Mining methods and occupational hygiene for the new millennium: from dust to dust

by Des Wrigley, Anglogold Limited, paper presented at the SAIMM, MVS Colliquium, February 2001, Mintek Randburg

The paper describes a dust risk assessment methodology for underground mines. In comparing this risk assessment methodology with the current accepted practice of dust measuring, it is evident that dust exposures have been underestimated.

Areas of high dust generation and/or exposure, as highlighted during the risk assessment on a typical underground gold mine, are identified and controls are discussed. Dust measuring technology and the health effects of frequent, high, short-term dust exposures are questioned. The way forward in preventing ill health associated with dust exposure is also discussed.

(The phrase "From dust to dust and from ashes to ashes" is heard at most funerals. The Bible tells us that we come from dust and return to dust. This is understandable and acceptable. It is not, however, understandable nor acceptable for occupational exposure to dust to hasten this process. Exposure to dust is the cause of more premature funerals than a combination of all other SA mining occupational health and safety hazards.)

Prelude

The results of the current gravimetric dust sampling system, as prescribed by the Department of Minerals and Energy (DME), suggests that occupational exposure to alpha quartz is well under control. These results, for AngloGold, show that 98% of the workforce are exposed to less than half the Occupational Exposure Limit (OEL) and that no persons were exposed to more than the OEL of 0,1 mg/m^3. However, the number of cases of Occupational Lung Diseases (OLD) and Silicosis in particular, is a major cause of concern and suggests that dust exposure in our mines is not under control. This is born out by the fact that the Silicosis rate for 1999 was estimated to be 8,3 per 1000 in the South African Gold Mining industry.

Although there is no international uniformity in occupational disease reporting, the SA mining industry appears to be significantly worse than other mining countries in terms of pneumoconiosis. Germany has a rate of 1,6 per 1000 and Western Australia reported a total of 28 cases in 20 years! The degree of medical surveillance, which generally differs from country to country, determines the disease prevalence. In this regard, medical surveillance in the SA Gold Mining industry, and AngloGold in particular, is second to none.

Introduction

As required by "section 11(1) and (2)" of the Mine Health and Safety Act (Act 29 of 1996), risk assessments must be done on all possible health hazards. This includes the dust health hazard.

Section 4.4.4 (page 46) of the Leon Report stated that:

"A safe working environment will remain a goal which cannot be reached so long as the fundamentals of occupational health are not more widely understood ..."

This paper explains the process that is being followed by AngloGold in addressing the Occupational Dust Health Risk. i.e. The utilisation of an appropriate dust concentrations evaluation and recording system which is used to control, minimise and ultimately to eliminate the associated health risks to which our employees are exposed.

Dust risk assessment methodology

The risk assessment caters for underground respirable particulate only.

To facilitate a systematic approach (enhancing quality management) the risk assessment consists of three very distinct phases, namely:

Phase 1:
- The determination of background dust concentrations
- The determination of "Areas" and "Activities" dust concentrations

Phase 2:
- The identification of critical occupations
- The analyses and survey of critical occupations

Phase 3:
- The development of a new personal dust monitoring strategy
- The establishment of a computerised system to link measured exposures to employees' medical records
- The development of a new dust control method
- The development of a dust control code of practice.

Phase 1

Determination of Background Dust Concentrations

The background dust load was established during an off weekend when there were (nearly) no activities that could theoretically give rise to elevated dust concentrations. The background dust concentration was determined by utilising gravimetric dust sampling instruments and by employing the following survey method:

Placing the gravimetric dust sampling instruments at the intake and return airside of all major areas, e.g. surface bank, shaft stations, start of haulage, end of haulage, stope intake and stope return.

The results were used to identify areas with elevated dust concentrations and this in turn was one of the indicators used to alter or improve existing dust controls.

Determination of Areas and Activities Dust Concentrations

This survey was done by using continuous monitoring dust measuring instruments, e.g. Hund. The instruments were placed at exactly the same locations as used during the "Background" survey. Activities and any identified dust sources were recorded at fixed time intervals. By analysing this information it was possible to establish which activities result in an increase (or decrease) in dust concentrations. Once again the information was used to investigate and implement better dust controls. This survey was conducted during day shift as well as night shift

Phase 2

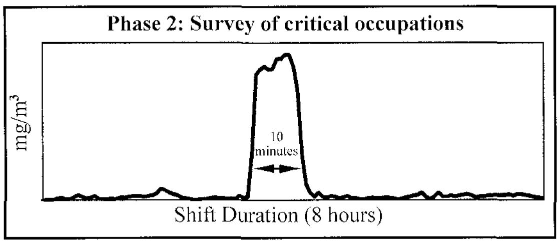
Identification of Critical Occupations

This was done by using recent historic medical information by:

- Obtaining a detailed list of all persons submitted for pneumoconiosis (PN) certification during the previous year
- Calculating the percentage of each occupation submitted for PN certification based on the total number of persons employed in the occupation
- Ranking the occupations from highest to lowest percentage (as calculated above).

Analyses and Survey of Critical Occupations

This is done by conducting a task analysis of identified occupations whilst taking continuous dust measurements with a continuous monitoring dust measuring instrument. The location, tasks performed and any identified dust sources are recorded. These surveys are still in progress and no results can be reported at this stage.



Phase 3

Development of a New Personal Dust Monitoring Method

The continuous dust monitoring is done utilising the current gravimetric dust sampling equipment and implementing the following strategy.

A percentage of the "highest exposed occupation" in each homogeneous exposure group (HEG) is issued with gravimetric dust sampling instruments for the purpose of continuous monitoring.

The percentage/number of continuous monitoring instruments to be issued and the frequency thereof, was calculated in accordance with internationally acceptable methods.

The determination of HEGs is based on areas with similar dust concentrations within a ventilation district. e.g. Fresh-air side stopes are one HEG, return air stopes is another and stopes where different mining techniques is used is yet another HEG.

A special investigation is called for should the trend of continuous monitoring sample results indicate a TWA (Time Weighted Average) above the set TWA limit/target.

Link to Personal Dose Register

In conjunction with an IT company, a computerised system has been developed to automate the process. The calculated dust exposure per shift for each employee is linked to the employees personal hygiene register. This information is also utilised to proactively identify areas where engineering controls may be required.

Development of a New Dust Control Method

By using the latest respirable dust concentration information, the HEGs are ranked from highest to lowest respirable dust concentration. The mine then investigates and decides if and to what extent corrective action plans need to be implemented. The ranking is revised at lease once per year in order to re-prioritise the high-risk areas.

The progressive respirable dust concentrations TWA value for each of the worst five high risk HEGs are then monitored on a monthly basis, to evaluate the effectiveness of any implemented corrective action plans.

By only addressing the worst five HEGs (reducing the respirable dust concentrations) the average respirable dust concentration of the mine subsequently also decreases.

Targets

To achieve the company's vision, i.e. "To halve the exposure levels in 5 years", the following respirable dust concentration targets are to be achieved.

First Target - To reduce the average TWA value to 0,40 mg/m^3 by the end of 2000.

This can be achieved by:

a. Reducing the TWA value to a value lower than the previous cycle average HEG TWA value

b. Reducing the TWA value to a value lower than the previous cycle average mine TWA value.

Second Target - To reduce the average TWA value to 0,25 mg/m^3 by the end of 2003.

Third Target - To reduce the average TWA value to 0,20 mg/m^3 by the end of 2005.

Results obtained from the new personal dust measuring method
(PREVIOUS vs NEW)

1998 (Previous Method)

At the end of 1998, results based on the DME gravimetric dust sampling methods, indicated that:

- No employee was exposed to alpha quartz concentrations above the internationally acceptable Threshold Limit Value (TLV) of 0,1 mg/m^3
- The highest exposed employees (0,2%) were only exposed to concentrations equal to half that of the TLV.

Despite the apparently low exposures, some employees were still contracting dust-related illnesses. Therefor these results indicated that there is no Dose / Response relationship.

1999 (New Method)

By the end of 1999, the mines' survey results, based on the new personal monitoring method, revealed that:

- 15,1% of employees were exposed to alpha quartz concentrations above the TLV of 0,1 mg/m^3
- The highest exposed employees (0,5%) were exposed to concentrations 3 to 4 times higher than the TLV.

These overexposures were recorded in an occupational environment virtually identical to that of 1998.

2000 (New Method)

By the end of 2000, the mines' survey results, based on the new personal monitoring method, revealed that:

- 6,5% of the employees were exposed to alpha quartz concentrations above the TLV of 0,1 mg/m^3

This reduction, in both percentage of employees overexposed and concentrations of overexposure, is of major importance. Not only are the mines providing healthier occupational environments, but compensation and treatment costs should also start to decline in years to come in real terms.

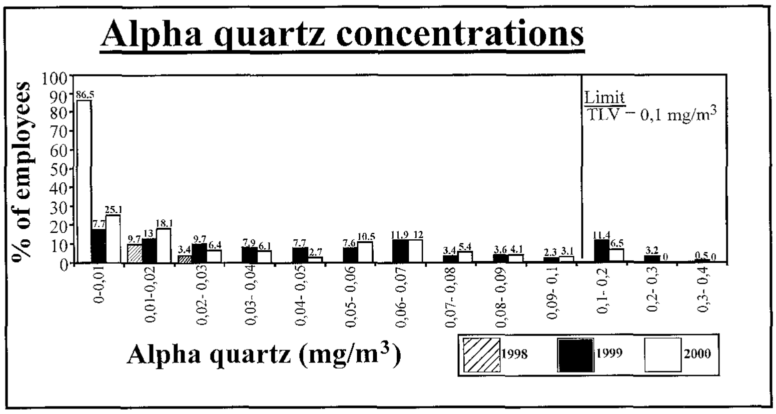
It is also clear from the mines' health statistics that dust (silica) is still the major contributor to occupational lung diseases. Of the employees compensated for lung diseases, 11% were compensated as a result of "pure" TB, 19% were compensated as a result of a combination of TB and dust (PN) and the largest portion (70%), was compensated as a result of "pure" dust (i.e. Pneumoconiosis).

Comparing the previous with the new

See table 1

ISSUE	PREVIOUS (up to 1998)	NEW (from 1999)
Statpop/HEG	Based on Mining Section	Based on "ventilation district"
Remedial Action Investigation	• Based on AQI (reactive) • Requires additional sample and interview	• Based on TWA trend forecast and targets (proactive) • Full investigation of area, occupation and tasks
Calculated Risk	• Used for levy determination	• Used as dosage determination • Used as engineering control indicator
Targets	Nil	5 year plan
Dust Control Method	Not scientific (± 6 month delay)	Formal scientific method (proactive)
Personal Dose Register	Inadequate information	Specific objective
Code of Practice	Not required	• Specific objective • Based on survey outcome and international best practice

Table 1 represents a comparison of the previous dust control methodology with the new.



High dust generating areas

The "Phase 1" surveys conducted thus far have revealed the following areas where high dust loads are being generated:

• *Shafts*

This appears to be mainly as a result of shaft spillage accumulations on buntons, and in some cases, sludge and/or backfill column leakages. (One mine has embarked on a regular "washing down" of the shaft by means of water sprays situated at the top of the shaft, thereby significantly reducing dust loads.)

• *Intake airways*

This appears to be mainly as a result of hopper spillage, drains overflowing and infrequent and/or inadequate watering down. In many cases it is argued that this is due to "cost cutting" (hence labour reduction) whereby "haulage minders" (responsible for cleaning drains, watering down, etc) have been reduced or eliminated.

• *Backfill Spillage*

Areas where backfill spillage had occurred revealed alarmingly high dust loads.

• *Main Ore Pass Systems*

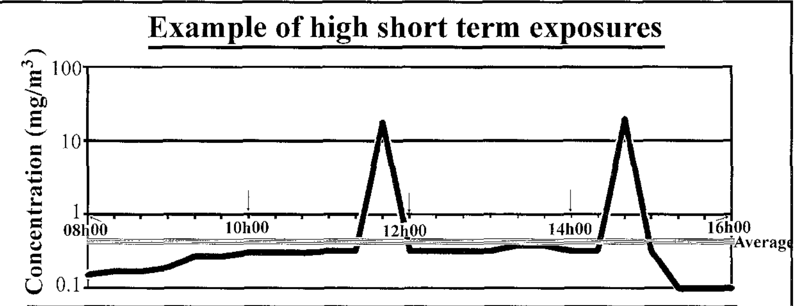
Ore pass systems are known to be high dust generating areas. However, where vertical or near vertical raisebored ore passes are used, the problem is orders of magnitude worse than for conventional ore passes. (In one particular case the air displacement created by the falling ore, and escaping from the ore pass system, was quantified to be approximately 350m³/sec representing an energy value in the surge pathway within the ore pass of approximately 925kW!)

• *Horizontal Ore Transport*

As mentioned under "Intake Airways" above, spillage from hoppers creates a problem. However, where a span of fully loaded hoppers is moving at speed against high air velocities, significant amounts of dust are liberated. (This is obviously worse when the ore is relatively dry.)

Occupational exposures

The "high dust generating areas" discussed above generally lead to frequent, high, short-term occupational exposures (e.g. intermittent, frequent dust "clouds" passing over people downstream). The health effects of these frequent high, short-term exposures are not known. Time weighted average (TWA) exposures in most cases are within acceptable/legal limits despite the high short- term exposures.



Location	Station	Hlge	X/cut	Stope	X/cut	Hlge	Station	Surface
Task	Traveling	Traveling	Meeting	Sweeping	Resting	Traveling	Resting	Reporting
Source ID	Nil	Nil	Nil	Sweeping	Nil	Nil	Tipping	Nil

These short-term exposures are assessed by means of a Tyndolometer and as such the actual respirable dust exposures are not known. Of concern is the absence of technology to accurately measure "real time" respirable exposures.

The way forward

A lot of research has and is being done on the health effects and dose/response relationship of occupational dust exposure. Although this research leads to a better understanding of the problem, it merely reconfirms that we still have a dust exposure problem! What the industry needs is more research aimed at effectively preventing exposure in the first place e.g. controlling dust generation to levels that could eliminate (or reduce) the health risk. Research could typically involve issues such as footwall treatment, filtrations systems, watering down systems, etc. If research indicates that the health risk cannot be eliminated by engineering control, administrative controls such as the "rotation" of people in and out of high-risk occupations could be considered. (The question, however, is how long can a person remain in a high-risk occupation? And at what exposure levels?)

As a last resort, Personal Protective Equipment (PPE) can be considered. However, the suitability, and more importantly, the acceptability of a "dust mask" in hot humid environments, would need to be researched.

Due to the long latency period before exposure manifests as an OLD, disease outcomes should not be used as the sole measure of success or failure (in the short term). Effective and adequate exposure monitoring (together with corrective action when and where required) is deemed to be the only way in which to track improvement or deterioration in the occupational environment. The success/failure of current dust control will result in an improvement/deterioration in OLD in the long-term (+5 years).

Conclusion

Every employee has a right to retire occupational disease and injury free at the end of his or her career. Therefore every employer has an obligation to provide an occupational environment that is conducive to good health and safety. However, the current situation in terms of dust exposure cannot be corrected overnight. Dust exposure, and occupational hygiene in general, should be a strategic focus area for SA mining companies wanting to meet their legal, as well as moral and ethical, obligations.

Besides the legal, moral and ethical issues, good health and safety makes good business sense. The costs associated with compensation, levies, insurance, treatment, absence, etc. are enormous and are largely due to inadequate preventive strategies. The risk of litigation, as per the "Cape plc case", and the effect thereof on market capitalisation (due to publicity) also needs to be considered from a "balance sheet" point of view.

To address the dust hazard the following needs to be done (amongst others):

- More attention to be paid to designing correct, fit-for-purpose, dust sampling strategies (bearing in mind the difference between sampling for dust control purposes and sampling to determine the health hazard/s).
- Real time dust monitoring technology to be sought and introduced.
- Further studies to quantify dust characteristics produced by various mining operations to be made.
- Epidemiological studies to determine the dose/response relationships should be continued and expanded.
- Composition of the submicroscopic dust particles occurring in mines should be studied in more detail.
- Effective dust control technologies, systems and techniques to be sought (researched) and introduced.

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