PLAINTIFF'S EXHIBIT

MAR-178

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

by: Don Frost, Lab Manager &
W. D. Rossnagel, P.E., President
ROSSNAGEL & ASSOCIATES
Engineering & Testing Consultants
Cherry Hill, N.J.; & Atlanta, Ga.;
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 some of the substances on which N.I.O.S.H. (National Institute of Safety & Health), a branch of H.E.W., prepares criteria documents for use by O.S.H.A. When O.S.H.A. initiated the Target Health Hazards Program in January of 1972, three of the primary contaminants of concern were asbestos, silica and cotton dust. N.I.O.S.H. maintains a current list of criteria documents for exposure to more than twenty hazardous materials.

The O.S.H.A. codes required that effective August 27, 1971, (except for asbestos) all plants with employees exposed to dust or fibers above the proposed limits stated in the FEDERAL REGISTER, be provided with protective equipment and the operation analyzed to determine if the contaminants 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 contaminant level. The similar effective date for asbestos was June 7, 1972.

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

A. 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: Chrysotile - 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 Chrysotile. The principal danger of asbestos fibers is caused by inhaling. Prolonged inhalation of asbestos fibers and dust of 5 or more microns (one-millionth of a meter or 1/25,000 of an inch) long can produce a lung disease known as asbestosis, a diffuse, interstitial, non-malignant, scarring of the lungs. The nasal pharangeal area and bronchial tubes tend to remove the nonrespirable 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 fibers and dust may cause a mesothelioma (lining of the lung or gut) or even gastro-intestinal cancer to develop.

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.

* Revised Sept. 1976

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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 sampling techniques. Figures on Page 4 show asbestos fibers at various magnifications with the Porton reticle in background. The statistical counting plan requires counting fibers as detailed later in the Lab Analysis section. Sometimes it is necessary to count the fibers in 100 or more "fields" in the Porton reticle. 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 as of July 1, 1976, the O.S.H.A. limits on airborne asbestos are more restrictive as shown in Table A. The future proposed codes are also shown below:

SUMMARY OF ASBESTOS REQUIREMENTS - in fibers/ml

Primary Requirements	Code Since 6/7/72	Present Code as of 7/1/76	Proposed Code
1. Allowable Ceiling Limit	10 fibers*	10 fibers*	5 fibers*
2. Allowable TWA (Time Weighted Average) for 8 hours exposure	5 fibers*	2 fibers*	.5 fibers*

* fiber defined as larger than 5 microns in length and having an aspect ratio of at least 3:1

TABLE A

The following page is taken directly from an asbestos test report conducted by ROSSNAGEL & ASSOCIATES. The Table I results, listed in the column headed "Extrapolated TWA 5 μ or longer fibers" shows three man's exposure above the 2 fiber limit (the limit allowed after July 1, 1976).

These asbestos levels were reached in a process of handling 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.

II

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 with an aspect ratio of at least 3:1					
			Total Count	Avg. Count	Concentration Fibers/ml (1)	Allowable Limit Fibers/ml (2)	Extrapolated TWA, Fib/ml (3)	Allowable Limit for TWA (4)
1	P39	Mr. Caster Casting Dept.	121	6.05	2.22	Ceiling concentration is 10 fibers/ml.	2.22	Two fibers/ml.
2	P40	Mr. General Helper Kiln Dept.	89	4.45	1.59		1.59	
	P41	Mr. Hand Molder Mold Dept.	514	25.7	9.16		9.16	
	P46	General Serviceman Mold Dept.	207	10.4	3.90		3.90	

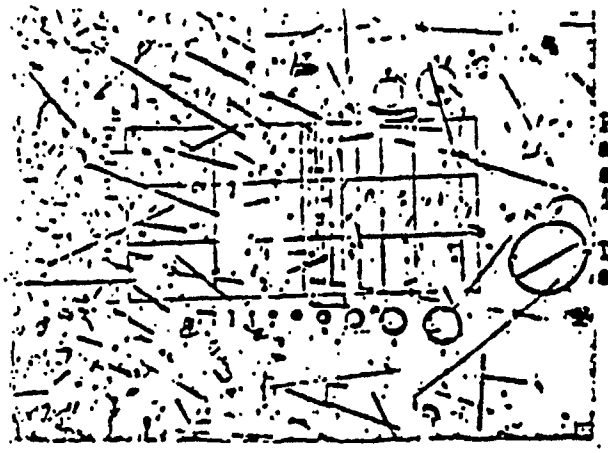
TABLE I

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

2) Allowable Ceiling Limit is 10 fibers/ml based on O.S.H.A. limit as of 7/1/76.

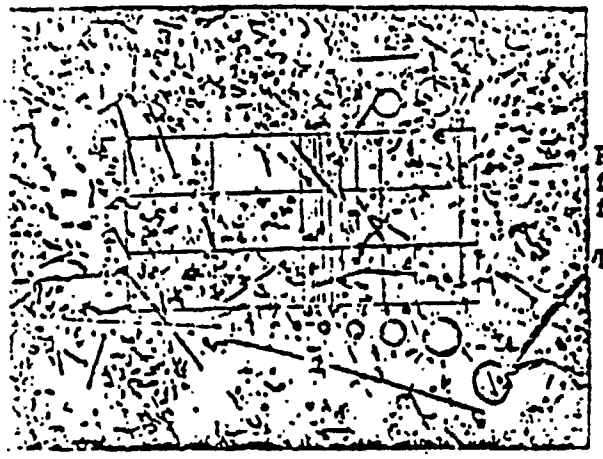
3) Extrapolated TWA is a mathematical calculation. TWA is Time Weighted Average.

4) Allowable Limit for TWA is 2 fibers/ml based on O.S.H.A. limit as of 7/1/76.



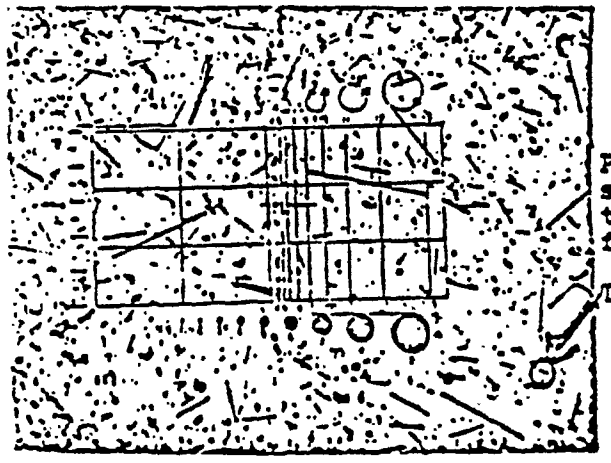
Photomicrograph showing numerous asbestos fibers of varying micron sizes found in the Personal Sampling.

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 workers, large masses of dense fibrous tissue develop in the upper portion of the lungs, leading to severe respiratory crippling. Tuberculosis is a frequent 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:	Calculation of Allowable Limits
Crystalline:	
Quartz (respirable)----------	$\frac{10\ mg/m^3}{\%\ respirable\ quartz + 2}$
Quartz (total dust)----------	$\frac{30\ mg/m^3}{\%\ quartz + 2}$
Cristobalite: Use ½ the value calculated from the formulae for quartz.	
Tridymite: Use ½ the value calculated from the formulae for quartz.	
Amorphous, including natural diatomaceous earth	$\frac{80\ mg/m^3\ (total\ dust)}{2\ mg/m^3\ (respirable\ dust)}$
Coal dust (respirable fraction less than 5% quartz)----------	2.4 mg/m^3
For more than 5% quartz----------	or $\frac{10\ mg/m^3}{\%\ respirable\ quartz + 2}$
Inert or Nuisance Dust:	
Respirable Fraction----------	5 mg/m^3
Total dust----------	15 mg/m^3

Notes:
1) Respirable quartz dust consists of particles which are less than 10 microns in diameter.
2) mg = milligram
3) m^3 = cubic meter

TABLE B

DUST PENETRATION INTO LUNGS

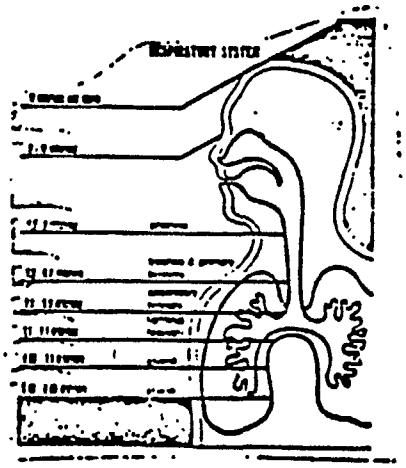


FIGURE I

The following pages are taken direct from a dust and silica test report 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.

In Table II 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.

The final results show on Table III that two of the operators' exposure to dust was over the TLV Threshold Limit of 10 mg/m^3 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).

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

PERSONAL SAMPLER FREE SILICA CONCENTRATION RESULTS

Sam-ple No.	Personal Sample No.	Location/ Activity	Filter Dust Loading Respirable mg	% Free Silica * in Total Silica	Free Silica Limit TLV mg/m³ #	Respirable Free Silica mg/m³
1	PS-1	Mr. Cupola Operator	4.1	10.0	.83	.41
2	PS-4	Mr. Grinder/Ladle	5.8	5.3	1.37	.30
3	PS-6	Mr. Line, Miscel-laneous jobs	5.0	4.1	1.61	.21

TABLE II

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

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

FIELD DATA & DUST LOADINGS

The data from the Personal Sampler tests is presented in Table III 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, m^3	Dust loading mg. Cyclone	Filter	Total	Dust Concentration mg/m^3 of air Respirable#	Threshold Limit* mg./m^3 of air
Mr. Cupola Operator	12/17	P30	43	1.86	.080	N/A	.3	4.1	8.26	10
		P34	120	1.86	.223		1.0			
		P37	104	1.86	.193		2.8			
Mr. Grinder/Ladle	12/17	P31	100	2.0	.200	N/A	1.0	5.8	13.7	10
		P36	111	2.0	.222		4.8			
Mr. Line, Miscellaneous jobs	12/17	P32	97	2.0	.194	N/A	1.0	5.0	12.9	10
		P35	97	2.0	.194		4.0			

TABLE III

* 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 then be excreted.

Cotton dust occurs throughout the textile industry and affects [illegible]ton, flax and soft hemp workers. The greatest exposure to cotton dust generally occurs during the carding of cotton - an operation that [illegible] cotton fibers and sets them parallel by drawing them between [illegible]ched 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 symptoms 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 the employees or work stations which are suspected to have too high a contamination level? First, Personal Sampler tests should be made only by a trained person. The person conducting the test(s) should be knowledgeable and experienced, whether they be an engineer, industrial hygienist, chemist, etc. The Personal Samplers should be properly cleaned, calibrated and with charged-up batteries for the test. The required filter (and cyclone if required) should have been properly desiccated, tare weighed and sealed for use in the field. The test is done with a Personal Sampler which consists of a battery operated pump, a flow regulator and a filter assembly. The 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 nonrespirable dust (see FIGURE II). The plain filter head is used for sampling fibers and gravimetric sampling. A filter head with an upstream particle elutriator is used for cotton sampling. The vertical elutriators are approximately 3" dia. and 4 ft. long.

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 nonrespirable categories. The respirable contaminants are < 10 microns for SiO_2 only. These are the contaminants which remain in the lungs.

To distinguish between respirable and nonrespirable contaminants, a cyclone must be used upstream of the filter in the Personal Sampler as shown in FIGURE IV. ROSSNAGEL & ASSOCIATES also makes use of the Andersen 2000 Mini-Sampler (see FIGURE II) head on certain dust 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 - [illegible] which area of the lungs is affected and for selecting control [illegible]

A summary of the filter types is shown in Table D on the following page.

SUMMARY OF FILTER & SPECIAL TEST REQUIREMENTS

Contaminant Substance	Filter Types*	Size mm	Micron Size	Special Test Requirements
Asbestos Fiber	1. Cellulose Membrane (recommended by NIOSH)# 2. PVC (recommended by MSA)	37 37	.8	
Silica (Free)	1. Cellulose Membrane (for colorimetric analysis) 2. PVC (for X-ray diffraction)	37 37	5	Cyclone required
Dust, Metals or Particulates	1. Cellulose Membrane 2. PVC 3. Andersen Mini-Sampler	37 37 N/A	.8	Separates catch into 5 categories
Cotton Dust	1. Cellulose Membrane (for fiber sizing use) 2. PVC (for gravimetric use)	37 37	5	Vertical Elutriator required

TABLE D

* The use of the proper type of filter is very critical when optical examination is performed since the filter itself must be cleared by a specific clearing solution. Some filters used in sampling, such as Triacetate, Vinyl and PVC, have a recommended clearing solution. However, the clarity is sharpest using the cellulose membrane filter. A different clearing solution is used for each filter type. ROSCHAGEL & ASSOCIATES has found that Cellulose membrane filters are best suited for optical analysis.

Cellulose Membrane filter is used whenever "clearing" (dissolving of the filter) is required for microscopic analysis.

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 filter 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, according to OSHA sampling data sheets, 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

PERSONNEL SAMPLING EQUIPMENT

Andersen Mini-Sampler

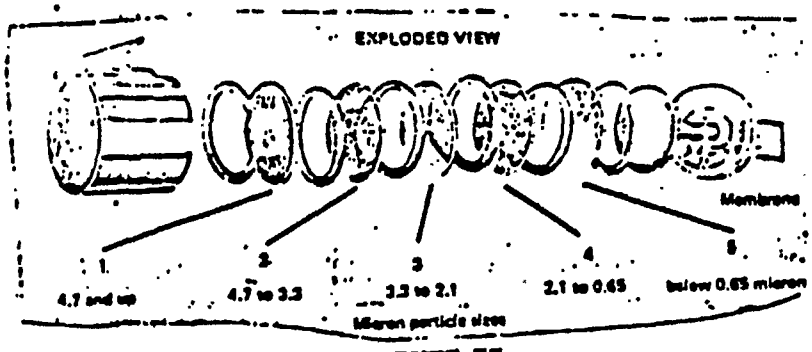
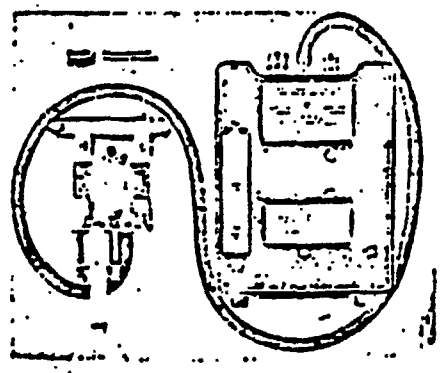


FIGURE II



Bendix pump, gravimetric filter and cyclone

FIGURE III

MSA pump, gravimetric filter and cyclone

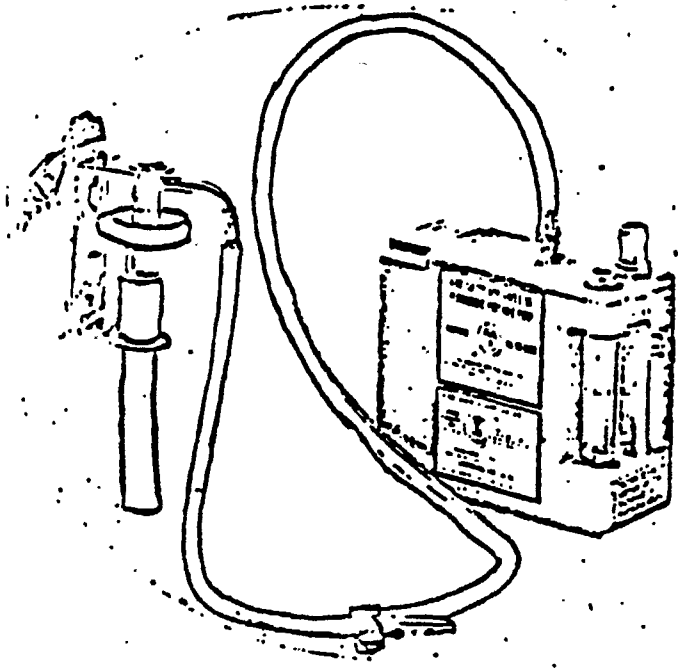


FIGURE IV

The final test report should include copies of all the original field data and calculation sheets as well as backup photomicrographs. ENGEL & 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, dated June 7, 1972,
(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 Crystalline Silica", 1974
(12) N.I.O.S.H. Criteria Document - "Occupational Exposure to Cotton Dust", 1974

Engineering & Testing Consultants
1999 RT. 70
CHERRY HILL, N. J. 08003
(609) 424-4440

Southeastern Division
230 ARIZONA AVE., N. E.
ATLANTA, GA. 30307
(404) 577-4243

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 mfg.
      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 filter 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

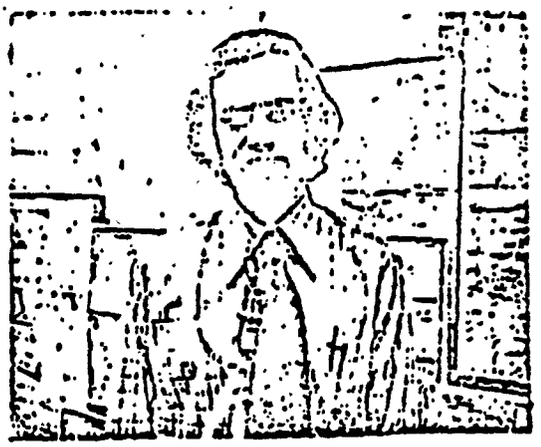
1. Start Events Log Sheet on RA Form #28 upon arrival and then contact operating personnel at test location.
2. Just prior to start of test, place pumps vertically and turn on and adjust flow rate for test. Use required flow rate. Filter head must be attached for this adjustment.
3. Carefully place equipment 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.

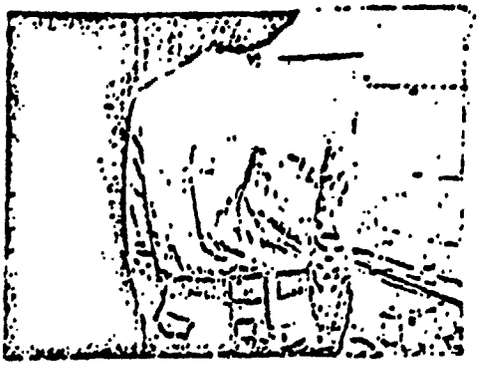
D. Microscopic Examination

1. Follow Micron Size Distribution Analysis Procedure #114 or O.S.H.A. Fiber Statistical Microscopic Sampling Procedure #115
2. Save all filter samples in proper labeled and dated case.
3. Take at least one typical photomicrograph of a group of filter if customer requires Particle Size Distribution analysis.

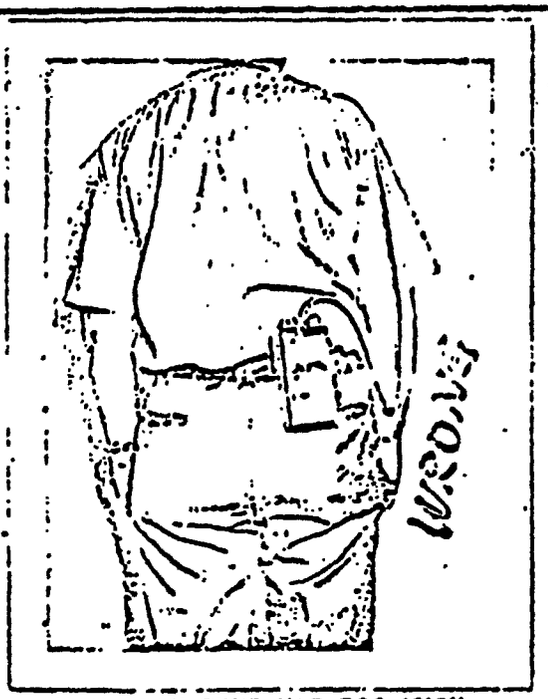


PROPER ARRANGEMENT FOR MSA RESPIRABLE DUST COLLECTION USING FILTER AND CYCLONE.

PROPER ARRANGEMENT FOR ANDERSON PERSONAL SAMPLER.



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



HOSE FROM PUMP HAS TOO MUCH SLACK AND WILL INTERFERE WITH

PROPER ARRANGEMENT.