

Feasibility of Personal Gravimetric Dust Sampling for Health Hazard Assessment in the South African Mining Industry

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SYNOPSIS

The potential health hazard from long-term exposure to dust remains an ever-present concern to mining industries worldwide. The impending introduction of personal gravimetric dust sampling throughout the South African mining industry, as an improvement on present methods of risk assessment, is therefore attracting considerable attention. This paper presents a broad review of the issues involved. Principles of dust sampling for assessing the health hazard from dust exposure are first outlined. Present dust sampling methods used on South African coal and gold mines are critically assessed on the basis of these principles. Personal dust sampling instrumentation and methods are described. An account of early Chamber research in gravimetric sampling is given together with the problems experienced in instrumentation. Recent improvements in sampling instruments and analytical methods are highlighted with particular reference to the measurement of single shift levels of silica dust in gold mines. The technical feasibility of personal dust sampling is demonstrated in the light of results from recent field trials designed to identify and evaluate suitable instrumentation for use on South African coal and gold mines.

INTRODUCTION

Routine dust sampling is conducted on South African mines for two main objectives. The first is concerned with assessing the health hazard associated with dust exposure for the allocation of percentage risk in terms of the Occupational Diseases in Mines and Works Act (No 78 of 1973). The second objective flows from provisions of the Mines and Works Act and is directed at dust control, the purpose being to identify working places where dust levels are high and where remedial action is required. The two objectives together constitute part of a programme whose overall aim is to reduce the incidence of pneumoconiosis on mines.

The need for improved means of assessing the health hazard associated with dust exposure has long been recognised within the mining industry, par-

ticularly for gold mines. In 1963, the Executive Committee of the Chamber of Mines authorized independent surveys of gold mines by a newly formed Dust Sampling Unit in order to obtain, at regular intervals, more precise information on the dust exposure of miners than was possible from routine surveys by mine ventilation departments.

The Executive Committee further requested that efforts be made to devise improved instrumentation and strategies which would provide more useful information to assess the health hazard associated with dust exposure.

During the last twenty-five years, considerable research efforts have been directed at achieving this goal, particularly with a view to replacing the konimeter as the instrument for risk assessment on gold mines.

This paper is concerned with the feasibility of introducing personal gravimetric dust sampling to the South African mining industry, primarily as an improved means for assessing the health hazard from dust exposure but also as an integral part in the effectiveness of dust control programmes.

MEASURING THE HEALTH HAZARD FROM DUST EXPOSURE

Principles

Modern principles of dust sampling for hazard assessment are founded on three main recommendations adopted at the 1959 International Pneumoconiosis Conference, Johannesburg (Orenstein, 1960). These recommendations have remained largely unchanged to the present day and the principles may be summarized as follows:

- (i) measurement of the respirable dust fraction
- (ii) gravimetric assessment of the collected dust
- (iii) long-period sampling to give average dust levels over a shift.

Measurement of respirable dust was advocated because it was known that only the fine fraction of inhaled particles was capable of penetrating to the lung, thereby creating the potential for pneumoconiosis.

The principle of mass concentration, at least for coal dust, was based on results of epidemiological studies where good correlation was found between the mass of respirable dust and progression of coal workers' pneumoconiosis. The relationship between silica dust exposure and silicosis has not been so extensively studied. In this country, early work (Beadle, Harris and Sluis-Cremer, 1970) demonstrated a relationship between dust exposure and radiological signs of silicosis, in conformity with opinion at the time that surface area of silica dust was the parameter of interest. The present consensus of opinion favours mass as the preferred parameter, in order to measure the hazardous nature of respirable silica dust.

Epidemiological studies also demonstrated that a worker's risk of contracting pneumoconiosis was directly related to his cumulative dust exposure and the time period over which this occurred. Dust levels vary widely over a shift so long-period samplers are used to obtain a reliable measure of dust exposure during the shift. The full shift is usually considered the most practical period of measurement.

Since 1959, these principles have gained widespread acceptance and they form the basis of occupational hygiene programmes designed to measure and control the hazard from long-term exposure to respirable dust. For this reason, almost all major mining industries have abandoned historical methods of dust sampling in favour of gravimetric sampling methods which incorporate these principles.

Limitations of Present Dust Sampling Methods for Risk Assessment

Coal mines

The modified thermal precipitator (MTP) is used on collieries to measure the concentration of respirable dust for risk assessment purposes. Results are expressed in photo-electric readings (PER), a measure of the surface area of dust particles. The sampling system has been in effect since 1956 and is reviewed by Haven (1966).

The MTP, developed by the Chamber of Mines, is well-tried, convenient to use and samples may be evaluated rapidly. It is largely for these reasons that the MTP has resisted replacement by gravimetric samplers. However, the MTP is used as a short period (10 minute) sampler providing respirable dust concentrations in terms of surface area. It therefore satisfies only one of the three principles for hazard evaluation (see section on "Principles").

The strategy of taking samples during periods of maximum dust production, including cutting, drilling and loading, also means that dust levels may not be used to provide estimates of dust exposure for the shift. The MTP is therefore not a suitable instrument for risk assessment, despite being used to good effect for dust control purposes in collieries (Kitson and Haven, 1968), and for indicating the relative dustiness of collieries across industry for levy purposes.

Gold mines

Member gold mines are surveyed independently by the Chamber Dust Sampling Unit approximately once every two years using the konimeter. The strategy is designed to allow a konimeter spot to be collected from the vicinity of every ninth person underground. The konimeter counts are pooled to give a mine dust index which is a measure of the dust hazard for each mine (Du Toit and Isserow, 1976).

The principle shortcoming of this strategy is that dust measurements taken do not provide good estimates of dust exposure, for the following reasons:

- (i) sampling is biased in that most samples are taken between 09h00 and 11h00, and this generally corresponds to the period of maximum dust production
- (ii) each person is sampled for a very short period
- (iii) sampling is conducted with the konimeter.

The konimeter is a spot sampling instrument providing respirable dust levels in terms of number concentration. Like the MTP, it satisfies only

one of the three principles of hazard assessment (see section on “Principles”). Use of the konimeter for risk assessment has attracted criticism (Quilliam, 1976(a)), although its value as a practical sampling instrument for dust control purposes has received much support (Van Nierop, 1973, Quilliam, 1976(b)).

Despite the above shortcomings, the present method is an equitable and cost effective means of assessing the relative dustiness of gold mines for allocation of pneumoconiosis levies. The results also provide a valuable indication of dust levels and their trends within industry.

However, spot sampling, as practised with the konimeter, precludes any measurement of dust exposure since neither time variations in dust levels during the shift nor the period of exposure are taken into account.

An alternative strategy using gravimetric sampling over the whole shift is necessary to determine whether or not given working conditions constitute a hazard to health from long term exposure to dust.

Personal Gravimetric Dust Sampling

Personal dust samplers essentially comprise two components a dust sampling head and a constant volume sampling pump. Miniature cyclones are commonly used in the head to separate the respirable dust fraction. Figure 2.1 shows an assembled dust sampling head. Dusty air drawn through the cyclone entrance (centre) is separated into a coarser, non-respirable fraction (collected in a ‘grit-pot’ at the base of the cyclone), and the respirable fraction, which is collected on a preweighed membrane filter sealed in a plastic filter cassette situated above the cyclone. A stainless steel assembly is used to protect the cyclone during use.

The sampling head is attached to clothing in the worker’s breathing zone and a short plastic tube is used to connect the cyclone to the air sampling pump worn on the worker’s belt (Figure 2.2). The battery powered pump provides a constant flow of air through the filter at a preselected flow rate for the duration of the shift. Figure 2.3 illustrates four personal dust samplers using the same dust head.

For coal samples, the mass concentration (in mg/m^3) is determined from gravimetric analysis of the dust on the filter and the volume of air drawn through the sampler (preset flow rate $\times$ sampling time). For gold mines, the mass concentration refers to the mass of respirable silica, as determined by, for example, X-ray diffraction.

Personal dust samplers must satisfy demanding requirements during routine mine use. Instruments will, of necessity, be used essentially on a daily basis throughout the year and a high degree of reliability is therefore important. Samplers are subjected to abrasion, vibration and impacts, particularly during normal underground use, and must be both internally and externally robust.

Instruments issued to mineworkers need to have their control functions accessible to environmental officials for operation and calibration purposes, but these functions should be immune to interference during the workshift. Good ergonomic design is obviously an important factor in augmenting

wearer acceptability. The sampling systems must therefore be small, lightweight, unobtrusive, free of noise or vibration during operation, and must not interfere with the wearer's normal duties.

Ease of use is a further factor in the choice of samplers. Instruments requiring frequent, lengthy or involved calibration and checking procedures are unsuitable for use on a regular basis.

The feasibility of routine personal dust sampling ultimately depends to a large extent on whether suitable instrumentation can be found to satisfy the above practical requirements.

EARLY CHAMBER DEVELOPMENTS IN GRAVIMETRIC DUST SAMPLING

The historical perspective of research conducted since 1960 leading up to early studies in gravimetric sampling on South African gold mines is described, followed by results of preliminary studies in personal dust sampling for local coal and gold mines.

Historical Perspective

During the 1960s, dust research in South African gold mines was directed largely at finding a replacement for the konimeter. Quilliam (1976(a)) reviews this period, including the instrument problems experienced with thermal precipitators and the potential benefit of rapid surface area measurement with the DISA technique.

Also during the same time, overseas developments had advanced sufficiently to enable gravimetric sampling to be introduced, particularly on coal mines. The fixed-position MRE 113A sampler was adopted by UK collieries in 1970 (Carver, 1976) while personal gravimetric samplers were mandated for US coal mines, following passage of the Federal Coal Mine Health and Safety Act of 1969 (Doyle, 1976).

Furthermore, the concept of mass rather than surface areas as an appropriate measure of the health hazard from silica dust was also gaining credence internationally. This posed a measurement problem in South African gold mines because of the much smaller concentrations of respirable dust compared with collieries (see section on "Improvements in Sample Analysis").

The challenge of developing a local gravimetric dust sampling method for gold mines, based on recommendations of the 1959 Johannesburg Pneumoconiosis Conference, was accepted with the development of fixed-position automatic gravimetric dust monitors (Quilliam, Krüss and Lindhout, 1974). These instruments, driven by compressed air, were designed to sample respirable dust over an eight hour shift or longer, for five consecutive days. They were left unattended and switched themselves on at predetermined times before work commenced, and off before blasting operations commenced, using a clock mechanism.

This innovative concept unfortunately failed for practical reasons, namely interference with compressed air supplies and contamination of the filters from blasting fumes. It was also established that considerable dust fall-out

occurred so that levels measured at the return air side of workings were not representative of dust conditions at the workplace. An alternative method was therefore required that still employed the concept of gravimetric sampling.

Preliminary Studies in Personal Dust Sampling

Despite successful moves overseas to introduce gravimetric dust sampling on collieries in the early 1970s, there seemed little impetus locally to follow suit and replace the modified thermal precipitator. Consequently, few research studies were made on coal mines, in contrast to the vigorous efforts made to replace the konimeter. Tests were, however, made on the continuous turbocaptor (Haven, 1976), a personal dust sampling device combined with the miner's cap lamp battery. Although the instrument was reported to function satisfactorily as a gravimetric sampler, it was not introduced on collieries for routine dust sampling because of the prevailing attitude at the time that surface area was the preferential dust parameter to measure. Consequently, the modified thermal precipitator has remained in use on collieries to the present day.

The 1960s saw the development overseas of many gravimetric dust samplers, particularly instruments intended to be worn by a worker during his shift. Such personal samplers were seen to offer a solution to the difficulties experienced in using fixed-position gravimetric samplers in gold mines.

One such personal dust sampler, which was developed by the Safety in Mines Research Establishment for the US coal mining industry, also incorporated the pump with the miner's cap lamp battery. This instrument was called SIMPEDS (Maguire and Barker, 1969) and, following commercial production, a number of instruments were purchased in 1975 for testing underground on local gold mines.

Field trials with the Casella SIMPEDS 70 Mk2 highlighted many deficiencies in the instrument, including inaccuracies in the timing device and the flow rate indicator. The sampling rate was also found to decrease with depth in a mine and excessive maintenance and repairs were necessary. To be fair, the instrument was designed for use in coal mines, but in any event, it was found unsuitable for use in gold mines.

In the absence of any other suitable commercial sampler, a decision was taken in 1977 to develop a similar version of SIMPEDS to suit local conditions. Considerable benefits were expected from an instrument which was manufactured locally, particularly as regards purchase price and availability of spare parts, and which did not require separate charging facilities to the cap lamp battery.

Following this decision, six instruments (COMSA MkI) were designed, constructed and tested on mines during 1978. Further modifications and improvements were made on the initial design, based on experience with the first six instruments, resulting in the COMSA MkII (Appelman, 1980). This instrument incorporated variable flow rate, automatic flow control and a digital display for elapsed time.

During 1981, a more sophisticated version incorporating underload and overload trips was designed to improve the validity of dust data obtained from using the sampler. Twelve of these instruments (COMSAD : Chamber of Mines Sampler for Airborne Dust) were made by the Research Organization in 1983 and were evaluated underground later in the year. The field trial uncovered an electronic fault which tripped out the sampler during the shift. Modifications to the electronic circuitry eliminated the tripping problem and this version was fitted with a pulsation dampener to smooth the airflow.

In order to finalise the design and specification prior to building a production version of this instrument, collaboration was started with a commercial concern. However, the prototype instrument was found to be inferior and in need of further development. No further attempt was made to find a suitable manufacturer, although the sampler continues to be used for research purposes.

The attractiveness of a design which incorporates the pump and cap lamp battery in one unit — thereby removing the need for an additional instrument to be worn by the worker — has grown with the recent mandatory requirement for wearing self-contained self-rescuers underground. This configuration has the added benefit of reducing the potential for tampering since a worker will not deprive himself of his light source. Commercial attention may turn again to this concept once routine gravimetric dust sampling has become fully integrated into the local mining industry.

FEASIBILITY OF PERSONAL DUST SAMPLING

The feasibility of introducing personal gravimetric dust sampling into the mining industry for health hazard assessment depends primarily on the availability of suitable instrumentation. Instruments should not only satisfy the basic principles of sampling for hazard assessment but must also function satisfactorily under routine mine use.

Preliminary studies outlined above show clearly that limitations in sampling pump performance, especially under practical mining conditions, were the prime cause of failure in early attempts to introduce personal gravimetric sampling, particularly on gold mines.

This section outlined the considerable improvements that have emerged in commercial sampling pump technology over the last decade, together with recent research that has focused on optimising dust head design for measuring low levels of respirable silica in gold mines. Results of field trials on instrumentation incorporating these developments are used to illustrate the feasibility of personal dust sampling on coal and gold mines.

Improvements in Sampling Pump Technology

First generation personal sampling pumps were relatively simple devices. Their lack of sophistication was apparent from statutory US regulations governing respirable dust measurement in coal mines which stipulated that the flow rate should be checked at least twice during the shift by an official.

Considerable effort was directed by manufacturers to improve the defi-

ciencies of gravimetric sampling pumps in what was a growing commercial market. Two major limitations of early designs were a lack of flow control and the absence of sufficient pulsation damping.

Second generation pumps have largely overcome the technical problems. Such instruments, in addition to automatic flow control and integral pulsation damping, may incorporate such features as digital time display, preprogrammed operation, tamperproof controls, out-of-control and low battery indicators, as well as being quiet, lightweight and vibrationfree in operation. Improvements in battery design enable pumps to operate for longer periods against higher loads. These factors are important in gold mines where high relative humidity is common and bank-to-bank periods are frequently in excess of eight hours. Impact resistant casing and ruggedized, corrosion-proof design are additional factors pertinent to gold mines where levels of environmental stress are generally greater than on coal mines.

Modern dust sampling pumps are sophisticated instruments that are designed to satisfy the prime technical requirement of drawing a constant flow of air through a filter at a preselected rate for the duration of the shift, within fairly restrictive ergonomic constraints. To what extent these instruments have measured up to these design principles when subjected to practical underground trials is described under "Scope of Sample Analysis".

Improvements in Sampling Head Design

Gravimetric analysis of respirable silica dust by X-ray diffraction is optimised when the dust deposit matches the size of the X-ray beam on the filter (see section on "Single Shift Analysis of Respirable Silica Dust"). Commercial cyclones are only available for use with 37 mm or 25 mm diameter filters and therefore preclude the use of a 13 mm filter. For this reason, a 13 mm liquid filtration filter cassette was adapted for air sampling using a low friction plastic washer to protect the filter and prevent leakage. The cassette was fitted to a commercially available cyclone assembly using a pair of brass cylindrical adaptors (Figure 2.1).

This universal dust sampling head has a number of advantages since it:

- (a) incorporates the 10 mm nylon cyclone design that is used internationally
- (b) is readily convertible to fit three different filter sizes
- (c) can be used for coal, gold, or base metal applications
- (d) is based on commercially available components
- (e) uses a cassette system that permits safe handling and transporation of filters to a central processing laboratory.

The sampling head and cassette system has been evaluated on underground trials and has proved to function satisfactorily.

Improvements in Sample Analysis

Differences in airborne dust characteristics between coal and gold mines are often conflicting with regard to personal dust sampling requirements. Full shift respirable dust levels in collieries are relatively high (ca. 2–10 mg/m³) compared with those in gold mines (ca. 0.5–2 mg/m³).

However, respirable silica dust — the major hazardous component of airborne dust in gold mines is considered to be twenty times as toxic on a mass basis as respirable coal dust, based on Threshold Limit Values (TLV) recommended by ACGIH (1984) of 2 mg/m^3 for respirable coal dust ($<5\%$ silica) and $0,1 \text{ mg/m}^3$ for respirable silica dust.

These two factors conspire to make gravimetric sampling on gold mines considerably more demanding in terms of accuracy and sensitivity. For example, personal samplers operating at 2 l/min over an eight hour shift on mines which just meet the above TLVs will collect approximately 2 mg coal dust but only $0,1 \text{ mg}$ silica dust.

Further complications arise with gold mines since the silica component may vary between 10% and 70% by mass of the respirable dust fraction, depending on the admixture of mineral and organic components. For this reason, simple gravimetric analysis using a microbalance to determine the weight gain of a filter, as used for coal dust, is not appropriate for gold mine dust samples. Instead, highly sensitive microanalytical methods, such as X-ray diffraction (Bradley, 1976), have been developed to measure the silica component directly.

Single shift analysis of respirable silica dust

Full sensitivity of the X-ray diffraction system (detection limit $10 - 15 \mu\text{g}$ silica) cannot be utilised when analysing dust collected directly on 25 mm diameter filters. This is because the X-ray beam area irradiating the filter is much smaller than the area of the dust deposit. For example, the effective detection limit using a 25 mm filter is only $60 \mu\text{g}$ silica. The absolute silica content may frequently be less than this quantity, especially in respirable dust samples with a low silica percentage.

The problem has been partially resolved overseas by introducing an additional transfer step in the analytical sequence.

Dust samples collected on 25 mm filters are redeposited on smaller filters before analysis. However, this procedure is unsatisfactory as it results in loss of sample, loss in accuracy and an increase in the analysis time.

The solution adopted by the Research Organization has been to collect dust directly onto a 13 mm filter, enclosed in a specially designed cassette, by modifying a commercial cyclone assembly to fit this cassette. Samples collected in this way may then be analysed for silica, without a transfer stage, using the direct-on-filter technique developed by Knight and Cochrane (1976) for Canadian hardrock mine applications.

This improvement in effective sensitivity allows single shift analysis for silica, thereby overcoming the previous difficulty of sampling gold mine workers over a period of a week in order to collect sufficient dust for analysis. In addition, time saved by direct filter assessment permits a higher throughput of samples. This has particular significance when logistics of analysing routine dust samples for the whole industry are concerned.

The development of improved sampling and analytical methods for estimating exposure to silica over a single shift has undoubtedly contributed to making personal dust sampling on gold mines a feasible proposition.

Scope of sample analysis

Analytical procedures for respirable dust samples collected on gold mines have been extended to include the combustible fraction (essentially diesel particulate and oil mist). Sequential analysis of a single sample therefore provides the following information:

- (i) total respirable dust (filter mass difference)
- (ii) respirable combustible dust (mass loss following ignition)
- (iii) respirable silica dust (X-ray diffraction).

Further microanalysis of the dust deposit is possible using particle induced X-ray emission (PIXE). This technique provides a wealth of chemical information on levels of inorganic constituents that may be used to estimate exposure to other potentially hazardous components of the mine atmosphere (Annegarn, Zucchiatti, Sellschop and Kusko, 1987).

Considerably more useful information, directly relevant to the health hazard, is therefore available from full shift personal dust samples than is obtained from the konimeter dust 'count' of which is at best, an indication only of the silica concentration.

FIELD EVALUATION OF PERSONAL DUST SAMPLERS

Coal Mines

An evaluation programme was conducted in 1985 to determine the performance and reliability of four personal dust samplers short-listed as showing promise for underground testing. The objective was to recommend suitable instrumentation to the coal mining industry for routine personal dust sampling.

The programme consisted of an initial paper evaluation, a field trial and a series of laboratory tests. Three of each of the four models were tested simultaneously underground by selected coal mine workers on a full shift (bank-to-bank) basis, over a twelve week period. Criteria evaluated in the field trial included reliability, robustness, worker acceptability, maintenance and repair, and ease of use.

Additional tests were made in a laboratory dust chamber to determine the dust sampling performance of the instruments. Factors under consideration included reproducibility and size selection of respirable dust, and correlation of dust measurements with the MRE 113A gravimetric dust sampler which is recognised as an international standard for measuring respirable dust.

The field trial highlighted weaknesses in several of the instruments that were not apparent from the paper evaluation. In fact, only one of the four dust samplers demonstrated good overall performance and reliability in both

laboratory tests and the field trial. Two other samplers showed promise but required further development.

Since this trial, both commercial instruments which developed problems have been modified to overcome their limitations. Other models now available on the market may also prove to be suitable for use on coal mines and, no doubt, new developments will emerge in the future. However, the important lesson learnt from this trial was that suitable instrumentation is available to make personal gravimetric dust sampling on South African collieries a feasible proposition.

Gold Mines

A similar exercise to the one described above was conducted on a gold mine in 1986 to evaluate personal dust samplers for the gold mining industry. An even greater exposure to environmental stress (hot, humid, dusty and corrosive conditions) was expected from underground tests on deep gold mines. The additional sampling problem posed by diesel exhaust particulate also had to be examined.

Three commercial sampling pump models were short-listed and fitted with the newly-developed dust sampling head. Three of each type were then subjected to a twelve week underground trial. The nine instruments were issued and collected on four consecutive shifts each week and worn by selected personnel on a full shift basis.

Criteria under evaluation were identical to those used in the coal mine trial. Reliability was assessed for each sampler by a critical analysis of the instrument and maintenance logs, which recorded the number of satisfactory shifts and details of any unsatisfactory performance on a daily basis. Performance was judged satisfactory if the instrument was returned in working order and the flow rate during the shift did not change by more than 10% of the starting value.

Ease of use was assessed after the trial by an analysis of the procedures found necessary prior to the issue and after the collection of personal samplers by field staff.

Worker acceptability for each type of sampler was judged from answers given to a simple weekly questionnaire. The questions were designed to provide answers as to why an instrument was unacceptable, whether it interfered with the work, and whether these objections would be removed if the person was asked to wear the sampler for only one shift per year. Acceptability was considered to be an important aspect of the programme as an essential feature of the success of personal sampling is general acceptance by the workforce, in order to avoid problems of tampering, such as removal of the sampler.

Results of this field trial showed that one instrument — the same model that was successful on collieries — also performed well on gold mines. A second model was also judged satisfactory for routine use, while the third sampler experienced problems with the battery pack that showed signs of being unable to cope with the 10 hour use/13 hour charging cycle over a weekly period. Additional difficulties were found with this model since grit entering the pump chamber blocked the rotor movement. It was significant that this

model used a vane pump and did not have an inlet filter fitted, in contrast to the other two models fitted with a diaphragm pump and filter.

No problems were found with using the improved sampling head fitted with a 13 mm filter cassette, although a larger 25 mm filter was found to be beneficial in sampling conventional dieselised and trackless mining sections, in order to prevent filter blockage from diesel soot particles.

None of the samplers chosen for either field trial met with strong worker criticism as regards carrying the instrument throughout a shift. Few of the workers interviewed complained about interference with their normal duties and all were willing to wear the sampler once during the year.

The successful performance of instrumentation tested in this field trial demonstrated, for the first time, the feasibility of implementing full shift personal dust sampling on South African gold mines.

SUMMARY

Present dust sampling methods used on mines for risk (health hazard) assessment do not adequately satisfy the principles of dust sampling laid down at the Johannesburg Pneumoconiosis Conference in 1959. The need for improved means of assessing the health hazard associated with dust exposure has long been recognised within the mining industry, particularly for gold mines. To this end, considerable research efforts have been directed at achieving this goal over the last 25 years.

Early attempts to replace the konimeter with gravimetric samplers met with limited success due mainly to the difficulty experienced in finding instrumentation that could perform satisfactorily under practical mining conditions.

Developments in sampling pump technology over the last decade together with recent improvements in dust sampling head design, which allow more effective use of sensitive analytical methods, have allowed single shift respirable silica levels on gold mines to be measured using personal samplers. Two recent field trials have identified suitable personal dust sampling instrumentation and demonstrated the technical feasibility of this method for risk assessment on coal and gold mines.

Dust sampling on South African coal and gold mines could be placed on a more acceptable and meaningful basis by a revision in instrumentation and strategies used for risk assessment and dust control purposes. It is confidently expected that routine use of personal gravimetric samplers over the full shift will provide a better measure of the potential hazard from dust exposure, will place risk assessment on a firmer scientific basis and will identify occupations or areas in those mine sections which may result in high dust exposure.

Follow-up studies in these sections with direct reading instruments should enable dust sources to be located and thereby direct dust control measures to places where they are most needed. The success of such a programme will hopefully be seen by a reduction in the incidence of pneumoconiosis.

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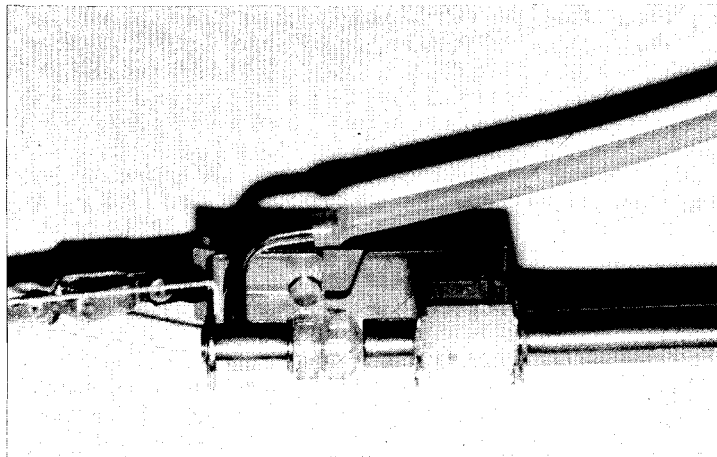


FIG. 2.1: Dust sampling head incorporating 10 mm nylon cyclone and 13 mm filter cassette.

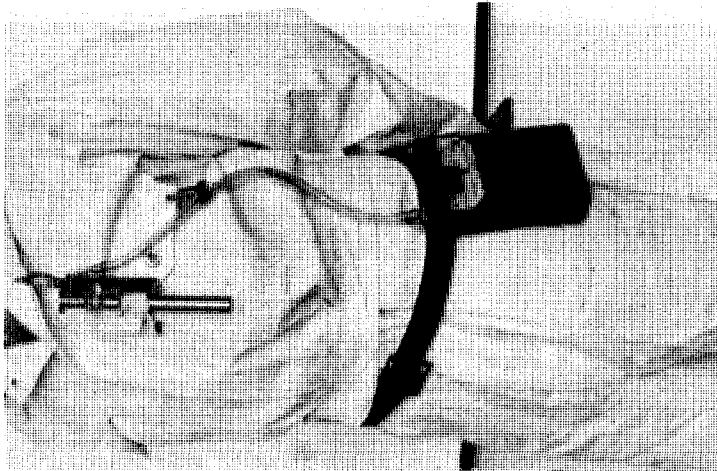


FIG. 2.2: Personal dust sampler attached to worker.

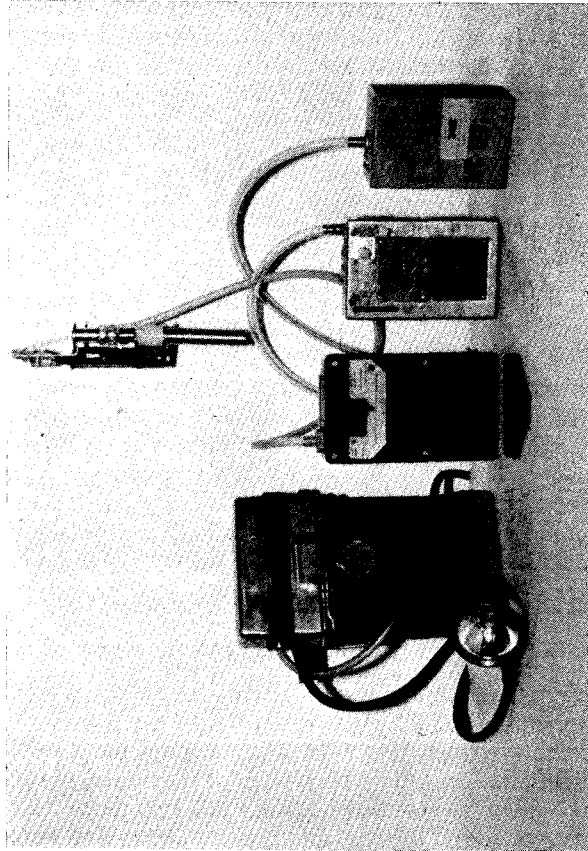


FIG. 2.3: Four different personal dust samplers using the same dust head.