

SOME OBSERVATIONS ON DUST

(by S.R. Rabson)

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CONTRIBUTION BY J. de V. LAMBRECHTS

Mr. Rabson has chosen a very wide and interesting subject for his Presidential address - one which fits this society admirably. The subject is so vast, in fact, that it is impossible in one address to touch on more than only a few facets. Mr. Rabson has wisely picked some of those facets which most intimately fit the activities of members of this Society.

Definition of Dust

I am personally very glad that Mr. Rabson has seen fit to concentrate largely on the rock-particle content of dusts. There are many "ifs" and "might be's" in connection with the possible harmful effects of different dusts; for example, "carbon particles might have a bearing on pneumoconiosis" or "traces of soluble silica might be the nigger in the woodpile" or "Salt particles might have to be counted with the rest, to be on the safe side" and so on. Personally I have little time for these possibilities because I think that, although they might have some small influence, they tend to confuse the issue quite out of proportion to their real importance. I would say, then, as I think Mr. Rabson also feels, that, as far as the prevention of silicosis or pneumoconiosis is concerned, we may as well define dust as consisting of very fine particles produced from the solid rock. This reasoning, of course, is at the back of the routine sampling technique used in Witwatersrand mines where dust samples are ignited and acid-treated to remove the carbon and soluble particles which do not greatly concern us.

Comparison of Number, Surface area and Weight

Continuing Mr. Rabson's arguments about number, surface area and weight of airborne particles, I have shown in figure 1 comparative size frequency curves for these three parameters. These are not graphs in the true sense of the word but, since the comparisons are for the same size intervals, they should hold. The basis for this comparison is an actual microscope count of over 37,000 particles on thermal precipitator records, collected in "wet" metalliferous mines in a variety of places where such operations as drilling, scraping, blasting, etc., were proceeding. The dust records were ignited and acid-treated and corrections were applied for the losses of rock particles during acid-treatment. The relative surface areas and weights were calculated on the assumption of constant shape factor and a square and cube relationship, respectively, with apparent diameter.

The medium values of these three parameters in figure 1 clearly show that widely differing significance can be placed on different sizes depending on which of these three criteria of dust concentration is used in silicosis studies.

Another point of interest arising out of figure 1 is Mr. Rabson's remark that the thermal precipitator probably is not very efficient in collecting particles of size 5 micron

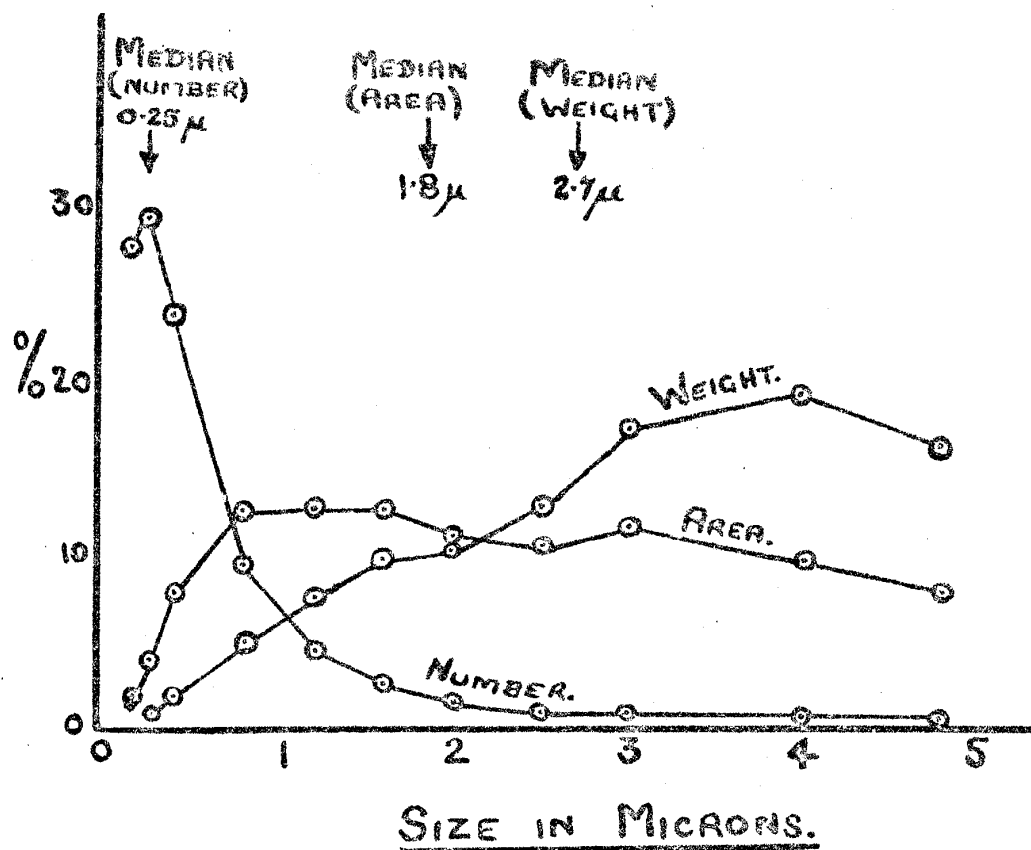


FIGURE. I.

SIZE FREQUENCY CURVES FOR
TYPICAL METALLIFEROUS MINING
DUSTS.

and larger. He bases this remark on his observation that by weight at least 50% of airborne dust is over 5 microns in size whereas by number it is almost completely absent. This, however, is only true if comparatively small numbers of particles are counted. If the 37,000 particles already referred to can be regarded as a fairly substantial sample, then it is found that the calculated weight of the particles over 5 micron could be more than 50% of the total weight. In other words, my findings are not inconsistent with the view that the thermal precipitator does, in fact, successfully collect particles of 5 microns and even larger.

There seems to be fairly strong support today, as Mr. Rabson has suggested, for the view that surface area may be the nearest approach to the correct criterion for measuring dustiness in pathological studies connected with pneumoconiosis.

On the Witwatersrand, however, the policy is to count every particle from 5 microns down to about 0.3 micron in konimeter work and 5 microns down to about 0.12 micron in thermal precipitator work. There is every indication that this policy may have to be reviewed and, if necessary, changed sooner or later and one may as well discuss this subject from time to time.

Mr. Rabson has very guardedly suggested that the very fine particles of say $1/4$ micron and smaller may play only a small part in silicosis causation, and here again I must agree with him. His figures 2, 3 and 4 are most illuminating in this connection. There has been much controversy about the relative injuriousness of different sized dust particles and, as long as we follow the policy of "counting" the dust concentration, the important question, as I see it, is whether a single "small" particle of silica can cause more or less damage than a single "large" particle, provided both are successful in penetrating the small alveoli in the lungs. The "small" and "large" referred to here might be taken, for example, as $1/4$ micron and 1 micron. Unfortunately, the medical experts have not always been entirely helpful in trying to answer this question. In those experiments that I know of, it has been customary to inject given weights, e.g. 300 mg, of dust of different sizes into animals and then watch the response. When it is found that the finer dust evokes a more severe reaction, it is concluded that the "fine" particles are more harmful than the "coarse" particles. This, to my mind, is a fallacy because obviously much greater numbers of particles and larger surface areas take part in the fine dust than in the coarse dust. I know of no experiments which have been successfully concluded where equal numbers of "fine" and "coarse" particles have been used in the experiments.

Treating this important aspect in purely arithmetical fashion, one might argue as follows: supposing that a 1 micron particle is split into two equal fragments. Due to the fact that there are now two particles instead of one, and also a larger total surface area, one can conceive of these two particles being together a little more harmful than the one parent particle, but certainly not twice as harmful. Each half particle, therefore, must be less injurious than the larger parent particle and, continuing this argument down the size scale, one concludes that the intrinsic injuriousness of single particles must decrease as they become smaller. Taken as a class, the finer particles

might gain in importance with decrease in size, provided that they increase in numbers inversely as the cube of the diameter. But we know that this does not happen. Read in conjunction with what Mr. Rabson has said about decreased retention of particles with decreased size, it would appear that there is definitely a size limit below which particles do not matter, either singly or as a class. This limit might very well lie between 1/2 and 1 micron. These arguments support the findings as shown in Mr. Rabson's figures 2, etc.

Taking everything into account, it would appear that already a fairly strong case can be made out for the choice of surface area as the best criterion for silicosis risk, rather than number or mass. If this should prove correct, then it means that we are erroneously placing far too much emphasis on the very finest particles which can be seen through our standard darkfield konimeter microscope or high power thermal precipitator microscope; and the electron microscope will err further still if one should assess air dustiness by counting with this microscope.

There seems to be general agreement throughout the world that particles larger than 5 microns are not of much importance. The lower limit to which particles are counted varies somewhat as follows:

TABLE 1

Country	Type of Dust	Sampling Instrument	Lower Size Limit (micron)
Great Britain	Coal	T.P.	1.0
" "	Stone	T.P.	0.5
United States	Rock	Impinger	0.8
Union of South Africa and N. Rhodesia	Rock	Konimeter	0.3
Union of South Africa	Rock	T.P.	0.12

There is, thus, considerable difference of opinion and technique when it comes to counting the very finest dust particles.

If it should be decided at some future date that surface area is a better criterion than number of particles, it does not necessarily mean that particles will no longer be counted. Bedford and Warner have shown that there is a high degree of correlation between surface area and number of coal dust particles in the range 1 to 5 microns and this correlation is probably at the back of the present practice in Great Britain, viz. counting of coal particles in this restricted range. I have found that in metal mines there is similarly a much better correlation between surface area and particle numbers in the range 1 to 5 microns than in the range 0.12 to 5 microns, as the following Table 2 will show:-

TABLE 2

Ref.	Locality	Type of Dust	$\frac{X}{Y}$	$\frac{X_1}{Y_1}$
A	Rand (gold)	Stope scraping (return)	1.42	0.23
B	" "	" " (intake)	1.62	0.27
C	" "	Dev. drilling (face)	2.13	0.24
D	" "	" " (intake)	1.72	0.21
E	" "	Test Chamber drilling	3.51	0.33
F	" "	Blasting	1.39	0.27
G	" "	Orebin (unfiltered)	0.76	0.22
H	N. Rhodesia (copper)	Dev. drilling (face)	2.40	0.23
I	" "	Test chamber drilling	1.84	0.25
J	" "	Secondary blasting	2.73	0.31
K	Transvaal (iron)	Drilling haematite	2.16	0.30

$\frac{X}{Y}$ = $\frac{\text{No. of particles}}{\text{Surface area.}}$ for range 0.12 to 5 microns

$\frac{X_1}{Y_1}$ = $\frac{\text{No. of particles}}{\text{Surface area.}}$ for range 1.0 to 5 microns

Note: The above ratios are based on relative values of particle numbers and surface areas.

It might mean then, that, if a suitable optical system can be found which reveals particles down to about 3/4 or 1 micron only, the particle count would bear approximately a fixed ratio to the surface area. Fixing this lower limit would naturally require considerable investigation, but I am not at all sure that the Americans have not been right all the time, fortuitously probably, in counting their dusts down to a size somewhere between 3/4 and 1 micron.

A further advantage, if this should become possible, would lie in the fact that then, probably, we would no longer have to treat our slides to remove carbon and salt particles because it is only below about 1/2 micron that they start being a nuisance.

I have not touched on all the other valuable things that Mr. Rabson has said. I can only say that I am in general agreement with him on practically all the views he has expressed. I sincerely hope this might be a case of "great minds think alike" and not "fools seldom differ"!

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CONTRIBUTION BY V. LANGKILDE

I am interested in the statement by Mr. Rabson that a new dust sampling instrument is desirable, and that it should be of a type to face the air stream and sample with an air intake velocity the same as that of the air. In considering such an instrument, it must be remembered that velocities fluctuate considerably underground. An example is a development end where, after sampling the face, the intake air, which enters at a high velocity in ventilation pipes, has to be sampled. The instrument must, therefore, possess a wide range of sampling velocities which, from a practical point of view, appears to be impossible, and it is doubtful if such an instrument can be produced.

In regard to making konimeters foolproof, it is doubtful if much more improvement can be made in this respect. As it is, konimeters are very robustly made and stand up well to the rough conditions which are met with underground in routine sampling. They need only little attention if sent in regularly every six months for examination and overhaul.

The variations which occur in sampling, treatment and counting have been reduced to some extent and are not such a serious factor as they used to be. This is due to the introduction of a standard treatment, more regular examination of konimeters and a marked improvement in konimeter technique.
