194	4.4	1.0	23.2	12.9	1
			P35	97	2.0	.194		4.0			

TABLE II

* from FEDERAL REGISTER, Vol. 36, No. 105, May 29, 1971. This is allowable limit for 8 hr. exposure of fugitive dust. It is also sometimes written as 30 m.p.p.c.f. (million particles per cubic feet).

\# Respirable concentration is based on filter catch only. This is the amount of particulates which went through the inlet cyclone and were deposited on the filter. This respirable portion represents particulates which are believed to be distributed as shown in the following table taken from the U.S. Department of Health, Education and Welfare, Public Health Service Publication #614.

100% respirable at 2 microns
75% respirable at 2.5 microns
50% respirable at 3.5 microns
25% respirable at 5 microns
0% respirable at 10 microns

Below .5 microns a major portion of the respirables are believed to be entrained into the lung tissue and to then enter the blood system, alimentary canal and are excreted.

See also, the reference page in the Appendix from the H.E.W. Syllabus on "The Industrial Environment."

The data from the silica analysis of the filter samples from the Personal Samplers is shown below:

PERSONAL SAMPLER AIRBORNE SILICA CONCENTRATION RESULTS

ITEM	Personal Sampler Installed on and Job Description	Filter Dust Loading Respirable mg	Percent Silica* by Wt.	Silica Limit mgm/m³ #	Respirable mg/m³	Respirable Silica Results (as compared with Table I, Col. 8)		TWA** mg/m
						Exceeds TLV	Within TLV	
1	Mr. Cupola Operator	4.1	10.0	.83	.41		✓	.23
2	Mr. Grinder/Ladle	5.8	5.3	1.37	.30		✓	.14
3	Mr. Line/misc.	5.0	4.1	1.61	.21		✓	.08

TABLE III

* See Section III for description of NIOSH method used to determine silica concentration. Silica (SiO_2) assured to be 100% quartz.

** Time Weighted Average (Corrected) - Each operator wore Personal Sampler for 3½ to 4½ hours. The other tasks projected over 8 hours were assumed to have no free silica involved.

\# $TLV = \frac{10 \text{ mg/m}^3}{\% \text{ Respirable Quartz} + 2}$ from A.C.G.I.H. Manual

Cotton dust occurs throughout the textile industry and affects cotton, flax and soft hemp workers. The greatest exposure to cotton dust generally occurs during the carding of cotton - an operation that combs out cotton fibers and sets them parallel by drawing them between toothed cylinders. However, machinery throughout the cotton mill must be cleaned frequently, and much exposure to cotton dust occurs then. While the exact effects of cotton dust are not known, prolonged exposure to heavy air concentrations can cause a disabling lung disease known as byssinosis. It has been determined that it is not the cotton fibers themselves but the materials adhering to cotton fibers, such as unwanted leaf, stem and boll trash, which when inhaled, elicit an allergic reaction or response.

Byssinosis generally advances through three recognizable stages. The first is commonly called "Monday fever" and begins only after exposure of more than 10 years. Workers develop an irritating cough, tightness of the chest and breathlessness. The attacks usually come on Monday, or after a period of absence from the plant and last only a day or so; hence the name "Monday fever". In the second stage, these symptom extend over more days in the week and finally become permanent. If exposure to cotton dust is ended at this stage, recovery can occur. In the third stage, the tightness of the chest and labored breathing become so distressing the worker must leave the industry. The disease can progress then to chronic bronchitis and emphysema.

Listed below is a summary of the cotton dust limits. These requirements are fully detailed in Reference (12).

SUMMARY OF COTTON DUST REQUIREMENTS

Primary Requirements	No government code A.C.G.I.H. suggests TLV of .2 mg/cubic meter
Allowable Limit	

TABLE C

Testing

Now that you understand the problem, how do you analyze each employee or work station? This is done with a Personal Sampler which consists of a battery operated pump, a flow regulator and a filter assembly. The two major suppliers of Personal Samplers are Bendix and MSA. MSA, Millipore and Bendix manufacture plain filters and Andersen 2000 provides a filter head which can separate the respirable and non-respirable dust (see FIGURE II). The plain filter head is used for sampling fibers and gravimetric sampling. A filter head with an upstream cyclone (vertical elutriator) is used for silica/dust and cotton sampling (see FIGURES III & IV). MSA and Bendix supply the vertical elutriators.

The reason for not using a plain filter when sampling for silica and cotton dust is that from a standpoint of health, only that portion of the dust which is deposited deep in the respiratory system is harmful (See FIGURE I for lung penetration). Therefore, NIOSH has divided the contamination levels into respirable and non-respirable categories. The respirable contaminants are between .5 and 10 microns. These are the contaminants which remain in the lungs.

Most common filter heads for measuring silica dust do not differentiate between respirable and non-respirable. ROSSNAGEL & ASSOCIATES uses the two category filters, but also makes use of the Andersen 2000 Mini-Sampler (see FIGURE II) head on certain tests for two reasons. One reason is the Mini-Sampler is smaller than any other filter head used for dust and the second is that it divides the respirable dust into 5 size categories. This is important both for which area of the lungs is affected and for selecting control equipment. We also use the MSA flat filter for many applications.

A summary of the filter types is shown in Table D below:

SUMMARY OF FILTER & CYCLONE USES

Substance	Filter Type*	Is Vertical Elutriator (Cyclone) Rec'd.
Asbestos Fiber	1. Cellulose Membrane (recommended by NIOSH)# 2. PVC (recommended by MSA)#	No
Silica, Free	1. Cellulose Membrane (for colorimetric analysis) 2. PVC (for X-ray diffration)	Yes
Dust	1. Cellulose Membrane 2. PVC 3. Anderson Cascade Impactors	Yes
Cotton Dust	1. Cellulose Membrane (for fiber sizing use) 2. PVC (for gravimetric use)	Yes

TABLE D

#(See Notes on following page)

* The use of the proper type of filter is very critical when examination is performed since the microscopic filter itself must be cleared by a specific clearing solution. Some filters used in sampling as Triacetate metricel have a clearing solution, however, the clarity with which to optically size fibers is not as sharp as other filters. A different clearing solution is used for each filter type.

37 mm. dia. filters

- - - - - - - - -

Extreme care must be utilized during the actual test to insure accurate results. The sampling period should be from 2-8 hrs.* depending on circumstances. If less than 8 hrs. of testing is done, the TWA calculation is corrected to an 8 hr. base. There is some confusion on whether the actual sampling period should include time away from the work station for lunch and breaks. We suggest the following guidelines. If an operator is exposed to severe dust, for example, only during unloading of bags for one hour at the start of the shift, then it would be an overly severe test to only conduct sampling on him during that time (unless a "worst case" test is desired). The time sampled should reflect his normal operations, preferably for at least 4 hours.

The photos in the attached Procedure #113 show the preferred location of the Mini-Sampler on the shirt lapel near the nose. The Mini-Sampler or filter head is pointed downward so as to simulate the nose and not collect particulates falling from gravity effects. The flow rate should be checked periodically during the test since it can change due to the filter loading or the battery discharging. The person being tested should also be watched to insure that he does not do anything which could affect the accuracy of the test. Persons wearing the equipment have frequently been caught taping the filter with a dirty glove to get a higher reading for vindictive reasons. The test pump is usually attached to the belt in back of the operator as shown in the photos

The sampling flow rates should be set for 1.0 to 2.5 liters/min. or as limited by the Personal Sampler pump capability. The person conducting the test should check the flow rate at least every half hour and more frequently if necessary.

However, this is only the first half of the test. ROSSNAGEL & ASSOCIATES can provide the samplers or you can buy them and do this part of the test in your own plant. The second important part of the test occurs when you end the test, shut off the pump, replace the cover on the filter and then face the lab analysis. The filters used in collection of cotton dust and silica dust are dried in a desiccator and preweighed to .1 mg. before the test and then dried in a desiccator and weighed again after the test to determine the weight of dust collected and then divided by the sample volume to arrive at a concentration level which is compared to the limits in Table B & C.

The attached Procedure #113, "Checklist for O.S.H.A. Personal Sampling," details the other important considerations to be taken to properly conduct such tests.

* sampling as low as 15 minutes is acceptable for asbestos

Andersen Mini-Sampler

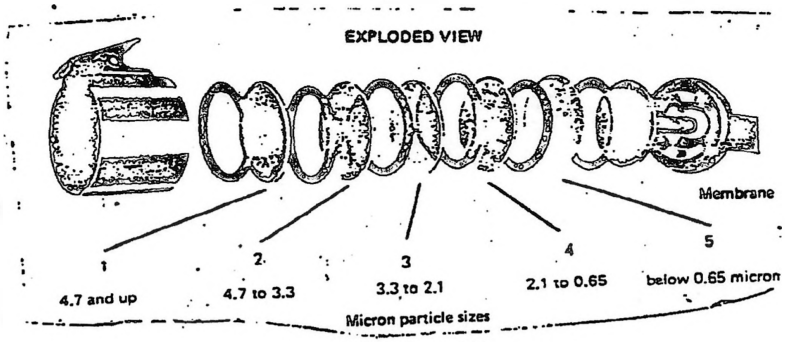


FIGURE II

MSA pump, gravimetric filter and cyclone

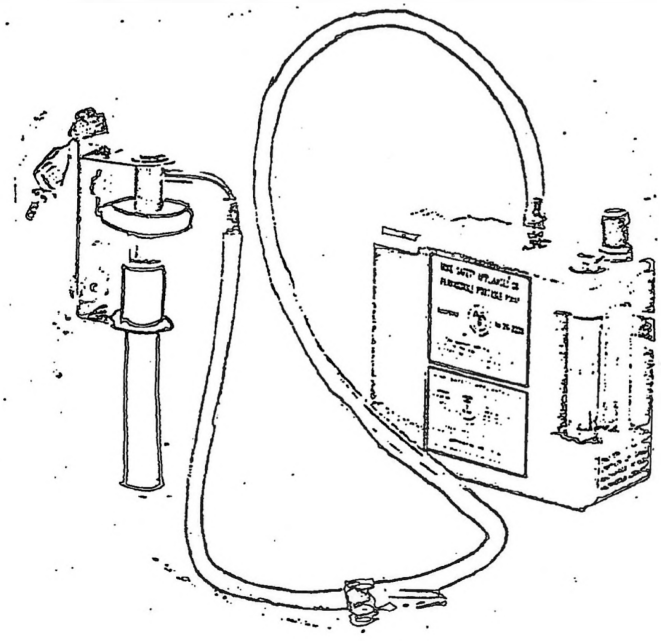
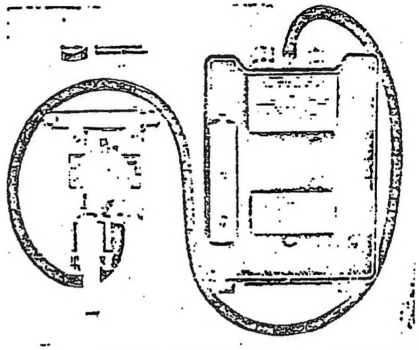


FIGURE IV



Bendix pump, gravimetri filter and cyclone

FIGURE III

The final test report should include copies of all the original field data and calculation sheets as well as backup photomicrographs. ROSSNAGEL & ASSOCIATES is able to issue all its O.S.H.A. test reports within a maximum of 10 working days.

If you have an inplant dust or fiber problem it is to your advantage to take steps to determine its severity before O.S.H.A., the union or a legal claim requires it. It is your minimum responsibility.

References:

(1) General Industry Guide for Applying Safety & Health Standards, O.S.H.A. 2072.
(2) Target Health Hazards, O.S.H.A. 2051.
(3) What Every Employer Needs to Know About O.S.H.A. Record Keeping, O.S.H.A. Report 412.
(4) Record Keeping Requirements under the Williams-Steiger Occupational Safety & Health Act of 1970.
(5) Federal Register, Vol. 37, No. 202, dated Oct. 18, 1972, Part II.
(6) Federal Register, Vol. 37, No. , dated June 7, 1972, Part
(7) Federal Register, Vol. 39, No. 125, dated June 27, 1974, Part II
(8) Federal Register, Vol. 40, No. 197, dated Oct. 9, 1975, Part II
(9) N.I.O.S.H. Manual of Analytical Methods, 1974
(10) N.I.O.S.H. Criteria Document - "Occupational Exposure to Asbestos" 1972
(11) N.I.O.S.H. Criteria Document - "Occupational Exposure to Crystalli Silica", 1974
(12) N.I.O.S.H. Criteria Document - "Occupational Exposure to Cotton Dust", 1974

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PROCEDURE #113
3/22/76

CHECKLIST FOR O. S. H. A. PERSONAL SAMPLING

A. Lab and Test Equipment Preparation

1. Determine which type of filters will be used:
   a. Cyclone & Preweighed Filters: Two types depending on r
      Size: 37 mm
      Mfg.: Bendix, MSA
   b. Filter in Plastic Holder
      Size: 37 mm Membrane Filter
      Mfg.: Millipore, Gelman
   c. Andersen Particle Size Distribution Filter Head
      5 plates plus final filter
      Filter: Type A Glass Fiber 25 mm
2. Verify the Personal Samplers are properly calibrated.
3. Desiccate filters for at least 24 hours before weighing.
4. Record weights on RA Form #26 and keep weighed reference fi in desiccator.
5. Get all batteries charged from power packs.
6. Check calibration of units for filter to be used.

B. On Day of Test

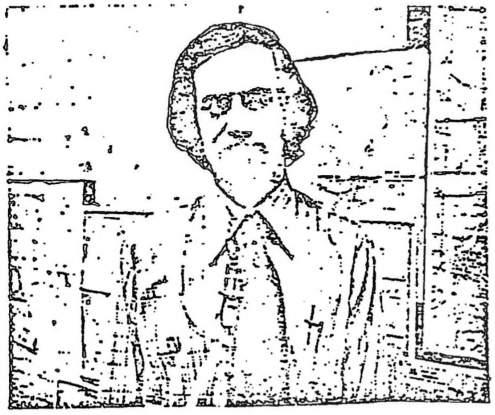
1. Start Events Log Sheet on RA Form #28 upon arrival and then contact operating personnel at test location.
2. Just prior to start of test, place pumps vertically and tur on and adjust flow rate for test. Use required flow rate. Filter head must be attached for this adjustment.
3. Carefully place equipment on person to be sampled. Be sure to have filter pointing down and close to nose of operator, see attached photo page for proper placement. Check each individual wearing a filter and flow rate at least every 15 minutes.
4. Record each time an individual's pump is turned on or off, such as for lunch or leaving the plant.

C. Post Test Lab Work

1. Dry filters in oven if gravimetric analysis is to be done.
2. Desiccate filters or sampler plates for at least 24 hours before weighing.
3. Weigh and record on RA Form #26.
4. Keep samples in laminar flow booth in particle size lab.

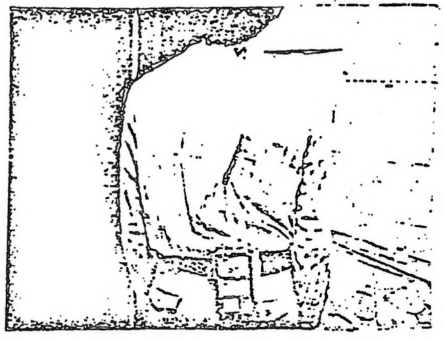
D. Microscopic Examination

1. Follow Micron Size Distribution Analysis Procedure #114 or O.S.H.A. Fiber Statistical Microscopic Sampling Procedure #
2. Save all filter samples in proper labeled and dated case.
3. Take at least one typical photomicrograph of a group of fi if customer requires Particle Size Distribution analysis.

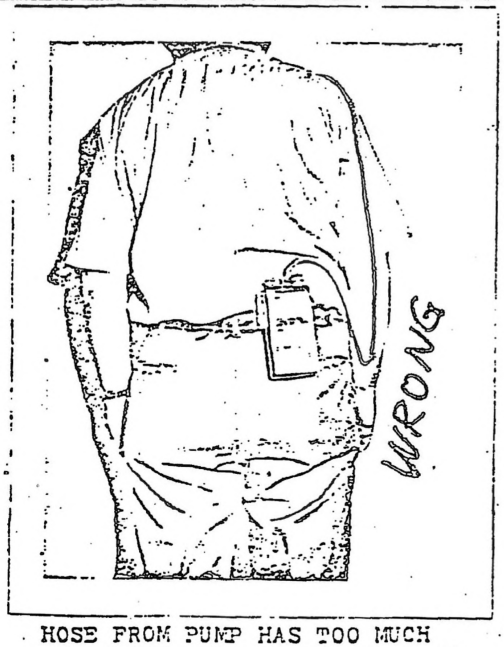


PROPER ARRANGEMENT FOR MSA RESPIRABLE DUST COLLECTION USING FILTER AND CYCLONE.

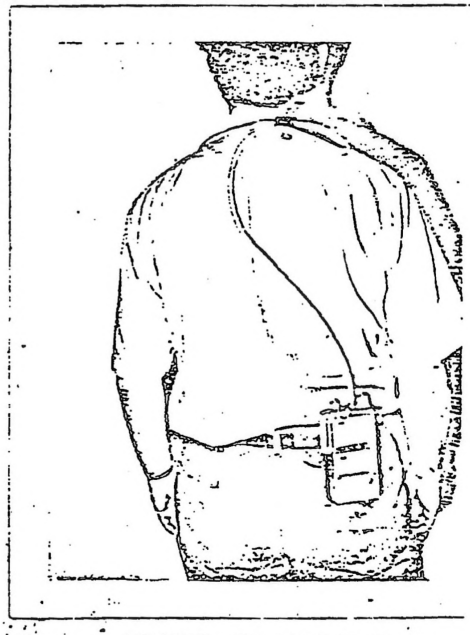
PROPER ARRANGEMENT FOR ANDERSON PERSONAL SAMPLER



REAR VIEW SHOWING PROPER ARRANGEMENT FOR TYGON TUBING WITH COIL CLIP.



HOSE FROM PUMP HAS TOO MUCH SLACK AND WILL INTERFERE WITH



PROPER ARRANGEMENT.

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AIR-WATER-NOISE

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- WATER POLLUTION TESTING

WE PERFORM FIBER AND DUST TESTING TO O.S.H.A. REQUIREMENTS

ROSSNAGEL & ASSOCIATES is fully equipped and experienced in conducting asbestos, cotton, rock wool and other fiber tests as well as dust tests to the O.S.H.A.* requirements. This includes performin both the "Personal Sampling" (at a rate of 2 liters/min.) plus the very specialized sample preparation and microscopic fiber counts using statistical techniques under 400X-430X magnification. A fiber is defined as larger than 5 microns in length and having an aspect ratio of at least 3:1. Analysis is done in our laminar flow "clean booth" in our temperature and humidity controlled laboratory. Our comprehensive test report will provide you with precise problem definition backed by photomicrographs.

We utilize Criteria Documents published by NIOSH:

- "Occupational Exposure to Asbestos," 1972
- "Occupational Exposure to Cotton Dust," 1974
- "Occupational Exposure to Crystalline Silica," 1974

If your company requires these tests, be assured ROSSNAGEL & ASSOCIATES will provide prompt efficient testing and analysis service

Call or write for further information:

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* Occupational Safety & Health Act of 1970

Form #RA-65E