

UNITED STATES GOVERNMENT

Memorandum

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TO : Chief, Engineering Section

DATE: August 21, 1963

FROM : Engineering Section

SUBJECT: Asbestos Dust Sampling Procedures

Work involving methods of sampling for chrysotile asbestos dust at the Jefferson Lake Asbestos Corporation, Copperopolis, California, left much doubt as to the effectiveness of the impinger for fiber collection. Many problems arise when the Standard Impinger Method is used. Some of these problems are:

1. Difficulty in obtaining complete settling of all asbestos fibers in a counting cell.
2. Inability to see fibers with light field illumination.
3. Strong possibility that fibers are "broken up" upon impingement.
4. Questions regarding the efficiency of the impinger for collecting fibers.
5. Apparent incongruity between the present Threshold Limit Value for asbestos environments and actual asbestos fiber concentration.

The activity at the Jefferson Lake plant involved a new technique using opaque filter papers for the sampling of asbestos. Also, samples were obtained so that an estimate of impinger effectiveness could be obtained. On June 10, 1963 samples were taken simultaneously with a Greenburg-Smith Impinger and an Electrostatic Precipitator. The collecting media used in the impinger was a 25% ethyl alcohol-75% distilled water mixture. This same mixture was used to wash down the precipitator tubes. After careful mixing, slides were prepared from each solution by evaporating solution drops and leaving a residue. Each slide was then sized measuring the horizontal projection or Martin's Diameter of each dust particle. No distinction was made between grains and fibers. Light field illumination with a 43X objective lens and a 10X eyepiece lens were used. The objective lens has a numerical aperture of 0.65. The results were:

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Sample No.	Air Vol.		G.S. Impinger Conc. (mppcf)	G.S.		ESP	
	G.S.	ESP		Mg-μ	σ	Mg-μ	σ
1	5 ft ³	15 ft ³	35.0	.84	3.99	1.29	3.1
2	"	"	46.0	.93	3.89	1.32	3.6
3	"	"	33.8	.94	3.79	1.30	3.16
4	"	"	24.5	.90	3.78	1.23	3.08
5	"	"	30.6	1.00	3.25	1.30	2.81
6	"	"	35.4	.98	2.6	1.43	3.28
7	"	"	33.2	1.02	3.3	1.21	3.82
8	"	"	28.3	.96	3.04	1.39	3.1
9	"	"	35.4	.89	3.48	1.33	3.0
10	"	"	36.2	1.00	3.02	1.42	3.52

Although the results of this sizing are quite consistent, not enough specific information about the asbestos in the samples was obtained. By visual estimate between 5% and 8% of the dust was asbestos fiber - the rest of the particulate matter in the sample being antigorite and other gangue material.

A closer look was taken at each sample. Each slide was sized using the following procedure:

1. All non-fibrous material was sized using Martin's Diameter as the significant length.
2. All fibers were sized by the measurement of the length dimension - regardless of orientation.
3. A tabulation was made in which both asbestos fiber and gangue material were logged.
4. A fiber was defined as anything which appeared to be asbestos.

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5. Phase contrast with a 43X objective lens and a 10X eyepiece lens.
6. Koehler illumination was used. The numerical aperture of the objective lens is 0.65.

The results of this sizing effort were:

Sample No.	ESP		G.S. Impinger	
	Mg-%	$\bar{D}$	Mg-%	$\bar{D}$
1	1.88	3.03	1.08	3.33
2	2.00	2.74	1.12	3.12
3	1.82	2.72	1.06	3.30
4	1.85	3.30	1.13	3.23
5	1.84	2.82	1.08	2.76
6	1.83	2.78	1.09	2.76
7	1.81	2.84	1.11	3.00
8	1.76	3.27	1.13	3.10
9	1.83	3.33	1.10	2.96
10	1.94	3.10	1.12	3.04

The Greenburg-Smith Impinger samples had a greater number of particles equivalent to a circle number one than the Electrostatic Precipitator samples. About 50% of the particles were "ones" in the Greenburg-Smith while about 29% of the particles in the ESP were "ones." No "one" circle size particles could accurately be identified as asbestos. In the ESP samples 27% of the dust sized was identified as asbestos. The G.S. Impinger samples contained 16% asbestos fiber content of all particles sized. It is interesting to note the much higher percentage of asbestos identified during the second sizing tabulation - indicating that phase contrast better delineates the asbestos fibers. It is also interesting to note that all dust identified as asbestos had a length to diameter ratio of at least 3:1.

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The tabulation of the particulate in all ten samples identified as asbestos gave the following results:

ESP			G.S. Impinger		
Mg-4	Q (upper)	Q (lower)	Mg-4	Q (upper)	Q (lower)
2.9	2.78	1.85	2.17	3.04	1.55

The asbestos fibers do not give the characteristic "straight line" on log-probability paper which describes the size distribution of so many mineral dusts. Instead, a gently sloping curve is the result. In this case a better description of the curve shape is obtained when a standard deviation is defined for both the upper and lower portions of the curve.

Since a marked difference was noted in the geometric mean of the Greenburg-Smith and ESP samples taken simultaneously in a concentration where the asbestos was the minority dust, it was desired to obtain data where the asbestos was in the majority. A cloud of chrysotile was generated by a dry method in the dust chamber. The airborne dust can be favorably compared with industrial asbestos dust encountered in working environments. Five runs were made. Simultaneous samples were taken with the Greenburg-Smith Impinger, the Midget Impinger, and the Electrostatic Precipitator. The sampling time was five minutes. The impinger concentrations were:

No.	Greenburg-Smith Impinger			Midget Impinger		
	MPPCF Grains	MPPCF Fibers	% Fibers	MPPCF Grains	MPPCF Fibers	% Fibers
A	6.3	13.2	67.6	22.6	15.3	40.4
B	7.3	7.7	70.0	11.1	5.8	34.4
C	9.4	8.2	46.6	15.3	9.4	38.0
D	6.3	4.4	41.2	10.2	6.2	37.8
E	5.6	4.2	42.8	9.1	5.6	37.8

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The samples were taken with an ethyl alcohol-water mixture consisting of approximately 25% ethyl alcohol. The sampling time was five minutes. The samples were counted in Dunn cells after a settling period of 50 minutes. The samples were counted using 10X phase contrast objective and 10X eyepiece.

In addition the ESP tubes were washed down with the ethyl alcohol-water mixture and slides were prepared from these tubes and the impingers by evaporating drops and leaving dust residues on the slides. Each slide was then sized using a 43X phase contrast objective with a numerical aperture of 0.65 and a 10X eyepiece. Any particulate matter was sized according to Martin's Diameter while all asbestos fiber was measured according to length. A separate tabulation of asbestos fibers was recorded. The results of the sizing are as follows:

Sample No.	G.S. Impinger			Midget Impinger			ESP		
	Mg-μ	∇	% asbestos	Mg-μ	∇	% asbestos	Mg-μ	∇	% asbestos
A	1.5	2.83	56	1.97	3.48	63	3.29	2.53	69
B	1.63	2.89	60	1.77	3.41	61	3.03	3.03	74
C	1.63	2.30	59	1.93	3.48	61	3.14	2.80	77
D	1.54	2.47	62	1.90	2.84	60	2.88	3.36	72
E	1.62	2.82	61	1.98	3.28	60	3.05	2.66	74

None of the dust equivalent to a "one" circle size could be classified asbestos or non-asbestos. The percentage of "One" circle sizes in each sampling technique was: Greenburg-Smith Impinger - 28, Midget Impinger - 22, ESP - 14.

When the asbestos fibers were totaled, the curved line, which appears to be characteristic of fibers, was plotted on log-probability paper. The curve may be best described by defining a Standard Deviation for both the top and bottom halves of the curve.

	G.S. Impinger	Midget Impinger	ESP
Mg	2.22 μ	2.78 μ	4.17 μ
Turner	2.76	3.06	2.75
Flower	1.71	1.76	2.18

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It is interesting to note that 19% of the ESP sample had a fiber length greater than 10 μ while only 8.5% of the G.S. Impinger sample was greater than 10 μ . The corresponding Midget Impinger figure was 13%.

Conclusions that can be drawn from these experiments are difficult to concretely formulate. However, it appears that the Greenburg-Smith Impinger does tend to break-up the asbestos fibers upon impingement and give a smaller geometric mean than the ESP which is a relatively gentle method of collection. Hence, when fibers are reduced in size by impingement a spurious dust concentration may be obtained.

A new means of collecting asbestos fiber was developed at the California Bureau of Occupational Health. Two types of filter papers, a green Gelman Filter and a black Millipore Filter, were used. Illumination was achieved with a Zeiss Epi-Illumination Condenser which delivered incident light to the stage. Dark field Epi-Illumination gave a sharper image on the colored filters than Light Field Epi-Illumination. Fibers of asbestos are well defined against the opaque background of the filter. A 40X objective lens with a numerical aperture of 0.61 and a 10X eyepiece lens were used in the fiber identification. Filter papers with 0.8 μ pore size were used for the collection of the dust. This gives rise to the question of how much of the dust collects below the surface of the filter and is not seen by the observer. This is presently under investigation.

R C Grimm

Roger C. Grimm
S.A. Sanitary Engineer
Engineering Section
Research and Technical
Services Branch

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