...st. A group of animals is exposed to each time interval concentration level point. After the animals have been observed for a month or six weeks after exposure a mortality table is established. The data are then plotted on log-log scale as used by SAYERS and YANT.[1] We have made one exception in this method. We plot two curves: one represents the lowest concentration level—shortest time interval where all animals die; the other representing the highest concentration level—longest time interval at which all animals survive. This chart gives a clear picture of the acute toxicity of the vapor studied.

Chronic Vapor Toxicity

SOME reasonable period of exposure had to be chosen in extended chronic studies. A period of eight hours exposure and an interval of 16 hours between exposures has been arbitrarily chosen. SMYTH and SMYTH[2] used the same interval. It has some reasonable basis in our standard work day. These eight hours per day exposures are continued with week end intervals of rest for a period up to six months. Occasionally a longer total than six months is used but this is our standard. There is no doubt that a different period of exposure or a different interval of rest between exposures would change the results profoundly. Studies of the effect of interval variation would be most illuminating when time permits. Several different species of animal should be tested in order to avoid the individual vagaries of any one species. We have, however, used the rat as preferable for a standard animal.

At intervals during the six months, exposed animals are removed for complete histological study and at the conclusion of any series of exposures all the remaining animals are so examined. Other important studies made during chronic exposures are blood examinations, tissue analysis, urine analysis, and function tests where such are indicated.

Such complete toxicological studies on the chronic vapor toxicity of even our common chemicals are few and far between. They are, however, the basis upon which the industrial hygienist and safety engineer must base his work. Nearly any material may be handled in industry without serious hazard if its properties including its physiological effect are clearly understood and intelligently used.

The procedures and apparatus just discussed are for the purpose of furnishing in so far as it is possible the toxicological data by which an intelligent engineer can design or control an industrial plant for the manufacture or use of essential chemicals with the minimum of hazard.

References:

1. SAYERS, R. R., YANT, W. P., THOMAS, B. G. H., and BERGER, L. H.: Physiological response attending exposure to vapors of methyl bromide, methyl chloride, ethyl bromide and ethyl chloride. U. S. Pub. Health Service Bull. No. 185, 1929.

2. SMYTH, H. F., SMYTH, H. F., JR., and CARPENTER, C. P.: The chronic toxicity of carbon tetrachloride; animal exposures and field studies. J. Ind. Hyg. and Tox., 18: 277, (1936).

Air Sampling of Asbestos Dust

—Comparison of Impinger and Electrostatic Precipitator Methods*

J. WM. FEHNEL,

Chemist, Industrial Hygiene Laboratory,
Metropolitan Life Insurance Company,
New York

DURING the past 16 years the Industrial Health Section of the Metropolitan Life Insurance Company has been studying the effect of the inhalation of asbestos dust by employees in plants in the United States and the Province of Quebec engaged in mining asbestos fiber and manufacturing asbestos products.

In 1929, the American asbestos industry was practically uninformed of the health hazard associated with asbestos dust, although a few British articles had been published describing cases of asbestosis contracted in English plants. In 1927, Cooke and Hill[1] and McDonald[2] gave the first detailed description of what are known as "asbestosis bodies." Asbestos fibers as long as 360 microns were described as occurring in the lung tissue of asbestos workers.

We, therefore, made an effort to distinguish asbestos fibers in our collected air samples and, while we used the impinger method of sampling for the determination of dust counts or concentrations, we also collected a large number of samples with the electric precipitator[3] for examination of physical structure and determination of particle sizes. We were, however, unsuccessful in finding much fibrous material in the air-borne dust and very few of a length greater than 50 microns and practically none of the 360 micron size. We found that 50% of the dust was less than 2.5 microns in the longest diameters while 97% was less than 10 microns. These particles are of the same dimensional sizes as those encountered generally in industrial plants.

Later Fulton[4] and his associates reported that not more than 3% of the air-borne plant dust was greater than 10 microns in the longest diameter which agrees with our findings, although he had surveyed only one of the dozen plants and mines studied by us. Recently the U. S. Public Health Service[5] issued a comprehensive report on the asbestos textile industry covering one of the plants we had previously surveyed, but also many others in other geographical locations. In their survey they took impinger samples for dust counts in order to evaluate the degree of exposure of employees engaged at various operations. On page 23 of this report the following statement is made:

"The relatively low percentage of fibers in suspended dust explains the small number of fibers observed while making dust counts of impinger samples." They determined the percentage of fibers by means of samples collected with the Owens jet dust counter, while Fulton made his fiber deter-

---

* [illegible]

NOTICE: This material may be protected by copyright law (Title 17 U.S. Code)

0068

PLAINTIFF'S EXHIBIT
MET-875

minations on electric precipitator collected samples.

Recent work published by [illegible] indicates that chrysotile fibers less than 3 microns is no more active than the silicate serpentine, which has the same chemical composition but which is massive rather than fibrous in structure. He states that by inhalation, chrysotile ground to such fineness that its fibrous structure is no longer recognizable, has produced no fibrosis in guinea pigs after a year's exposure. All his observations suggest a mechanical rather than a chemical form of irritation. Also that the reaction to asbestos is restricted to the lungs because only these organs possess the proper structure and physiological activity to permit friction with a stiff fibrous foreign body.

Recently, the electrostatic dust collector has been placed on the market. This device employs a combination of ionization and electric precipitation in entrapping dust. It is highly efficient in entrapping fine dusts and fumes. It was, therefore, considered advisable to study its efficiency, as compared with the impinger, in determining asbestos dust with the object of distinguishing fibers.

While cotton is used in the manufacture of asbestos textiles, no attempt was made to differentiate between cotton and asbestos fibers. The U. S. Public Health Service in their study were unsuccessful in distinguishing individual types of fibers.

In our study the standard impinger method of

TABLE I.

Sample No.	Impinger Sampling: Cu. Ft. Air Sampled	Impinger M.P.C.F.: Total Dust	Impinger M.P.C.F.: Fibers	% Fibers	Electrostatic Precipitator Sampling: Cu. Ft. Air Sampled	E.P. M.P.C.F.: Total Dust	E.P. M.P.C.F.: Fibers	% Fibers
Preparation Department								
1	38	3	.10	5.0	180	4	.40	10.0
2	40	3	.10	2.0	144	4	.25	6.0
3	45	3	.08	3.0	180	2	.20	10.0
4	56	4	.4	10.0	144	4	.20	3.0
5	44	2	.03	2.0	120	5	.40	8.0
6	56	5	.07	1.0	225	6	.50	8.0
7	38	3	.20	7.0	135	6	.50	8.0
8	36	3	.70	21.0	135	4	.50	12.0
Average	47	4	.30	6.0	150	5	.40	9.0
Carding Room								
1	42	2	.1	5.0	133	2	.1	5.0
2	42	2	.1	5.0	135	2	.1	5.0
3	44	2	.2	10.0	135	4	.4	10.0
4	42	3	.1	3.0	135	3	.3	10.0
5	44	3	.1	3.0	135	2	.1	5.0
6	44	2	.3	15.0	135	3	.4	13.0
7	44	2	.1	5.0	135	4	.3	8.0
8	37	2	.2	10.0	114	3	.4	13.0
9	36	2	.1	5.0	114	3	.2	7.0
10	52	1	.1	10.0	162	2	.2	10.0
11	45	3	.3	10.0	135	4	.3	8.0
Average	43	2	.2	7.0	134	3	.3	9.0
Mule Spinning								
1	29	3	.1	3.0	90	4	.5	13.0
2	34	3	.2	7.0	No sample			
3	34	3	.2	7.0	93	4	.6	15.0
Average	32	3	.2	6.0	92	4	.6	14.0
Spooling, Twisting & Winding								
1	34	3	.1	3.0	135	6	2.0	33.0
2	44	3	.1	3.0	135	6	2.0	33.0
3	36	2	.1	5.0	135	4	.4	10.0
Average	38	3	.1	4.0	135	5	1.5	25.0
Weaving								
1	44	3	.1	3.0	135	4	.3	8.0
2	34	1	.1	10.0	135	3	.3	10.0
3	44	3	.1	3.0	135	4	.4	10.0
4	46	3	.4	13.0	135	2	.3	15.0
6	44	1	.1	10.0	135	1	.2	20.0
Average	35	2	.1	5.0	135	2	.3	11.0

TABLE II.	% Fibres		
	Metropolitan Findings		U.S.P.H.S. Findings
	Impinger	Electro.	Owens Jet Dust Counter
Mule Spinning Department	6	14	
Preparation Department	6	9	1 - 8
Carding Department	7	9	7
Spooling, Twisting and Winding	4	25	5
Weaving	5	11	12 - 26

sampling was used with an air ejector to provide suction. Samples were taken simultaneously and at the same locations and at the same elevation with an electrostatic precipitator. The impinger samples were diluted to the required volume and the electrostatic precipitator samples were washed into a standard volumetric flask and diluted to an equal volume in preparation for counting. In some instances further dilution on one or both duplicate samples was necessary where too heavy a concentration was encountered.

Counting was done by the light field method for total dust and for particles distinguishable as fibers. Both factors were recorded. Counts were made immediately after sampling in order to avoid clumping and solution of particles in the case of the impinger samples.

Samples were taken at representative operations throughout the plant and the following tables enumerate the findings.

It will be noted that from three to four times the volume of air was sampled in taking electrostatic precipitator samples, as compared with duplicate impinger samples. Average total dust concentrations agree for both methods of sampling in the preparation, carding, mule spinning and weaving departments.

Spooling and twisting are done in the same room adjacent to looms, while the winding is done in a room next to the mule spinning frames. Pollution from these adjacent operations may account for the variation in the total dust counts in these samples. There is also the possibility of the number of samples not being sufficient to eliminate personal or other discrepancies.

It is interesting to note the increase in the number of fibers counted in going from the preparation department, through carding, spinning, twisting, into the final operation of weaving.

The U. S. Public Health Service gave percentage of fibers at crushing and picking operations only in the weave room and no figure for spinning. From our observation of the type of operation, we believe more fibers may be thrown off in mule than in ring frame spinning. We found more fiber in the spooling, twisting, and winding than the U. S. Public Health Service reports, although they report on twisting only.

Again we fall close to the U. S. Public Health Service average of fibers in the weaving department. Of course, we must consider the three methods of sampling, in comparing these figures.

Conclusions

ALTHOUGH this report is limited to a relatively small number of comparative samples, it may be concluded that in the determination of asbestos dust in asbestos textile mills:

1. The impinger and electrostatic methods of sampling agree in the determination of total dust concentrations.

2. The electrostatic precipitator does entrap more fibers than the impinger. There is, however, the question of any hygienic significance in the increase determined.

References:

1. COOKE, W. E., and HILL, C. F. *J. Royal Microscopical Society*, 47:232 (Sept. 1927).

2. MCDONALD, S.: *Brit. M. J.*, Dec. 3, 1927 (Vol. 2): 1025.

3. DRINKER, P. THOMSON, R. M., and FITCHET, S. M.: Atmospheric particulate matter. II. The use of electric precipitation for quantitative determinations and microscopy. *J. Indust. Hyg.*, 5:162, (1923-24).

4. FULTON, W. B., DOOLEY, A., MATTHEWS, J. L., and HOUTZ, R. L.: Asbestosis, Part II. The nature and amount of dust encountered in asbestos fabricating plants. Part III. The effects of exposure to dust encountered in asbestos fabricating plants on the health of a group of workers. Pennsylvania Department of Labor and Industry, Special Bulletin 42, September 20, 1935.

5. DREESSEN, W. C., DALLAVALLE, J. M., EDWARDS, T. L., MILLER, J. W., SAYERS, R. R., EASOM, H. F., TRICE, M. F.: A study of asbestosis in the asbestos textile industry. U. S. Public Health Service Bull. No. 241, 1938.

6. GARDNER, LEROY U.: Etiology of Pneumoconiosis, *J.A.M.A.*, 111:1925-1936 (1938).

Physiologic Effects

—of Hot Atmospheres—

F. C. HOUGHTEN,

Director, Research Laboratory of the American Society of Heating and Ventilating Engineers, Pittsburgh;

M. B. FERDERBER, M.D.,

Research Fellow, Fever Therapy, Department of Industrial Hygiene, School of Medicine, University of Pittsburgh; and

A. A. ROSENBERG,

Research Engineer, Research Laboratory of the American Society of Heating and Ventilating Engineers, Pittsburgh

WITH the growing interest in the well-being of industrial workers and the extension of so-called hot industries, the physiological effect of hot atmospheres on man is becoming of increasing importance. Probably the earliest recognition of the effect of heat on workers was in certain branches of the mining industry where workers penetrated in the earth's interior to high temperatures, produced either directly or indirectly by volcanic action or due to the adiabatic heat of compression resulting from the increased barometric pressure. Considerable early information