PHOTOELECTRIC READINGS.

THEIR SIGNIFICANCE FOR DUST CONTROL IN COLLIERIES

By **G. H. J. Kitson*** (Member) and **Y. J. F. Haven†** (Visitor)
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Contribution by Mr D. G. Beadle‡

I have read this paper with considerable interest. By using an automatic instrument to assess the dust samples taken in South African collieries, the authors are ahead of the gold mining industry, which still uses the laborious method of microscopic assessment, with its limited accuracy, of the half-a-million dust samples taken each year.

As the authors state, the result obtained from the photoelectric assessment of the samples is approximately proportional to the surface area of the respirable dust. However, modern theory is that, in assessing coal dust, it is the respirable mass which is important in determining the danger to health. Thus Table II of their paper is of considerable value in showing the relationship between the P.E.R. value and the mass concentration measurement. Unfortunately this table only gives the mean relationship. The important point is to know the scatter around this mean. If the scatter is small, then this mean value (for different operations) would have considerable value in converting from respirable surface area to respirable mass, but if the scatter is large, then such a conversion, using a fixed factor, will have little value. In the text the authors mention the range of values as being between 3 to 24, but without a statement on the number of samples used to determine this range and their distribution, this is a rather nebulous statement. I hope, in their reply, that the authors will give, in statistical terms, some statement on the overall correlation between these two parameters. I might add that at present a member of my staff is working on similar relationships for dust samples taken in gold mines.

Another factor which may well be most important in determining the danger of dust levels in coal mines is the composition of the dust, specifically its quartz content. I understand that the authors have some information on this point, and to make their results of greater value in International comparisons of dust levels and the concomitant development of pneumoconiosis, it will be extremely useful if they could place this information on record.

Even though, as I have said above, modern theory postulates that respirable mass is a better parameter to use than respirable surface area, the problem remains of how to measure this parameter with short time sampling, which, as the authors point out, is their preferred strategy for dust sampling and dust control. I know of no easily portable instrument, independent of external power supplies, which can, in 5 to 10 minutes, collect sufficient dust to enable it to be weighed accurately. Thus the authors' implied intention of continuing to sample by their present techniques and using their present parameter to report the results is, in my opinion, an entirely valid decision.

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*Contribution by Mr P. H. Kitto**

In this paper the authors give an excellent account of the methods used for dust control in South African collieries and the relationship between the photoelectric readings used for assessing the dust and other more conventional units. The reasons for using these methods are also explained.

The techniques of dust measurement and control which have been adopted are both practical and effective, but no attempt has been made to give the dust exposures of different categories of worker, and readers may be inclined to think that this detracts from the value of the paper. It might be thought, for example, that by combining a simple time study with the P.E.R. values for different operations it would be easy to arrive at the average exposures of different workers, and then to correlate these with certifications of pneumoconiosis so as to find a reasonably safe standard of dustiness.

In practice, however, it is impossible to find a dust standard by such simple means, for the following reasons.

Firstly, the operators of the different machines—cutters, loaders, drills and so on—are normally Africans, and they very seldom have long spells of continuous mining. Their periods of work are invariably interrupted by periods when they return to their homelands. The exposure of the European miners is much more difficult to assess with any degree of accuracy, and a large proportion of them have had 'mixed mining' experience. This means that without a complete record of dust exposure, which is not available, very little correlation, if any, can be expected between estimated exposures and certification of pneumoconiosis.

A general 'maximum allowable concentration' of dustiness can therefore be based at present only on those used in other countries, and, apart from the doubtful validity of accepting standards from a different mining situation, the values themselves vary considerably from one country to another.

The only alternative, as long as certifications still occur amongst 'pure' coal miners, is to accept that dust levels must be reduced by all practical means, and the obvious ones to be tackled first are the highest ones, which in our mines means, mainly, the dust from coal cutting. As a practical guide the figure of 100 P.E.R. has been chosen from experience as a reasonable target which should not be exceeded during the operation of the coal-cutter.

The dust from other operations in bord and pillar mining is of lesser importance, but nevertheless by keeping records, as the Collieries Dust and Ventilation Laboratory has done, the position can be watched from year to year to see that conditions do not deteriorate.

Long-wall mining and the use of machines such as continuous miners will create further problems, but until more information is obtained the figure of 100 P.E.R. will still be used as the arbitrary 'maximum allowable concentration' value.

Contribution by Mr M. J. Martinson†

This contributor sympathises with the authors in their efforts to paint an optimistic picture of dust conditions in South African collieries, but respectfully submits that the paper in fact epitomises the reactionary and muddled thinking that has so long characterized dust sampling in South African mines.

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A good example of confused thinking occurs in the final paragraph of the Conclusion, where the authors say 'It would have been a highly satisfactory conclusion to this investigation if it had been possible to indicate with assurance the maximum dust concentration which would be considered to represent safe working conditions, but a clear and indisputable specification of such concentrations cannot be made from available data'. This somewhat trite and rather curiously worded statement could be dismissed as harmless pie in the sky if the authors had not taken considerable pains to point out earlier that the dust sampling procedure employed in South African collieries '(is) not intended to measure dust exposure of personnel'. It must surely be obvious by now that there can be no hope of determining 'maximum dust concentrations which would . . . represent safe working conditions' until incidence of respiratory disease has been correlated epidemiologically with dust exposure expressed in terms of some meaningful characteristic (or characteristics) of the inhaled dust cloud. Whatever characteristic is measured, the total dust exposure of each individual is patently all-important. No reliable correlation between disease and exposure has been established yet, but in the meantime in at least one country the total exposures of individual miners are already being assessed at regular intervals so that workers with high exposures can be deployed to low-exposure occupations to reduce the risk of contracting coalworkers' pneumoconiosis. Efforts are also being made overseas to develop more efficient and reliable personal samplers for direct measurement of individual exposure.

The authors claim that although routine sampling does not measure dust exposure it does enable management to enforce dust control measures, and they present tables of P.E.R. values which purport to show how underground and surface conditions have improved since the introduction of the present sampling procedure in 1956. It is arguable that 'control' sampling which does not measure exposure is meaningless, but giving the present data the benefit of the doubt a quick inspection of all the figures in Tables V and VI does not convince this contributor that there was any material improvement in conditions between 1957 and 1967. This could perhaps be tested statistically.

Turning now more specifically to the system of dust sampling and assessment described in the paper, three brief comments are called for. Firstly, the system disregards completely the principal recommendations made in the field of dust and engineering at the end of the 1959 Johannesburg Pneumoconiosis Conference, i.e. that dust measurements should relate to the 'respirable fraction' of the dust cloud (as defined by the Conference); that in coal mines the mass concentration of respirable dust should be measured; and that dust measurements should be expressed as the average level of dustiness over a period such as a shift. The 1959 Conference was attended by many of the world's leading authorities on pneumoconiosis, and one wonders why the South African coal mining industry has failed to implement any of these recommendations in the intervening decade.

Secondly, the authors state that the sampling procedure 'is based on intermittent sampling during periods of maximum dust production'; bearing in mind that we are only interested in the production of (invisible) respirable dust, how can an observer determine periods of maximum dust production without sampling throughout the working shift? The system introduces an undesirable subjective element in the sampling procedure, and is in any case contrary to the 1959 recommendation.

Thirdly, the authors include three studies 'to indicate a very rough guide to the absolute value of a P.E.R.'. Intuitively one doubts if there is any such thing as an 'absolute' value of a P.E.R., and seemingly this doubt is shared by the authors. One also suspects that because the P.E.R. has no intrinsic significance its impact on colliery personnel is probably minimal. If selective gravimetric sampling were to be employed—as recommended by the 1959 Conference—it would be very much easier for personnel to associate sampling results with respiratory disease.

Finally, assuming again that individual P.E.R. values have some limited significance, little survives when they are lumped together and presented as industry means. Lamentably few dust sampling results of any sort are published, and seemingly there is a tacit convention everywhere which bars publication of raw sampling results for individual mines. This policy stifles meaningful analysis, excludes competition between mines in dust suppression and control, and unfairly denies an employee the opportunity of deciding on health grounds whether or not to work in a particular mine. The pneumoconiosis hazard is only one facet of the far wider field of occupational health and safety in mines, and there are strong grounds for suggesting that a statutory body should be established to set standards, supervise enforcement and initiate research in this field.

*Contribution by Dr R. S. J. du Toit**

I wish to congratulate Messrs Kitson and Haven on their paper which I found most interesting. Their paper is a valuable contribution to our knowledge on the dust encountered on collieries.

I found particularly interesting the estimates of the conversion factors between P.E.R. and mass of dust below 5 micron, and P.E.R. and the number of particles in the size range 1 to 5 micron. The conversion factors vary quite a lot. Nevertheless, for rough and ready computation, one may conclude that 1 mg/m^3 approximates 10 P.E.R., which in turn approximates 100 p.p.c.c. in the size range 1 to 5 micron.

In other words, the number-mass index amounts to about 100. This means that 1,000 p.p.c.c. (1-5 micron) amounts to about 10 mg/m^3. According to Walton[1] number-mass indices for British coal mines range from 6 to 33. In the central value of this range, say 20, represents the overall average for British coal mines, it would seem that the dust produced on the Vereeniging and Witbank fields is on average not as coarse as that on British coal mines. This is logical, because it is known that South African coal is, on average, harder than British coal. It is also well known that the dust produced is the finer the harder the mineral disintegrated. It would be useful if similar results for coal mines in other fields could be obtained.

There are, however, a few statements in the paper which I should like to comment on. I agree with the authors that the results of routine dust samples are indispensable for the suppression of dust, but I cannot accept their statement that routine sampling in South African collieries is . . . '*not* for the purpose of assessing the level of exposure to a dusty atmosphere' (writer's accentuation). Neither can I accept their statement that 'routine control sampling of airborne dust on collieries is *solely* concerned with the examination of the environment to *pin-point* dusty operations and places and to inform managers as soon as possible so that remedial steps can be taken without delay' (writer's accentuation).

If this were indeed so, in other words if the dust level to which persons are exposed were *not* a factor which had to be duly kept in mind when taking samples,

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why then their specific statement that 'coal face samples are taken *at head height as close to the workmen as can be arranged* on the return side of the main mining operations'? (writer's accentuation). It is quite impossible to dissociate completely the dust level and, therefore, the exposure of persons on collieries from the results recorded during routine dust sampling.

Admittedly, the results recorded do not estimate the *actual* average dust level to which the average person is exposed, but the results recorded are certainly *related to* the average dust level and to the average dust exposure of the average person employed in dusty atmospheres.

The authors rightly conclude that there was a 'general improvement in dust conditions for the industry as a whole over the period 1956 to 1967'. From this it is logical to conclude that the average exposure to dust of the average person employed in dusty atmospheres decreased.

Although very desirable, it is not absolutely essential to measure the actual dust level to which persons are exposed. One has mostly, for practical and economical reasons, to be content with something related to the dust exposures of persons.

It is perfectly logical to argue that the mean exposure of the average person employed on collieries where samples are taken at a number of strategic positions such as the places mentioned by the authors is related to the average dust level recorded at the strategic positions. This average may either be obtained as the straight mean, or by loading the dust levels recorded at each strategic position by the proportion of persons employed at or about that position.

The writer investigated this association and Fig. 1 is a scatter diagram of the dust indices recorded on a number of collieries where the mean dust index was computed in two ways. The one dust index was computed as the straight mean of the main dust levels recorded at the six strategic positions:

Surface, intake, return, cutting, drilling and loading

whereas the other dust index (for the same mine) was computed from the dust level recorded at the persons encountered whilst criss-crossing the mine, the dust level at each group being weighted according to the number of persons encountered. The scatter is sufficiently close to the 45° line to conclude that the one index is, for practical purposes, an estimate of the other.

I now wish to deal with the emphasis laid by the authors on the fact that they take samples during periods of 'maximum dust production' and their intimation that samples are taken only during actual cutting, actual drilling and actual loading. In other words, sampling is stopped when these operations are stopped and that, therefore, their results should not be used to estimate personal exposures because it would over-estimate personal exposures.

In the first instance, one may argue that it is normal for certain stops to occur during cutting, loading and drilling and that it is, therefore, more correct to continue sampling during such stops. In the second place, one may argue: how does one know that one has in fact only picked out the peaks of dust concentration unless short samples are also taken when one thinks that the dust level is below the peak and then discards those results which are below the peak concentrations? This is not done, otherwise the authors would have said so. Hence, the results they record are somewhere between 'true peak' and 'true average'.

Arguing further against the emphasis laid on peak sampling, it should be stated that routine dust sampling on collieries by officers of the central laboratories are acceptable to the Government Mining Engineer in the place of routine dust samples which should otherwise be taken by persons employed by individual collieries, as called for by Mines and Works Regulation No. 6.9(3).

This regulation calls for 'measurements to be made during the main working shift, not less than once in six months, of the amount of dust in the air in representative working places in each section while drilling, cutting, breaking, loading or transfer of coal or rock is taking place'. The regulation neither stipulates during periods of maximum dust production nor during actual cutting only, nor actual drilling only, nor actual loading only.

The main purpose of the regulation is to ensure that persons are not exposed to unsatisfactory dust levels.

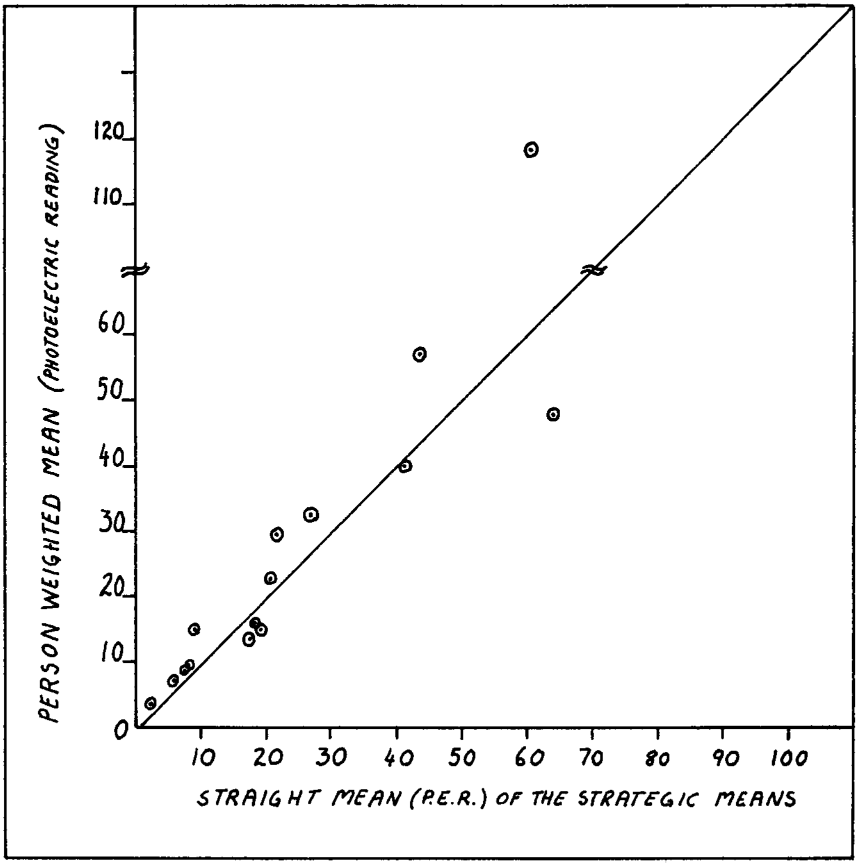

Fig. 1

Hence, the spirit of the regulation is more closely complied with when samples are taken so as to reveal the average concentrations which occur during intermittent operations such as cutting, drilling, loading, than when samples are only taken so as to reveal the peaks. Furthermore if the strategy of peak sampling is used as an argument against utilization of the results recorded for estimating mean dust levels, I would rather see less stress being laid on obtaining the peaks during intermittent operations.

Two further objections to this designed 'peak sampling strategy' are the following:

(*a*) It makes one used to seeing high readings;

(*b*) It spoils those who have to lower dust levels because it is much easier to lower peak dust levels than to lower average dust levels.

Turning to the question of whether routine dust results may or may not be used to estimate average dust levels, my view is that one is fully justified to base estimates of mean dust levels and estimates of mean personal exposures on any set of dust samples, whether or not the samples were taken for this particular purpose (even whatever defects the results may have), as long as such results are *the best available evidence* of the dust levels to which the persons concerned were exposed.

With reference to the laying down of standards, the authors claim that matters such as 'the probable fact that a workman who is engaged on heavy manual labour retains more dust in his lungs than a workman who is inactive', and that 'the variation in individual susceptibility of workmen must be weighed in the balance in the formulation of standards'. This is impracticable, because under such conditions, no one would ever be in a position to lay down any standard. All that is necessary, in my opinion, is to be convinced that the dust standard decided on is in the range where an increase in dust level is associated with an increase in the risk of causing pneumoconiosis. As dust causes pneumoconiosis on account of its *cumulative* effect, any dust level, however low, adds its share to the risk of persons contracting pneumoconiosis. The actual level decided on for a particular set of conditions depends on what can reasonably be achieved in actual practice.

In this connection, it has recently been decided to set the following targets for the main classes of places and operations on coal mines in general.

Place or operation	*Photoelectric reading*
Cutting	100
Drilling	35
Loading	20
Return air (from a section)	15
Intake air (to a section)	7
On surface	20

Now view these targets in the light of what is known about conditions on coal mines and this is another reason why the results submitted by Messrs Kitson and Haven are so valuable.

From the figures submitted by Messrs Kitson and Haven the writer estimates that the average dust level to which persons employed in dusty atmospheres during the years 1957/67 on the coal mines reported on were exposed to is of the order of that related to a reading of 40. The average exposure prior to certification of (White and Coloured) persons employed on coal mines only, is of the order of 25 years. From this, it is in the light of several factors (which need not be mentioned here) reasonable to assume that a dust dosage of about 1,000 (i.e. 40 × 25) P.E.R.—years on the mines reported on is one at which a person could be expected to be certified for pneumoconiosis.

One method of judging a dust level is to assume that pneumoconiosis will be contracted at constant dust dosage and to view this dust level in the light of the expected years of service prior to certification. Hence, for cutting, the estimate becomes 10 years; for drilling, 29 years; for loading and on surface, 50 years; for return air, 67 years and for intake air, 140 years!

Naturally, these are very rough estimates.

The attitude to the intake and return targets should, to my mind, be that these are reasonable targets for those classes of places which, when exceeded, increases unnecessarily the overall risk of pneumoconiosis on the mine, rather than to ask, why set targets at levels below which persons are likely to contract pneumoconiosis.

Having got that off my chest I wish to conclude by thanking Messrs Kitson and Haven once more for a very valuable and interesting paper and by expressing the hope that they will follow this paper up with further information which I am sure they have. What is particularly needed is information on the composition of the airborne dust even if it only concerns the percentage of incombustible material.

ACKNOWLEDGEMENT

I wish to thank the Government Mining Engineer for persmission to publish this contribution.

REFERENCE

1. WALTON, W. H. 'The airborne dust problem in coal mines in Great Britain.' *The Mining Engineer*, No. 74, Nov., 1966, p. 108.

Contribution by Mr F. E. Kirstein

The techniques of winning coal have been developed into a series of repetitive interdependent operations, especially in mechanized mining. These operations go hand in hand with the creation of a dusty atmosphere. The degree of contamination of the atmosphere depends on a number of factors, e.g.

(*a*) Type of operation,

(*b*) Measures taken in dust suppression,

(*c*) The type of coal dealt with.

Since the introduction of dust sampling on collieries by the Collieries Dust and Ventilation Laboratories a very useful gauge became available to Colliery Managements to assess effectiveness of dust suppression methods applied. Routine control sampling of airborne dust stimulated interest especially where the six surface and six underground operations were sampled separately. Hence the general improvement indicated by the downward trend of the percentage of samples where the P.E.R. value exceeded 100, as reflected in Table VII. This general improvement is however mostly confined to cutting and drilling operations where the relatively coarse dust is present in greater proportions.

Messrs Kitson and Haven have put it clearly at the outset of their paper that routine sampling is not introduced to assess the level of exposure but to indicate conditions which are abnormal. This very practical and useful approach assists in dust suppression control. In their effort to correlate P.E.R. values with other physical units Messrs Kitson and Haven conclude that no indisputable specification of dust concentrations for safe working conditions can be arrived at.

The P.E.R. readings cannot, however, be used as an absolute measure of dust suppression effort since different coal seams differ in rank and proportions of type, e.g. Fusain, Durain and Vitrain, etc. These fractions differ in their characteristics and must differ in physical behaviour to water, which is presently the main dust suppressor. Although it is encouraging to note the improvements generally, much more research will have to be undertaken to arrive at standards for the industry.

In the efforts to obtain higher productivity a higher degree of mechanization in coal mining is resorted to, resulting in higher rates of cutting, drilling and loading which inevitably results in a higher rate of dust generation. It remains a challenge to mining engineers to maintain the low P.E.R. readings presently obtained.

I wish to congratulate Messrs Kitson and Haven for a very interesting paper, not only for the statistics provided, but also for so clearly describing their value and that of dust sampling to mine managers.

*Contribution by Dr W. P. M. Matla**

This paper is interesting not least of all because it is a practical approach to dust problems. It does not contain theories that might be withdrawn within a few years, as I have seen in several countries during my 31 years with the mining industry.

The newly developed South African method for the determination of the dustiness of ventilation air, of course, is not the only possible solution to the problem. I remind you for instance of the fact that the 'handpump' rendered excellent services in coal mines of South Wales. What was wrong with the 'handpump' was the 'establishment' of dust limits on hygienic grounds.

In view of the vast literature on the subject of dust concentration limits, with many contradicting facts, my personal opinion is that in general these limits should not be incorporated in the law. Other possibilities exist, e.g. prescription of dust abatement measures such as wet drilling in stone, use of sprays during shotfiring, and a minimum ventilation current. My belief is that with well organized dust prevention and suppression, in the large majority of cases the dust levels are low. Herein lies the important point of the human relations between Mines Inspectorate and mine management. Must the results of dust determinations remain hidden from the Mines Inspectorate? Of course not. I personally think that the Mines Inspectorate must have access to all the results of dust determinations annotated in suitable reference books (but please not hundreds of reports read by nobody). The point is that this is the best aid to come to a fruitful exchange of views between Mines Inspectorate and mine management. It will be of help in finding shortcomings in dust prevention and dust suppression and in re-establishing good practices for the benefit of mining companies and of the miners. (In the Dutch mining law until now no dust limits are

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prescribed, although the Inspector-General has the right to do so; on the other hand the Mines Inspectorate has access to the results of all dust determinations made in the underground workings by the responsible services).

There is another problem, namely the frequency of dust measurements. In some countries the practice is to make many dust determinations (even imposed to the mines) in places with a high dustiness level, whereas in places with a low dustiness very few dust measurements are made. My plea is to reverse the practice. In dusty environments we know something must be changed. In environments of low dustiness there may be a tendency to believe that it remains low, but only results of dust measurements will give the facts. When these measurements are made only once in three or six months, and a higher level of dustiness is found, then in my opinion it is too late.

A last remark on dust measurement in mines. The same dustiness in a chosen parameter does not necessarily mean the same occupational hazard. It is clear that with particular mining machines with rotating drums (such as the Anderton shearer), when cutting in a sandy floor, very fine dust may be created with a more pronounced health hazard for the miners than in other circumstances. On the other hand, with a simple routine dust measuring apparatus it remains possible to find out whether there are shortcomings in the planned dust abatement measures.

*Contribution by Mr A. Bain**

I would like to congratulate Messrs Kitson and Haven on their fine paper dealing with P.E.R. readings used in assessing the trend in mine dust allaying programmes. I appreciate the simple setting out and the clear and precise presentation of the facts, and I am sure many of our student members will also appreciate it.

To those of us who are actively concerned with dust in a mine, trends are of great importance. Whether the size of the particles are becoming progressively larger or smaller, angular or more spherical would be the concern of the research departments and not of the mining man concerned with a hundred and one other everyday events. Therefore a quick and accurate means of assessing the degree of dustiness in the workings is a most necessary tool in the hands of our Ventilation Engineers.

The time spent in correlating the P.E.R. readings with the microscope assessment was well spent and we can congratulate those persons who did the tremendous amount of work in finding the relationship and which we now refer to as a P.E.R. reading.

The regular returns from the Chamber Laboratories giving the Mine Manager a quick set of dust count readings which can be easily read, and which can give him an immediate picture of what is the position of a certain section of the mine, is a tremendous aid. As this check of an area is a sample of the mine it could be representative of the whole mine. Knowing what is the suggested standard of the Mines Department it becomes an easy matter to delegate an appropriate official to immediately investigate the reason for the dustiness and in a matter of a few days the whole mine can be checked by our official or by the officials directly concerned, within 24 hours. Such control and quick action is a most desirable feature for management, and the laboratory is the key in this control.

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The significance of the reduction of dust in the mines is probably due to:

(*a*) Having set standards, the mines now have a target to aim for.

(*b*) Having the assistance of the laboratory, the effort made to attain the target is reasonably assessed from the laboratory readings.

(*c*) Managers and staff in general have become more dust conscious and the result is an overall improvement in dust allaying practices.

(*d*) No mention is made of the quantity of air circulating in the mines. I do believe the quantity has been increased considerably and this could be a contributory factor to the lowering of the dust count.

(*e*) The effort made by the mines to reduce dust by introducing gadgets such as dust catching buckets and water sprays of improved performance must reduce dust.

(*f*) Getting the message across to all the workers is slowly making itself felt and this is a most significant factor.

(*g*) The introduction of adequate water reticulation systems has been a major step towards dust suppression.

I am sure if the laboratory readings could have been available not only from 1957, but from 1947, they would have revealed the most astonishing improvements in our coal mining conditions.

It is a fact that most mines made a very poor attempt at dust allaying prior to 1947, and it was generally said that to put in water reticulation was a cost quite beyond our means. We have survived those days and conditions have improved and I am sure that our ever watchful dust engineers will find that in the years to come they will find their dust sampling equipment is going to be the cause of their unemployment as dust will not longer be the enemy amongst us due to its elimination.

Contribution by Mr A. C. Hofmeyr

The authors have demonstrated that the modified thermal precipitator can be usefully employed to correlate the dustiness of the air encountered in coal mines with the photoelectric readings obtained.

Although no absolute measurement of that portion of the dust causing silicosis is obtained, the P.E.R. figures as submitted by the Collieries Dust and Ventilation Laboratories to Management can be used to concentrate on excessive dust making operations with a view to eliminating, as far as possible, dangerous conditions.

From the figures submitted in Tables V and VI it can be seen that the Laboratories' efforts have been successful. It is assumed that the higher the P.E.R. values obtained, the greater the concentration of silicosis-bearing dust.

It is noted in Table I that the mean P.E.R. values obtained at the Vereeniging Laboratory are appreciably higher than those obtained at the Witbank Laboratory. Can this be ascribed to the higher specific gravity of the dust in the Vereeniging Area, viz. $1 \cdot 69 g/cm^3$ as compared with $1 \cdot 58$ g/cm^3 for the Witbank Area? Does it mean that if P.E.R. readings from the two areas are to be compared, a factor would first have to be introduced to make these readings comparable?

The authors state that the elutriator cut-off of the M.R.E. sampler is close to 7 microns, and that this figure is lower than that observed for the M.T.P.; what is the cut-off for the M.T.P.?

In the continuing campaign against silicosis in our mines all data obtained is valuable; the authors are to be congratulated on their paper which endeavours to relate absolute P.E.R. values with those dust concentration values obtained by more laborious and time-consuming methods.

*Contribution by Mr C. G. Sowry**

It is useful to consider what a P.E.R. Unit is. Apparently, it represents the degree to which a dust spot obscures the transmission of a constant standard beam of light. If this is so, it must be proportional to the sum of the projected areas of all the dust particles in the spot. In the past, there were two views of the relationship between atmospheric dust content and hazard; briefly, surface area and mass. If the former is the true parameter, then the hazard is approximately proportional to the P.E.R. value. If the latter, then the hazard is approximately proportional to $(P.E.R.)^{1 \cdot 5}$. I understand that leading opinion at present favours Mass, but as a layman I prefer to keep an open mind.

What is needed, by mining officials, is some practical measure of dust conditions which will indicate whether suppression methods are effective, and where the most effort should be directed. It used to be said, before the days of the modified T.P.—that all dust was dangerous. Necessarily, this meant visible dust, and it may have come as a shock to some mining officials, that the most dangerous dust is nearly all invisible.

Mr Kitson and his colleague Mr Haven were entrusted in 1956 with the task of establishing a Dust Control System in all collieries in the Transvaal and Orange Free State, backed by proper laboratory facilities. The question is whether they have succeeded, and to what extent? As a Manager who arrived in the Witbank district 10 years before their campaign started, I can testify to the obvious *visible* improvement in underground conditions which has been achieved in this period, which is truly remarkable. In terms of Pneumoconiosis incidence, I can only note that the Industry's contributions to the Compensation levy show a gradual decline, from which I deduce that incidence is declining.

I have only one serious criticism of the present sampling technique to offer. Because producing sections are only sampled two or three times a year, such a visit is something of an occasion, and it is usually possible for an underground official to accompany the sampler. As a result, workers are on their best behaviour, and what is sampled is the result of everyone doing his duty. Unfortunately, human nature being what it is, this is not necessarily the position at other, unsampled, times. To cover this situation would involve a major increase in sampling frequency, and also, of course, sampling staff. Nevertheless, by certain simple criteria (such as how dirty one's eyes and nose become after a day underground) there certainly has been a marked improvement.

To make this Dust Control system work, one essential was to obtain the full co-operation of Colliery Managers, production officials, and production workers, without which the staff of the Dust and Ventilation Laboratories would have been wasting their time. The results achieved are sufficient proof of their success, both in the technical and diplomatic fields.

Finally, I wish to congratulate Messrs Kitson and Haven on their interesting paper, which will, I am sure stimulate some useful discussion.

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*Manager, Witbank Colliery.

*Contribution by Mr G. E. Smith**

From the point of view of one who has been associated with mining for approximately 30 years and has been dust sampling for approximately 20 years in both gold and coal mines, I agree with the authors that the particular sampling technique and procedure described in the paper fulfils the requirements of control sampling very satisfactorily, viz., (i) repeatability; (ii) relatively short period of sampling; (iii) ability to take several samples; (iv) rapid and convenient use and (v) rapid and convenient analysis of results.

The instrument used for routine sampling in collieries is the modified thermal precipitator and the evaluation of samples is done with a photoelectric assessor, thus eliminating all human errors such as are commonly known in microscopy.

All the ventilation officials at present employed at the Chamber's Collieries Dust and Ventilation Laboratories have had years of experience in both collieries and gold mines. The routine sampling procedure and the number of samples taken near the well-known dust producing operations in collieries may differ slightly to suit individual conditions. Basically the pattern of sampling in collieries is to take dust samples in the intake air, at the coal face and in the return air.

The main objects of routine dust sampling are:

(*a*) to obtain a measure of the dustiness of the air breathed in by the workers;
(*b*) to detect places with unsatisfactory dust concentrations;
(*c*) to determine the causes of such conditions;
(*d*) to determine the efficiency of the methods of dust control, and
(*e*) to provide records of dust conditions.

Although the instrument is called the modified thermal precipitator it has undergone further improvements over the course of years, but the principle has remained the same. The improvements include:

(*a*) the battery used was the cap lamp battery which required topping up with distilled water regularly, now a dry cell type of battery is being used which weighs 1 lb less and can keep its charge for longer periods;
(*b*) the ammeter was built into the head which fitted onto the battery, now the ammeter is built into the instrument;
(*c*) the original instrument was designed to allow 12 samples to be taken on one slide, now there is a model which allows only 10 samples to be taken on the same size slide which means the spacing between strips is larger and is useful when strips require counting;
(*d*) the volume to be sampled is set out on the instrument. As soon as this is done the instrument starts sampling and makes a noise to detect whether the sample has been completed. The instrument must be held tight against the ear to make sure the instrument has stopped. Now, with the later models, as soon as the instrument starts sampling a green light comes on, when finished a red light comes on.
(*e*) a small electrically driven pump is being tried out replacing the bellows which employs small pulleys and cords with a motor to deflate and inflate the bellows. This arrangement tends to be troublesome.

*Collieries Dust Laboratory, O.F.S.

*Contribution by Mr J. H. van Dyk**

The authors are to be congratulated on a very informative paper.

The sampling procedure followed by the Dust and Ventilation Department of the Natal Coal Owners' Society is basically the same as that employed by the Collieries Dust and Ventilation Laboratories of the Chamber of Mines. The main object is compliance with Mines and Works Regulation 6.9(3) relating to the measurement of the amount of dust in the air in representative working places whilst certain mining operations are taking place, viz. cutting, drilling, loading and in the intake and return air streams.

The thermal precipitator/photo-electric technique of dust assessment has been proved practical and satisfactory for the purpose of routine dust control in Natal collieries.

Routine sampling of airborne dust pinpoints those operations which create dust as well as any abnormal dust conditions. Sampling frequency, naturally, is a most important factor in the dust control of any mine.

Reference to Table V indicates that whilst there is general overall improvement in dust conditions, the reverse is the case of the individual operation of mechanical loading. It will be noted that the Mean P.E.R. for this category has deteriorated nearly two-fold when comparing the years 1968 and 1957. This is significant.

Increasing attention is being given to the mining of thin seams in Natal coal mines and, coupled with a desire to combat periodic Bantu labour shortages and escalating production costs, mechanized or partially mechanized mining methods are being resorted to, to an increasing extent.

There will, therefore, have to be much thought given to more effective means of dust suppression with the increasing introduction of mechanical equipment if the present P.E.R. values are to be lowered or even maintained.

Contribution by Mr A. W. L. Brereton†

Messrs Kitson and Haven tell us in their interesting paper that the specific purpose of routine sampling is for control, i.e. to pinpoint dusty operations and places and to inform management as soon as possible and that additional sampling is often necessary to pinpoint the peaks.

Unfortunately the average worker underground is not yet fully dust conscious and with incentive bonuses on production any increase in dusty conditions in a working place is so often ignored and it is only the conscientiousness of the underground officials prompted by propaganda that keeps dust down.

Up to the present there is no satisfactory quick reading instrument for locating dust other than one's sense of sight and smell and they are only able to locate the denser clouds of dust that probably are the peaks mentioned by the author.

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*Chief Ventilation Officer, Natal Coal Owners' Society.

†Manager, Witbank Consolidated Mines.

Unless dust suppression is being carried out particularly during drilling and cutting operations visible particles of dust can be clearly seen in the rays of light from the ordinary cap lamp used underground. Can the authors give us some idea of dust counts, P.E.R. values, etc., in relation to the density of the dust clouds as seen in the beam of an ordinary underground cap lamp?

*Contribution by Mr T. Bulloch**

I wish to write a few lines on coal dust in collieries prior to and after the establishments of the Collieries Dust and Ventilation Laboratories. In doing so, may I add my congratulations to Mr Kitson and his staff for the wonderful improvements they have obtained over the past 14 years.

The greatest source of dust underground is obtained from coal cutting with blasting as a close second in normal circumstances. When a working face is blasted a period of time is allowed for fumes and dust to be cleared before entry, but in cutting, men are required to stay in a thick dusty atmosphere to do this work. A point to remember here, is that as the seam varies in thickness, the lower the mining height the higher the concentration of dust per cubic foot of air. A coal cutter crew is expected to cut a large number of working faces per 8½ hour shift, here again, the lower the mining height, the more working faces to be cut to produce the required tonnage. Before the introduction of electric coal cutting machines, the working face was cut by hand or by compressed air; both these methods produced very little dust. About the year 1899 the first electric coal cutters were introduced in the collieries in South Africa.

I was apprenticed underground in March 1935 with the underground fitter who was responsible for eight Mavor and Coulson arcwall coal cutters and insisted that the first thing I should do was to learn to drive a cutter. The mining height was 54 in. and the dust so thick you could cut it with a knife. In those days coal dust was not thought to be as harmful as gold mine dust, particularly in South Africa where the coal was 'softer'. It was not until about 1950 that some thought was given to the suppression of dust in collieries and the eventual establishment of the Collieries Dust and Ventilation Laboratory. This brought about experimenting with some very primitive, and some 'Heath Robinson' ideas to produce a water spray at each working face as it was cut, drilled, blasted and loaded. In the bord and pillar system of coal mining the cost of setting up a working supply of water to each working face or area, which advanced so rapidly, was thought to be prohibitive, but over the last 19 years each mine has installed some water reticulation underground and it is now part of the general layout.

I think the finest proof of the progress made in the suppression of coal dust is to stand and watch the continuous coal borer in use in a South African colliery produce upwards of 700 tons per 8½ hour shift with the minimum of visible coal dust.

The article by Messrs G. H. J. Kitson and Y. J. F. Haven is of great interest and to my mind a timely warning that all is not so well, see Table VII. We are creeping up again. The reason probably differs in each mine but a problem to be faced in the very near future is the education of the worker on the working face of the damage to his health in 15 to 20 years of mining in coal dust.

In conclusion I would like to congratulate the authors on presenting a clear and precise paper which I am sure is of great practical interest.

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*Manager, S.A. Coal Estate, Navigation Section

*Contribution by Mr H. L. Neethling**

I wish to congratulate Messrs Kitson and Haven for their informative paper which has been well written in simple and understandable language acceptable to all mining personnel.

This type of paper and resulting discussions make mining personnel more aware of the dangers of respirable dust and therefore keener to accept suggested dust suppression methods. The Bantu are unfortunately still not very worried about dust suppression, but they too should be made more aware of the existing dust hazard in their own interests.

The tables show improvements in dust reduction over the years and therefore the suppression methods used are proved, to some degree, to be effective. Some mining officials consider that the suppression of dust has led to the decrease in the accident rate due to better visibility.

The theory at present is that in assessing coal dust it is the respirable mass which is important in determining the hazard to health. The P.E.R. method of assessing samples gives a result approximately proportional to the surface area of the samples. Table II in the paper shows the mean relationship between the P.E.R. values and mass concentration measurements, and this is useful when comparing P.E.R. with the parameter used in other countries.

There is to my knowledge, as yet, no easily portable instrument depending on its own internal power supply that can in 2½ to 10 minutes collect enough dust to enable an accurate mass assessment. The MRE 113A gravimetric sampler at present being used for mass assessment in trials is not practical for dust control in our collieries because it takes too long to collect sufficient dust for accurate analysis.

Another point that arises is that sections are sampled approximately twice a year and a visit is then something like a red carpet occasion and all dust suppression methods are employed properly. The results of sampling then reveal conditions where everyone concerned makes an all-out effort to suppress dust. Now this is not always the condition during periods when the sections are not sampled and different conditions can exist. To cover this situation would call for increased sampling and, consequently, an increase in the Laboratory personnel.

Contribution by Mr J. H. Moore†

I would like to add my congratulations to the authors of the abovementioned paper; they adequately described and detailed the methods used, and the improvement in dust conditions over the years on collieries must certainly be, in part at least, attributed to the efforts of the sampling team and laboratory.

One point, in my opinion, emerges, and that is that, while agreeing with the principles that the worst possible conditions must be discovered, sampled, and the results conveyed to managers for direct attention, there is the possibility of an over-zealous sampler spending too much effort in finding adverse dust conditions. Reports of this nature have, in fact, been reported to me, but I have refused to attach too much importance to them, mainly because proof was lacking.

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*Ventilation Officer, Chamber of Mines Colliery Laboratory
†General Manager, Douglas Colliery

I do feel that some effort by the sampling and research staff could be devoted, following direct observation and concentration on this one aspect of mining, to the development of ideas for dust suppression, as well as dust detection.

These comments are intended only to be constructive.

Reply by the authors to the discussion

The gratifying and lively response to their paper is for the authors a welcome sign of the increasing realisation that dust control is an important aspect of management within the coal mining industry. It is with great interest that they studied the contributions but to answer them all in detail would probably cover as many pages as the original paper. We see in the contributions received a variety of opinions and statements which seem to supplement or answer each other as one reads on. Our thanks go to every single contributor but in particular to Dr W. P. M. Matla, whose lifelong interest in the dust problems is well known. We wish him many happy years of retirement.

We prefer not to answer Mr D. G. Beadle's queries fully at this stage because the points raised by him form the substance of another paper. In brief, the results obtained from samples taken on 22 collieries in the Transvaal show variations in the mean ratios of P.E.R. to mass from 4 to 10. The individual ratios vary appreciably, about 70 per cent of them (29 out of 41) falling in the range 5 to 14. If the observations from the surface plants are excluded about 76 per cent (29 out of 38) fall within the range mentioned. The correlation coefficient between P.E.R. and mass concentration is 0·68 for all 41 pairs of observations and 0·66 for 38 pairs from underground.

Mr M. J. Martinson has, we hope, gained a better understanding of the dust sampling strategy on coal mines since his contribution was written. Airborne dust sampling is carried out with the specific aim of improving conditions underground and follows recommendation No. 6, in the field of dust and engineering, adopted by 1959 Johannesburg Pneumoconiosis Conference: 'That more attention should be paid to designing correct dust sampling strategy, bearing in mind the difference between sampling for purposes of dust control and sampling in order to determine the health hazard.' Tables V and VI are (for obvious reasons) a condensed form of a statistical analysis carried out by Mr A. H. Munro, at the time Head of the Mathematical Statistics Division of the Chamber of Mines Research Laboratories.

Dr R. S. J. du Toit has dissected our paper in a very efficient and amicable manner. Let us try to state our viewpoint still more clearly in the same spirit. We want to know the maximum dust concentrations miners are breathing and where the dust comes from and when it affects them most but we do not associate this with any dust level or average dust exposure or health hazard. To find the sources of dust we have to ignore idle periods in the production cycle as far as possible. Our interest lies not in 'true peak' or 'true average' or any other theory except to pinpoint dusty conditions with the knowledge that if they are improved upon, something worthwhlie will have been achieved. The 'general improvement' which we describe in the paper is basically a reduction in dust production and not *per se* a reduction in the pneumoconiosis risk. Dr du Toit differs from us primarily because he wants to know the miners' health hazard while we want to know that dust production is being controlled. We cannot agree at this stage with the targets given by Dr du Toit in his contribution, neither has there ever been a suggestion on our part that 100 P.E.R. is a satisfactory dust level. Under present mining conditions with the present sampling technique

100 P.E.R. is a value used to distinguish on a statistical basis between 'satisfactory' conditions and conditions that require 'close watching' or 'special attention'.

In answer to Mr Brereton's query there is no general correlation between the density of dust clouds visible in the light beam of an underground cap lamp and the photoelectric measure of 'respirable' dust present in such dust clouds. In nearly all attempts to control airborne dust the majority of the coarser, less dangerous dust particles are eliminated first while the 'respirable' dust particles remain airborne more easily; thus the dust cloud is less 'visible' than before. Respirable dust particles in very large amounts can be seen by the naked eye not because of their size but because of their high concentration per unit volume of air. The tyndalloscope is the nearest approach to a quick reading instrument for locating dust underground but like any scientific instrument it has to be used with care.

In answer to Mr Hofmeyr's queries, P.E.R. values do depend slightly on the specific gravity of the dust. The rate of settling of the coarser particles in the horizontal entrance channel to the modified thermal precipitator depends on the square root of the density of the particles. With the relatively small difference in densities of the two types of coal, the practical difference in P.E.R. values is negligible. The results shown in Table I are for those samples which were assessed microscopically and do not include all the samples taken by the laboratories. The cut-off for the M.T.P. as observed with the microscope is around 10 microns for coal dust particles.

Finally we hope, Mr Bain, that we are not going to be unemployed too soon due to improved dust conditions on coal mines as there probably will have to be somebody to make sure that conditions do not deteriorate. To support Mr Bain's statement, 'I am sure if the laboratory readings could have been available not only from 1957, but from 1947, they would have revealed the most astonishing improvements in our coal mining conditions,' and Mr Sowry's statement, 'I can testify to the obvious visible improvement in underground conditions which has been achieved in this period, which is truly remarkable,' the photoelectric readings of samples taken during a special investigation in 1957 when cutting dry and cutting wet are given below[1].

Colliery	Dry cutting samples	Wet cutting samples	% reduction
Colliery A . .	1,043	154	85
Colliery B . .	421	68	84

REFERENCE

1. Kitson, G. H. J. 'Dust and ventilation conditions in South African coal mines.' *J. Mine Vent. Soc. S.A.*, Vol. 15, No. 4, April, 1962.