RESULTS OF SURVEYS ON DUST CONDITIONS IN CONTROLLED GOLD MINES

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INTRODUCTION

At a meeting held on 21st August, 1963 the Gold Producers' Committee approved the recommendation of the Technical Advisory Committee that a dust sampling unit be formed by the Chamber of Mines.

The main objective of the dust sampling unit was twofold. Firstly, the aim was to establish the dust conditions in gold mines. Secondly, it was to obtain reliable and representative figures, based on konimeter measurements, of the dust concentration levels to which personnel are exposed on an industry-wide basis. A further objective was to indicate the relative dust levels to which personnel being engaged in different mining operations are exposed. The variations of dust conditions at different times during a work shift and the differences in average dust levels from mine to mine and in various mining areas were to be indicated. Suggestions as to the manner in which dust suppression measures could be most advantageously applied also were to be made.

Seven dust surveys have been conducted. In the first two, conducted during 1964/65 and 1968/69, only underground operations were considered while operations on surface where dust was encountered were included in the third survey (1971/73). Subsequent surveys (fourth: 1974/75; fifth: 1976/77; sixth: 1977/78 and seventh: 1979/80) included surface risk work plus other dust producing operations on surface.

In 1971 the Gold Producers' Committee agreed that controlled gold mines be classified into dust index groups for the purpose of imposing differential pneumoconiosis levies. This was recommended subsequently to the Compensation Commissioner for Occupational Diseases and was accepted in June, 1971. Differential levies have been imposed as from June, 1972.

The results of the Chamber of Mines dust surveys were used for this purpose. The results of the three most recent surveys for any mine, after weighting against the labour complement at risk, formed the basis for the apportioning of levies.

This paper reports on the seventh survey and compares the results obtained to those of the previous surveys.

SAMPLING PROCEDURES

Prior to the commencement of sampling, mines were asked to provide a list of all shift bosses and their sections. The distribution of the total labour force for the morning, afternoon and night shifts underground as well as in surface workshops, reduction plants and assay offices was requested.

UNDERGROUND

In order to obtain a representative set of dust samples a number of samples equal to about one ninth of the total of the work population underground for a 24 hour period was taken. This number was divided amongst one third of the shift bosses of each mine overseer's section, selected at random. Samples were then taken at approximately every third person encountered at work in these chosen shift bosses' sections. Personnel who were engaged in travelling on or off shift or who were between working places were not sampled.

On mines using a double shift system, sampling was evenly distributed during the morning and afternoon shifts. Day shift sampling was usually carried out over the whole shift from its beginning until morning operations ceased (about 08h00 to 13h00). As far as was possible, sampling was evenly distributed over this period. Starting times varied and depended on blasting and travelling times required to reach the working sections.

Night shift sampling was undertaken when the number of personnel involved justified it and when the work being performed was not the same as that during the main shift. Approximately one-ninth of the overall night shift labour compliment was covered. Sampling was done only at the times at which the work was in progress, and the starting and stopping times therefore varied from mine to mine.

Notes were made of the time, locality and work in progress at each locality.

The following localities were covered:

- haulages
- drives
- haulage loading boxes
- cross cuts
- main tips
- shaft loading boxes
- stopes
- development ends (including shaft sinking)
- engineering departments
- service departments (samplers, surveyors, mine overseers, shift bosses and other officials).

SURFACE WORKSHOPS AND REDUCTION PLANTS

As from the third dust survey samples were taken in all sections of workshops and reduction plants except for change houses and carpenters' shops. They were taken also in any other places encountered where personnel were working in dusty atmospheres.

Where day shift only was worked, i.e. in workshops and assay departments, a dust sample was taken at the workplace of every third person encountered. In the reduction works where three identical eight-hour shifts were worked, the total labour force engaged during the main day shift was obtained. Samples were taken during the day shift of one third of the total.

In the case of uranium-producing gold mines, on the uranium section of which the Air Pollution Division carries out annual surveys of silica dust, the data from these surveys was used in assessing the surface dust concentration.

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The following locations were covered:

- crushers
- tube mills
- rotary filters
- assay crushers
- grading rooms
- rockdrill sharpening shops
- welding shops
- blacksmiths' shops
- boilermakers' shops
- truck busting shops.

A correction factor was applied to samples taken near a person engaged in welding because of the welding fumes.[1]

INSTRUMENTATION AND ASSESSMENT OF SAMPLES

As from the third dust survey Witwatersrand or R-type konimeters with size selectors were used. For the first two surveys Witwatersrand konimeters without size selectors were used. These selectors became available only in 1972 when it had been shown that they effectively removed coarse aggregates and water droplets prior to the sampling of dust particles in the respiratory range.[2]

Slides coated with adhesive and containing the dust "spots" were assessed by the standard ignition-acid immersion-ignition treatment.[3]

A method was used for daily cross-checking at random intervals each microscopists' assessment.

After completion of the survey on each mine a report containing a frequency distribution of the dust concentrations obtained, together with information regarding dust indexes applicable, was sent to the manager of the mine. Copies of the detailed results for each mine were submitted to the Group Environmental Engineer concerned in order that any remedial measures indicated could be applied.

CALCULATION OF MINE DUST INDEX AND PERCENTAGE RISK

The overall mine dust index used for the allocation of levies was based on the dust concentrations obtained underground and in those surface workshops and reduction plants which have been declared 'risk work' areas in terms of the Mines and Works Act, 1956 (Act No. 27 of 1956, as amended).

A sample-weighted average was calculated, taking cognizance of the fact that underground a sample was taken at the vicinity of approximately every third person encountered in one-third of the shift bosses' sections, that is, one-ninth of the labour complement, whereas on surface one sample was taken at every third person encountered. Thus:

$$\text{dust index (p/ml)} = \frac{\left[\begin{matrix}\text{total no. of}\\ \text{u/g samples}\end{matrix}\right] \times \left[\begin{matrix}\text{av. dust}\\ \text{conc.}\end{matrix}\right] + \frac{1}{3}\left[\begin{matrix}\text{total no. of}\\ \text{surface risk}\\ \text{work samples}\end{matrix}\right] \times \left[\begin{matrix}\text{av. dust}\\ \text{conc.}\end{matrix}\right]}{\left[\begin{matrix}\text{total no. of}\\ \text{u/g samples}\end{matrix}\right] + \frac{1}{3}\left[\begin{matrix}\text{total no. of}\\ \text{surface risk}\\ \text{work samples}\end{matrix}\right]}$$

.....EQUATION 1

A percentage risk for the allocation of levies was calculated from the mine dust indexes of the last three surveys and the labour complement of the mine for the period sampled.

$$\text{Thus} \quad \%\ \text{risk} = \tfrac{2}{3}(2i)^2 + 4 \quad \text{..... EQUATION 2.}$$

$$\text{where } i = \frac{d\ (\text{p/ml})}{50}$$

and d = labour weighted dust index for the last three surveys

RESULTS AND DISCUSSION

Table I lists the industry data obtained for the seven dust surveys performed since 1964. The average values obtained are illustrated in Figure 1.

INDUSTRY DATA OBTAINED FOR THE VARIOUS DUST SURVEYS SINCE 1964

SURVEYS	*1964/65	*1968/69	1971/73	1974/75	1976/77	1977/78	1979/80
OVERALL							
Number of mines sampled	49	44	45	42	44	40	42
Total number of persons	310 682	284 312	303 878	270 822	278 194	304 431	313 571
Total number of samples taken	63 730	29 141	38 065	33 836	34 770	37 455	40 060
Dust index (average konimeter count, p/mℓ)	250	217	203	189	173	158	166
UNDERGROUND							
Number of persons	310 682	284 312	284 866	252 785	260 204	286 089	294 508
Number of samples taken	63 730	29 141	31 758	28 070	29 002	31 802	34 064
Average konimeter count (p/mℓ)	250	217	204	190	173	158	166
SURFACE (ALL DUSTY OPERATIONS)							
Number of persons	N.A.	N.A.	19 012	18 037	17 990	18 342	19 063
Number of samples taken	N.A.	N.A.	6 307	5 766	5 768	5 653	5 996
Average konimeter count (p/mℓ)	N.A.	N.A.	188	164	162	155	139
SURFACE (RISK WORK ONLY)**							
Number of persons	N.A.	N.A.	N.A.	8 087	7 809	7 884	7 866
Number of samples taken	N.A.	N.A.	N.A.	2 780	2 803	2 715	2 632
Average konimeter count (p/mℓ)	N.A.	N.A.	N.A.	160	173	157	154

*Konimeters without size selectors were used.
**Risk work as classified under the Occupational Diseases in Mines and Works Act, 1973.

TABLE I

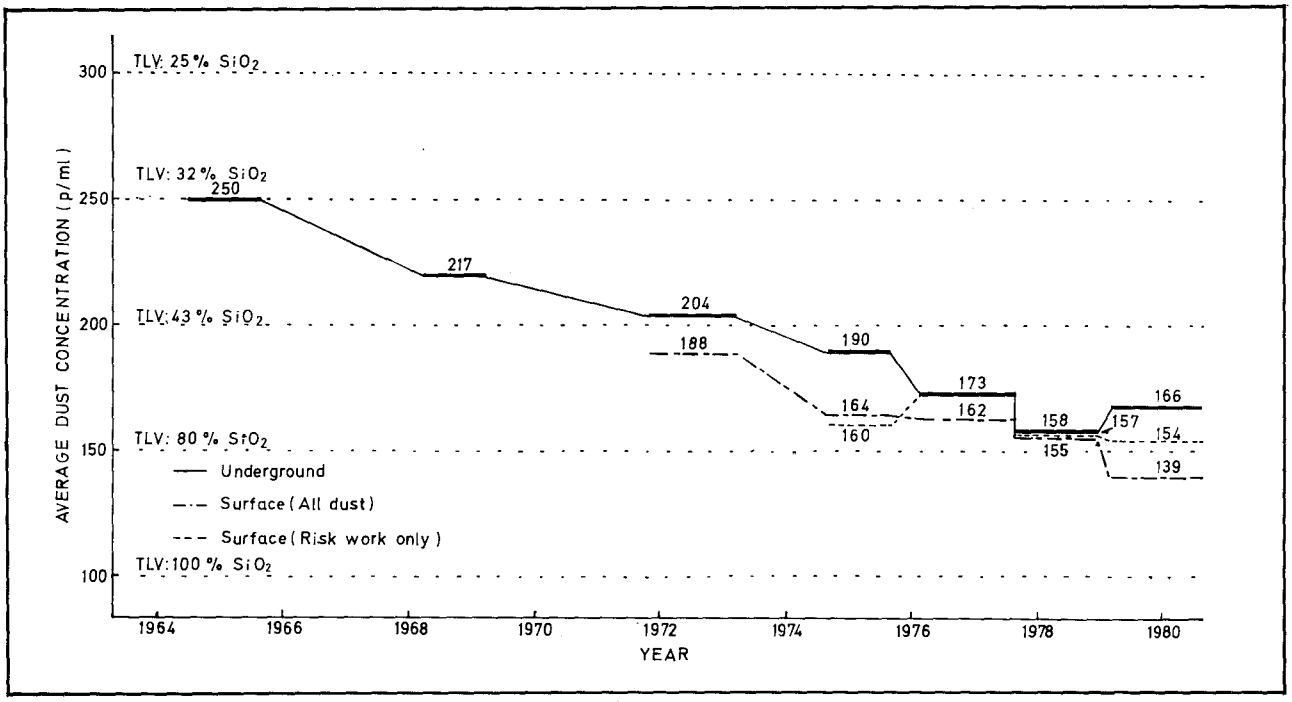

Figure 1

A steady decline in overall dust index was observed. That for the 1979/80 survey was, however, slightly higher than that for the previous survey (166 p/mℓ). This deterioration could be attributed to underground operations, since the surface operations, both risk work and total, had a lower index.

An increase in the dust concentrations underground over the past two surveys was noted for all the main classed areas, except for development ends. The difference was most marked for tips and loading boxes, where an increase of 17 per cent was found. These therefore require special attention with regard to programmes for dust control.

Surface works showed consistent improvement since samples first were taken (1971/73).

The percentage frequency distribution pattern also showed a persistent improvement as evidenced by a gradual increase in the 0-99 p/mℓ fraction over the seven surveys. For the last survey (seventh) on average 6,5 per cent of samples taken underground had a dust concentration in excess of 400 p/mℓ.

A fair number of workplaces therefore still exist which require special attention as to programmes for dust suppression.

In most mines the dust concentration values were highest in stopes. As could be expected, those in haulages, drives and cross-cuts were usually lowest.

The overall average dust concentration (dust index) for individual mines varied from 69 to 286 p/mℓ while the risk (%) ranged from 11 to 68 per cent. For the last survey eight mines had an index in excess of 200 p/mℓ, this being the threshold limit value for airborne dust containing some 43 per cent of quartz[4], a figure quite often encountered in South African gold mines. This presented an increase over the previous survey (two mines only) in agreement with the overall increase from 158 to 166 p/mℓ for the industry index.

The number of surface risk works for which the average dust concentration was more than 200 p/mℓ increased by one (five to six). For all dusty work on surface this decreased from eight to only three.

For all seven dust surveys the annual percentage of mines having a dust index of more than 200 p/mℓ followed the same trend as that for the industry index. While this percentage consistently decreased since 1964, it was up on the last survey.

The results presented here underlined the constant effort required of environmental control officers to achieve effective utilization of ventilation air and to apply techniques for suppressing dust effectively.

CONCLUSIONS

From the results obtained it may be concluded that:

- dust conditions in controlled South African gold mines steadily improved over seven dust surveys performed since 1964;
- over the past two years dust conditions have, however, slightly deteriorated, mainly due to an increase in dust concentration underground, especially near tips and loading boxes;
- the average dust concentration in stopes is still high and requires constant attention so that effective utilization of available ventilation air and suppressing of dust may be achieved.

REFERENCES

1. QUILLIAM, J.H. and J.A.L. KRÜSS.
Suggested correction factors, based on the quartz equivalent concept for konimeter samples contaminated by welding fumes in surface workshops.
J. Mine Vent. Soc. S. Afr., 28, 165-169, 1975.

2. QUILLIAM, J.H. and J.A.L. KRÜSS.
The performance of standard konimeters fitted with size selectors.
J. Mine Vent. Soc. S. Afr., 25, 60-68, 1972.

3. The konimeter.
In: "Routine Mine Ventilation Measurements".
Chamber of Mines of South Africa, 1-12, 1972.

4. TLVs — Threshold limit values for chemical substances and physical agents in the working environment with intended changes for 1981.
American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio OH 45201.