SOUTH AFRICAN METHODS FOR THE ASSESSMENT OF DUST IN GOLD AND COAL MINES

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Abstract

Events leading to the development of the latest methods used in South Africa for the measurement of dust are described briefly. Reasons for the lines of research and development followed are given and a comparison is made between the photoelectric assessor and DISA and between 2 different types of elutriator used with the modified thermal precipitator.

It is shown that the instruments agree well with each other and that the elutriators used conform reasonably well with the recommendations of the 1959 Pneumoconiosis Conference held in Johannesburg.

The methods used in Southern Africa for the sampling of dust and for the assessment of the samples are not used routinely in any other country. Some countries do use the konimeter, but it is not usually the Witwatersrand konimeter, and the method of treatment normally differs from that used here. It may be of some value to give the background to the methods used in this country and to give the reasons for adopting some of the more recent techniques.

It is well known that the earliest dust sampling methods used in this country were gravimetric. The so-called 'sugar tube' was adopted as the standard instrument, and this served a useful purpose in the early years of gold mining when dust concentrations were high. Samples were, however, not elutriated, and as dust conditions got better the results became less and less accurate because of the small weights involved and the erratic effect of large particles. Hence the change to what was undoubtedly a more sensitive technique, even if it did not prove to be very accurate, namely, konimeter sampling with microscope assessment.

The konimeter has also served a useful purpose for many years, but for research and investigational work it has been largely superseded by the thermal precipitator in one form or another. Apart from being more accurate the thermal precipitator takes more representative samples in such a way that they are more easily examined by high or medium power microscopy, and for the first time information started to accumulate on differences in the size distribution of dusts produced by various processes.

The main difficulty associated with microscopy as applied to dust samples arises because of the wide size range covered by most dusts and the impossibility of arriving at an absolute dust count. All air contains some dust, much of it very fine, and in industrial processes we are concerned only with the dust which is added to what is already there. Then come the usual problems every dust physicist knows—how to distinguish between the particles in which he is interested and those in which he is not, what size range to cover and how this can be defined reasonably accurately, particularly at the lower end, what treatment to give the slides, how to avoid contamination—these and many other problems are always associated with the microscopy of dust.

For many years, therefore, the aim in this country has been to try to evolve methods of assessment which would be quicker and less tedious than ordinary microscopy and, preferably, more accurate as well, because dust microscopy is not, under normal routine conditions, an accurate method of assessment.

Research and Development

To simplify dust sampling with the thermal precipitator the instrument was modified in various ways, the most important of which was the change to enable several samples to be taken on one slide, firstly with the long sampling thermal precipitator[1] and then with the modified thermal precipitator.[2] At the same time a simple form of horizontal elutriator was introduced, and although this elutriation was not quite the same as that proposed some years later at the 1959 Pneumoconiosis Conference in Johannesburg (a cut-off of 10 microns for quartz dust was aimed at), it was at least introduced and used.

Parallel with these developments work was proceeding on the development of a simple instrument aimed at photoelectric assessment of the total sample—the photoelectric dust assessor as it was later called.[3]

The modified thermal precipitator with elutriator and the photoelectric assessor were adopted as routine instruments for dust control in our collieries in 1956 and have been used in the same way ever since. The results have been supplemented by gravimetric sampling and dust analyses, but for dust control purposes there has to date been no other technique available with sufficient advantages over that currently used to warrant a change.

In our gold mines the position is different. Dust levels based on surface area or weight are much lower than in the collieries, and the photoelectric assessor was not considered to be sufficiently accurate for measurement of such dust levels.

DISA is at present being used for the assessment of samples in large-scale field trials at several mines as a possible alternative to the konimeter with microscope assessment technique for routine dust control.

Attempts were also made to improve the performance of the konimeter and to develop a simple instrument for automatic assessment of samples. Some progress has been made and better results may be obtained with the aid of an elutriator which has been designed for the konimeter, but the 5 c.c. samples are rather small for reliable automatic assessment.

All methods of automatic assessment developed here have been based on the parameter of surface area, whereas the trend elsewhere has been to turn to gravimetric methods.

While gravimetric sampling combined with elutriation has several advantages as a measure of dust exposure, it does not have the same attraction for day-to-day control of dust con-

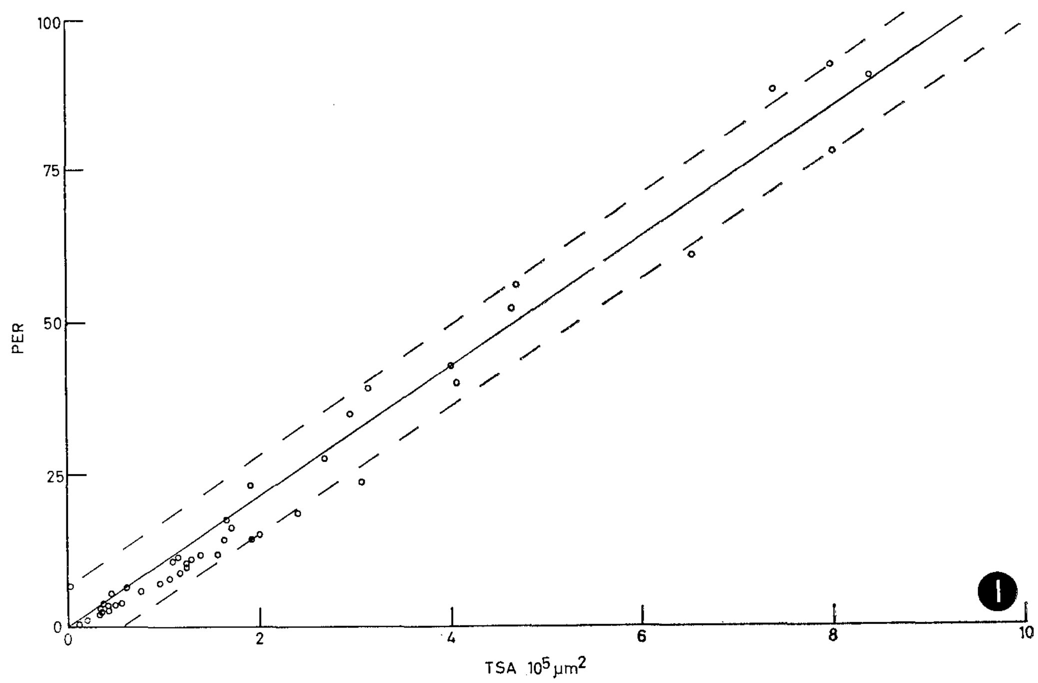

Fig. 1. Comparison between the PEA and DISA with coal samples. R = 0·988.

Various other methods of assessment were therefore considered, some of which were tried out, and eventually the diffraction size analyser (DISA) was evolved.[4] With a new form of the modified thermal precipitator designed particularly for routine sampling,

ditions, particularly where dust levels are low.

Using the only available portable instruments with elutriators, even a whole shift sample may give inaccurate results because of the small weight of sample, and it is therefore felt that a short-term sampler such as the thermal precipitator with assessment of surface area by DISA is more suited to the needs of the mines. Information concerning acceptable dust levels and the correlation between average exposures (measured in various ways) and radiological evidence of pneumoconiosis is being obtained by methods such as the epidemiological survey described in another paper by Mr. Beadle.

Comparison of the Methods in Use

The photoelectric assessor used on collieries is said to give a result which is related approximately to the surface area of the particles down to a certain size below one micron, and the results are quoted in arbitrary units, whereas DISA gives a read-out in square microns per c.c., having made certain approximations. Furthermore, the modified thermal precipitator elutriates the samples, which are then assessed *in toto,* whereas the thermal precipitator as used with DISA samples all the dust and DISA then applies an artificial correction to give Respirable Surface Area.

If these statements are correct, there should be a good correlation between readings obtained by each method. The magnitude of the difference between the 2 methods of 'elutriation' should also become apparent if the techniques are compared.

This has been done and the results are given below.

1. Correlation of Photoelectric Readings with Surface Area as Measured by DISA

Samples of coal and quartz dust were taken in a dust chamber with the modified thermal precipitator, assessed photoelectrically and then shadowed with aluminium and the total surface area measured on DISA. The results are given in Figs. 1 and 2, with 95% confidence limits.

It will be seen that the correlation is very good, with correlation coefficients of 0.988 and 0.964, and that in terms of surface area 1 PER = 94 μm^2/c.c. for coal dust and 1 PER = 99 μm^2/c.c. for quartz dust (**N.B.** the PER is the reading for a 100 c.c. sample).

Assuming that DISA gives a good measure of surface area, these results indicate, firstly, that the photoelectric assessor also gives a good measure of surface area and, secondly, that its response is not very different even for

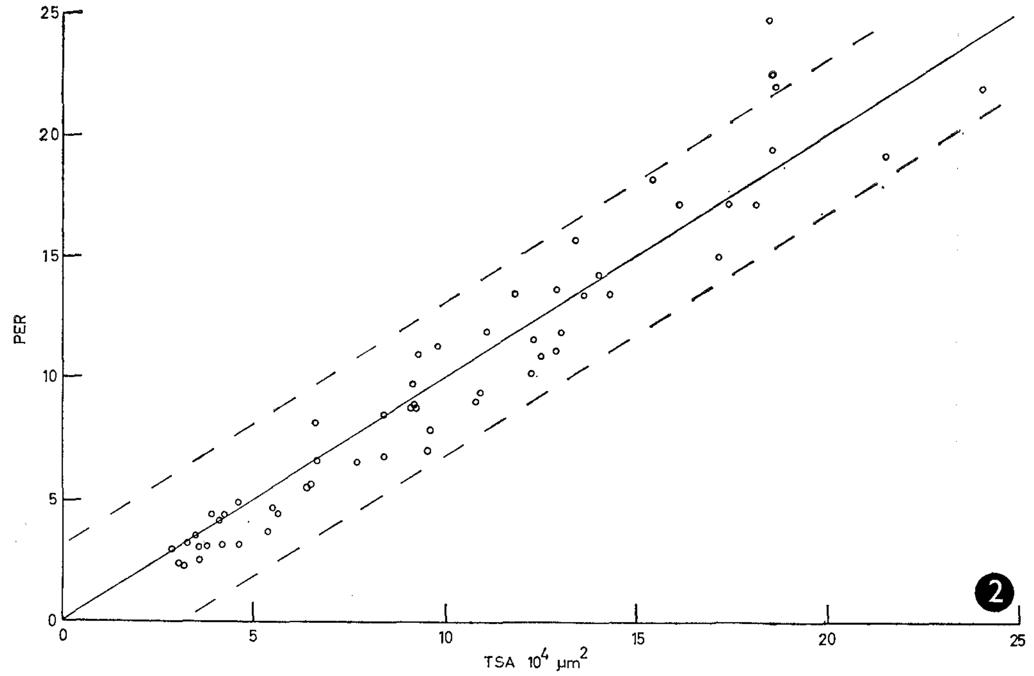

Fig. 2. Comparison between the PEA and DISA with quartz samples. R = 0·964.

particles which are as different optically as coal and quartz.

2. THE ELUTRIATORS USED WITH THE MODIFIED THERMAL PRECIPITATOR

The older type of modified thermal precipitator, as used on the collieries, has an entrance channel which was designed to eliminate all quartz particles of diameter above about ten microns. Also for quartz particles, RSA as given by DISA has a cut-off at about seven microns.

Parallel samples were taken with two modified thermal precipitators, one sampling in the normal way and the other sampling with the entrance channel facing upwards. Each was assessed by DISA, the first as total surface area (TSA) and the second as respirable surface area (RSA), and the comparison is shown in Fig. 3.

The new thermal precipitators have an impingement type of elutriator designed to cut off at an equivalent diameter of approximately 7 microns, and the results of a comparison similar to the one described above for the older instruments are given in Fig. 4.

In both cases, as would be expected, the elutriator surface area is somewhat higher than RSA by DISA, indicating a 'tail' of particles above 7 microns, but the differences are not large, the ratios being 1.1 and 1.2 respectively. The results indicate that the instruments sample approximately in accordance with the recommendations of the 1959 Johannesburg Pneumoconiosis Conference.

DISCUSSION

Elutriation during sampling is the usual way of obtaining the respirable fraction of dust, and it has the advantage of elutriating the dust in the same condition in which it is being inhaled. Collection of the total dust for subsequent examination or elutriation opens up the possibility of a change in state of the dust by, for instance, the evaporation of moisture or aggregation of the particles (in a gravimetric sample).

Underground tests in our gold mines under saturated conditions, using modified thermal precipitators, did not given elutriation results appreciably different from those obtained in laboratory tests and it was therefore decided

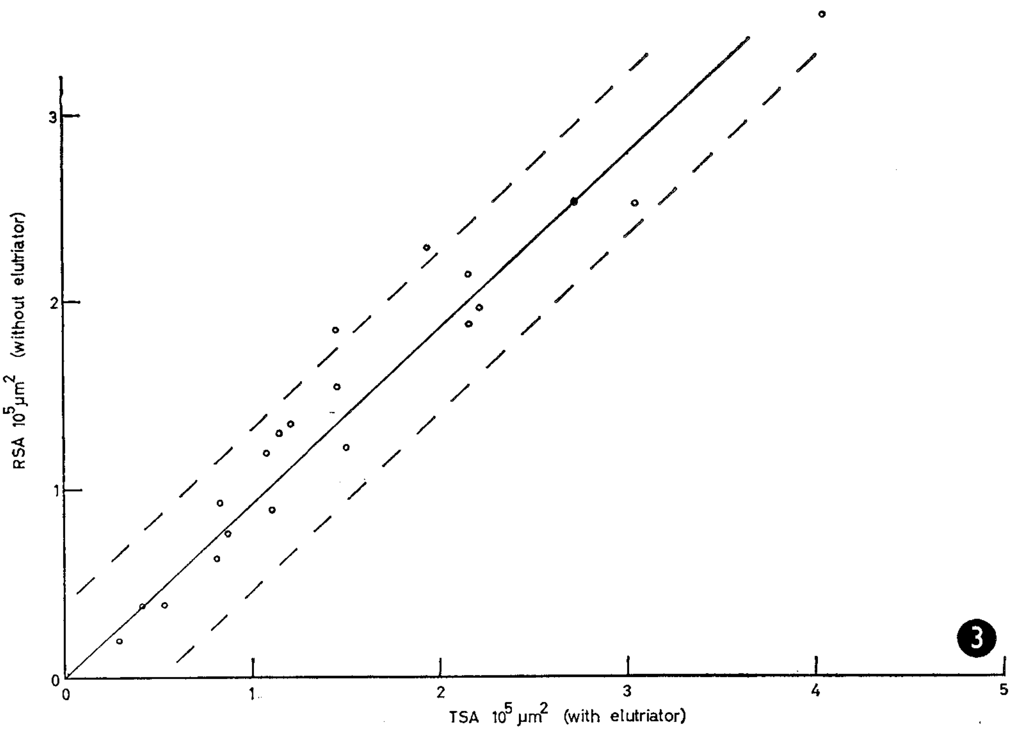

Fig. 3. Elutriator tests with quartz samples. R = 0·977.

for the newer models to sample all the dust and correct to RSA by means of DISA. The main advantages of this method are:

(*a*) Any desired correction curve can be applied to the size distribution without change in the instrument.

(*b*) Contamination by large particles, scratches and other marks in the aluminium film will be eliminated by DISA. The surface area figures can be very misleading if this is not done.

With gravimetric sampling, elutriation must take place during sampling because redispersion of particles is impracticable, and in our mines the respirable sample so obtained is very small, even over a whole shift. Assessment by some means other than weighing might be worth investigating, and, in fact, is already in use by our Laboratories in the case of the quartz content of the air, which is measured by X-ray analysis of the dust collected on membrane filters.

Failing this, there seems to be no good reason why routine investigations and dust control work should not continue to be carried out with respirable surface area as the criterion of dustiness.

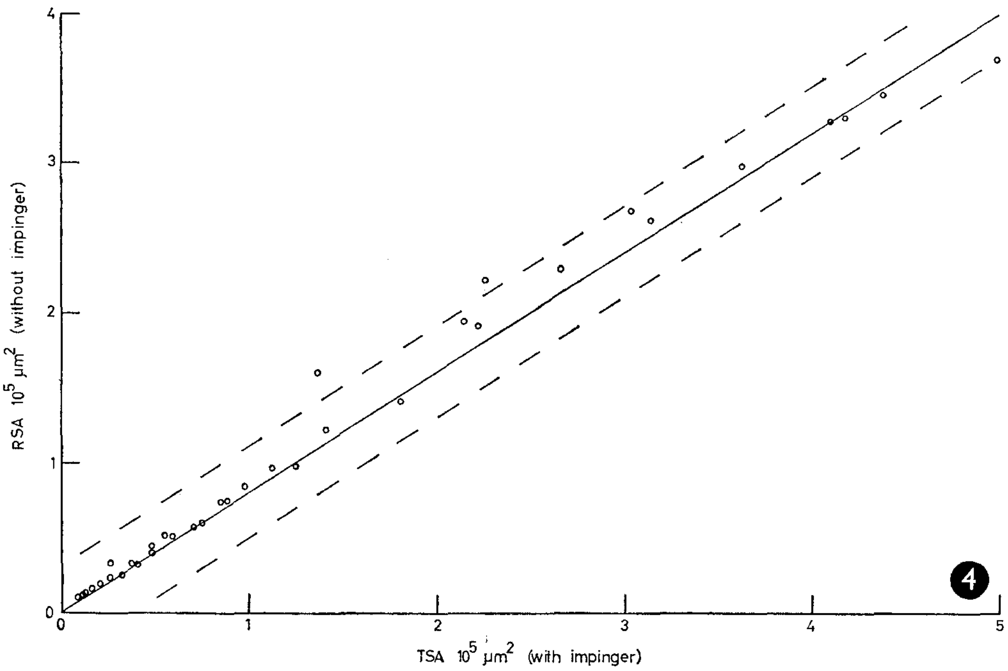

Fig. 4. Impingement separator tests with quartz samples. R = 0·993.

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