An holistic approach to managing dust in underground gold mines

By Kobus Dekker Paper presented at the 2003 MVSSA Conference titled: "Managing the Basics" Pretoria 13 - 14 February 2003

Synopsis

"While our historic preoccupation with the recognition of occupational diseases and the compensation of workers have value in their own right, we must focus on prevention."

May Hermanus, Chief Inspector of Mines - October 2001[1]

The aim of this paper is:

- *To describe the management process that was adopted to facilitate the implementation of a process used to control, minimise and ultimately to eliminate the associated health risk to which our employees may be exposed , and*
- *To highlight some of the findings that resulted from the implementation of this process.*

Introduction

In his award wining paper "from dust to dust"[2] Des Wrigley explained the process being followed by AngloGold in addressing the occupational dust health risk. He discussed in detail the implementation of an appropriate dust concentration evaluation and recording system which is used to control, minimise and ultimately to eliminate the associated health risk to which our employees may be exposed.

Silicosis and tuberculosis are only two of the lung diseases listed in the Occupational Diseases in Mines and Works Act (Act 208 of 1993). Silicosis occurs as a result of exposure to silica dust particles[3] that are small enough to reach the alveoli of the lung. Exposure to silica dust can also increase a person's susceptibility to tuberculosis.[4]

The main sources of dust and dust generation in underground mines have been well defined and documented by both Mine Ventilation Engineers[5] and research organisations, such as SIMRAC. These sources include dust generation from blasting operations, rock cutting and loading, raise and blind hole boring equipment, drilling operations, transportation of rock and ore tipping at transfer points.

For numerous years the mining industry has been developing methods to control dust concentrations liberated by these sources. Traditionally, controls were implemented, but sadly not always maintained. In some instances so called best practice controls were implemented and the same controls later proved to be totally ineffective.

Without the resources to inspect each dust control mechanism on a daily basis it become apparent that a holistic approach was required to monitor and control dust concentrations in the underground environment.

Resources

During February 2002 AngloGold reviewed its safety and health thrusts.

During this meeting dust was identified as one of the strategic thrust areas. The Dust Steering Committee was tasked to lead AngloGold in the management of dust exposures.

The Dust Steering Committee was established during 1998 and pioneered the implementation of HEGs (based on ventilation districts) to determine dust exposure profiles, instead of the previously used Statpops (based on mining sections).

This team's vision is to achieve a quantum reduction in dust exposure in AngloGold, thereby achieving a significant improvement in the long-term health outcomes of employees.

To achieve its vision the Dust Steering Committee adopted the "Effective Dust Management Program" philosophy (figure 1).

The Dust Steering Committee consists of the Head of Occupational Environment Safety and Health (O-ESH), the Manager Occupational Environment, the Occupational Hygiene (Dust) Specialist, the Consultant Occupational Health, a

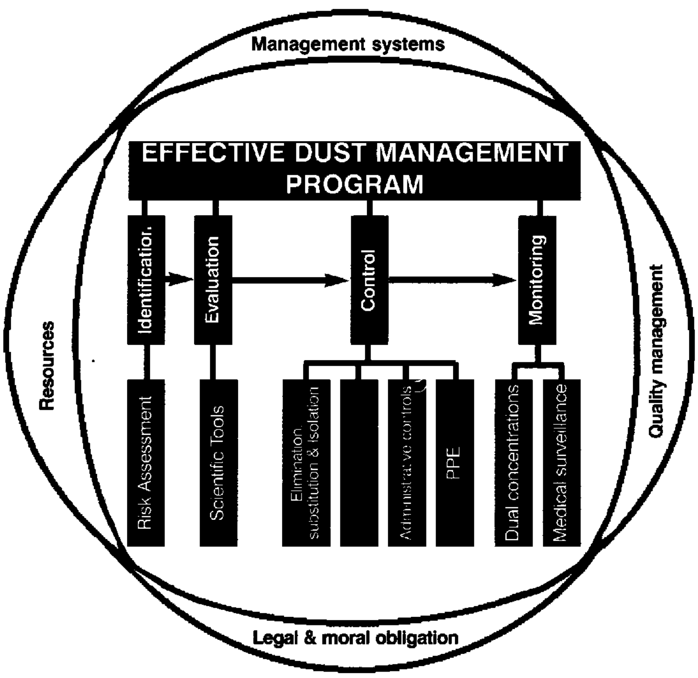

Figure 1. *Effective Dust Management Program philosophy*

Senior O-ESH Representative from the deep mining environment and a Senior O-ESH Representative from the metallurgical plants. The main function of this committee is to determine strategic direction and ensure the implementation of the dust management program.

A dust technology and innovation supporting team was also established, headed by the dust specialist. The team consists of representatives (Mine Occupational Hygienists) from each of the South Africa region business units. This team meets on a monthly basis and information and practices from all levels within the organisation and industry is shared, evaluated and (if required) adopted for implementation throughout AngloGold SA Region.

The establishment of these two committees not only ensures proper implementation of appropriate technologies but also ensures clear communication between the executive level and mine operational level (management, employees, unions and associations).

Management systems

Introduction of a new dust monitoring method

The new personal dust monitoring method (as described by Des Wrigley in his paper)[2] has been implemented at all AngloGold South Africa region business units as from October 2001. This method mainly incorporates the establishment of ventilation districts (sampling areas) and activity areas (Homogeneous Exposure Groups) within these ventilation districts.

Integrated risk management system (IRMS)

A computerised system was developed to assist AngloGold in managing its health and safety risks. The dust-monitoring module of this program was also revised to include all airborne pollutants, including toxic gases and vapours. It also addresses all the requirements of the Department of Minerals and Energy's "Guideline for the compilation of a mandatory Code of Practice for Airborne Pollutants".[6]

Personal monitoring sample results are entered into this program on a daily basis. The program is then utilised to update employees' personal occupational hygiene exposure records (on a monthly basis) and to generate engineering control reports (discussed in detail later in this paper).

Key result indicators

Four main key result indicators where identified, namely:

- % of employees exposed to total respirable dust concentrations above 1 mg/m^3
- % of employees exposed to total respirable dust concentrations > 0,5 to 1 mg/m^3
- % of employees exposed to total respirable dust concentrations below 0,5 mg/m^3
- Average total respirable dust concentration.

It must be noted that these indicators are for total respirable dust concentrations and not just for a specific pollutant such as alpha quartz. The use of total respirable dust as an indicator facilitates proactive management of dust concentrations, as no delay for pollutant analysis results are required.

These indicators are monitored on a monthly and quarterly basis for each business unit, each ventilation district (sampling area) within the business unit, and each HEG within each ventilation district.

This information is then utilised to monitor the results of any implemented controls and track dust exposure trends at operational level, to identify any problem areas. For example, if we interpret the information presented in figure 1 it is evident that:

- the controls implemented to reduce dust exposures in "high" dust exposure areas (more than 1 and more than 0,5 mg/m^3) are rendering the required results, but:
- overall dust concentrations are on the increase, and if not addressed may result in overall "high" dust exposures.

By viewing the same information for each ventilation district the problem ventilation district can be identified. Similarly, by viewing the same HEG information for the problem ventilation district, the problem HEG can be identified and corrective action plans can be formulated (after proper area investigation).

Auditing / evaluation

Gravimetric dust sampling results are mainly used to measure our dust performances and also to direct remedial and technology initiatives. A comprehensive dust auditing protocol has been formulated and implemented. The purpose of the annual audit is to maintain good quality management and accurate statistics. The following issues are evaluated:

- Measuring equipment (maintenance, calibration, etc)
- Statistical analysis of homogeneous exposure groups (2 standard deviations at 95% confidence level)
- Sampling methodology (correct classification of ventilation districts and HEGs)
- Integrated risk management system (IRMS) dust and hygiene modules
- Reporting (appropriate level, follow-up, etc)
- Remedial action (reduction of "high" exposures)
- Technology and innovation (implementation of new initiatives)

Employee hygiene register

This requirement is addressed by the implementation of the IRMS Airborne Pollutants and Hygiene Register modules.

Interesting discoveries / findings during implementation of controls

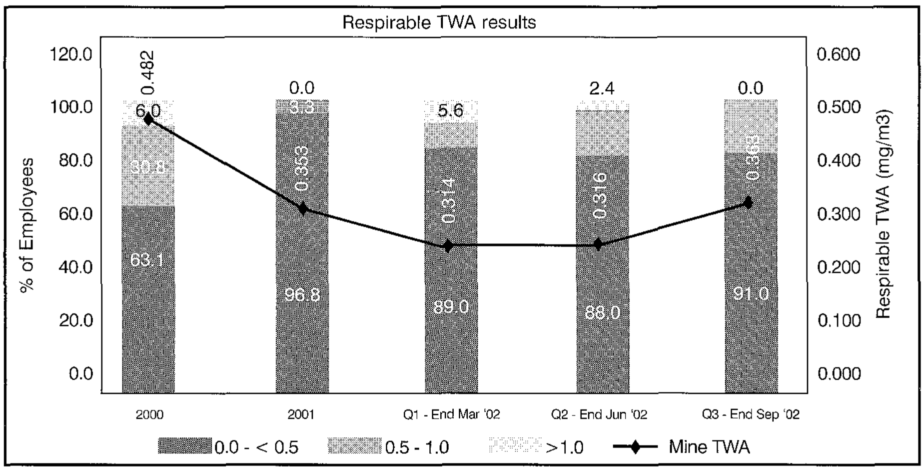

Figure 1. *Quarterly total respirable dust results*

(NOTE: Only brief summaries of major findings are stated as it is intended to publish more comprehensive papers on the subjects listed below)

Footwall treatment

Scientific tests were conducted on the flammability and evolution of gases during combustion, toxicity and corrosivety (on various footwall treatment products) and these proved to be within acceptable limits. The tests were conducted to ensure that the utilisation of these products would not result in the introduction of other health and safety risks.

Most footwall treatment products consist of molasses or sugar compounds, which also contains lignosulphonate. Lignosulphonate is an additional binding agent added to the molasses. Once applied the binding effect of the product is visible on the footwall.

A project was conducted to establish the dust allaying effect of these products. The underground working levels selected were those with the highest air velocities and highest tramming-traffic. Gravimetric sample positions were selected and samples were taken at the selected points before the application and again after treatment with the dust allaying products.

This project proved the effectiveness of the product to control footwall dust.

Dust filtration

Each type of fabric bag dust filter (currently utilised) was tested to determine its fractional dust filtering efficiency and dust holding capacity[7,8]. It was decided to determine the fractional dust filtering efficiency as small dust particles (> 1mm) are capable of entering the deeper regions of the respiratory tract. Even if a high overall dust filtering efficiency (all particle sizes) is maintained it is still possible for large quantities of small particles to enter the respiratory track. The fractional dust filtering efficiency was determined by utilising instruments that could count the number of dust particles within a specified dust size category. A summary of the main findings is depicted in figure 2.

This initial investigation would suggest that fabric dust filters (currently in use) have no meaningful effect on the elimination of harmful airborne pollutants. In perusing the test data, it becomes apparent that the combination of pre-filtration with high efficiency secondary filtration offers the best prospects for success in the underground environment.

Administrative controls

Numerous administrative controls are already implemented (blasting schedules, re-entry periods, etc) to prevent employees from being exposed to the harmful contaminants generated by blasting operations.

It is of utmost importance that the effectiveness of these controls be audited on an ongoing basis. A theoretical simulation revealed that persons exposed to blasting fumes for only 30 minutes at a typical dust concentration of 90 mg/m^3 will receive a Time Weighted Average (TWA) exposure of 5,63 mg/m^3 for the shift (assuming no exposure for the remainder of the shift), compared to the international limit of 1 mg/m^3. It also begs the question: "What is the long-term health effect of frequent exposures to short-duration high-concentration exposures?"

Respiratory protective equipment (RPE)

Because of a variety of ergonomic constraints, the 'Personal Protective Equipment route' should always be regarded as the last resort in any strategy designed to protect employees from workplace hazards.[9]

To gain the maximum benefit of any intended PPE; the most fundamental issue is employee acceptance. This is a complex requirement and also the single most important motivation for conducting a PPE field trial. The primary purpose of the trial was to assess ergonomic acceptance of PPE for different realistic scenarios. It is of no use to issue employees with the best and most costly PPE, if they do not want to wear it. Eight different types of respirators (1360 units) were evaluated.

The results of the trail indicated that employees prefer to use valve fitted disposable PPE. The majority of employees working in critical occupations or employed in areas with "high" dust concentrations preferred half-mask, non-disposable PPE.

Real-time dust monitor

The objective of the real-time dust monitor project is to design an automated monitoring system for measurement of airborne silica dust. This instrument must also have an alarm capability that can be used to warn employees when "high" dust concentrations are experienced. Employees can then withdraw from the affected area until normal conditions have been restored. Meetings held with leaders in the instrument-manufacturing field revealed that the technology does not yet exist for this objective to materialise. It has therefore been decided that this project will be put on hold.

Effect of (hydropower) water jetting on dust concentrations

The project was conducted during day shift (figure 3). Two water jets were in operation at the time of the investigation. Gravimetric dust samples (used to monitor the panel dust conditions) were taken at 15-minute intervals. The forces created by the 2 water jets were adequate to hamper the designed ventilation flow as it reversed the ventilating airflow direction.

The 2 operating water jets resulted in an 86,7% (0,341 to 0,636 mg/m^3) increase in stope dust concentrations and a 433% (0,341 to 1,818 mg.m^3) increase in panel dust concentrations.

This increase in dust concentrations was mainly due to:

- The reversal of the ventilating airflow direction. Thus not sufficient dilution ventilation is available (in the panel) to reduce the dust concentration.
- The lack of proper watering down practice. The hanging wall is washed by using the water jet guns. This practice is deemed by the stope team as adequate watering

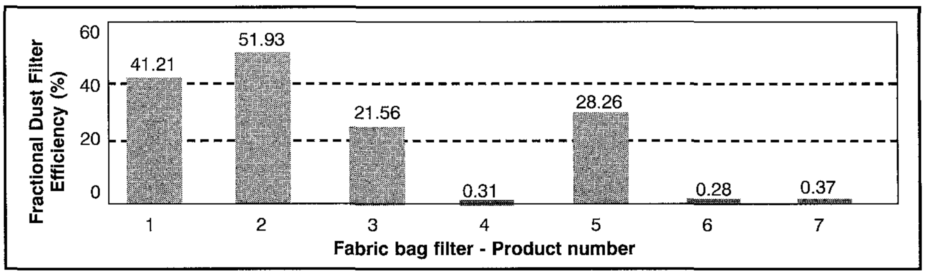

Figure 2. Overall fractional dust filtering efficiency

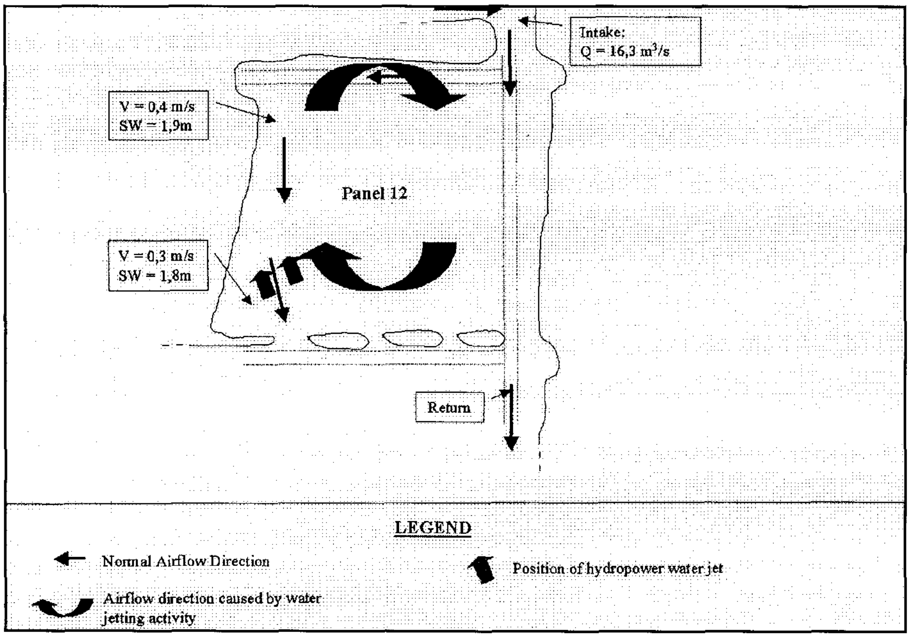

Figure 3. *(Hydropower) water jetting project*

down, as the water used to clean the hanging wall also falls onto the footwall.

- The dust kicked up by the "pressure wave" of the water jet.

Other medium- and long-term dust issues

Some medium and long-term dust issues have also been identified by the "Dust Technology and Innovation Supporting Team" for investigation and possible projects for 2003 onwards. These include:

- Ore transfer areas: Dust load determination methodology, filter efficiency determination methodology, dust characteristic determination methodology, captured displacement and excavation (capacity) determination methodology and maintenance program content.
- Intake airways: Drain cleaning methodology, shotcrete dust control, backfill pipes maintenance and possible enhancement / substitution, washing of side walls and hanging walls and influence of foot wall treatment products on water quality.
- Shaft areas: Backfill pipes maintenance and possible enhancement / substitution, management of sludge pipes and spillage's with regards to skips and management of empty material cars and hoppers.
- Working places: Drilling operations, scraping operations, transport of employees and material, exposed backfill, installation of support, ore handling / loading, water jetting operations and employee exposure to blasting fumes.

Conclusion

It should be apparent that the management of dust (airborne pollutants) in the underground environment is no small order. Implementation of the management program (as described in this paper) will certainly assist mine management to better manage the dust health risk.

Some immediate issues (actions that can be / were immediately implemented / reinforced) are:

- Regular watering down of intake airways
- Watering down on re-entry (from intake side where possible)
- Dust filter plants to be regularly cleaned and maintained
- Respiratory protection to be worn by persons at or involved in tipping operations, sweeping, water jetting, filter plant cleaning / maintenance, etc.
- Ore pass controls (finger controls, chutes, tip covers, etc) to be in working order at all times.
- Settler efficiency to be rigorously maintained
- Ventilation controls to be rigorously maintained.

Only dedication, commitment and enthusiasm by all stakeholders (management, employees, unions and associations) will result in reduced dust concentrations thus reduced medical outcomes

Acknowledgement

Thanks are due to the following:

- AngloGold Manager Occupational Environment for permission to publish and present this paper.
- The AngloGold Dust Steering Committee and AngloGold Dust Technology and Innovation Supporting Team for their valued contribution, dedication and commitment in designing and implementing the dust management program.

References

1. GUILD, R., EHRLICH, R.I., JOHNSTON, J.R., ROSS, M.H. 2001. SIMRAC Handbook of Occupational Health Practice in the South African Mining Industry. Johannesburg. Creda Communications. Foreword.
2. WRIGLEY, DE. 2001. Mining methods and occupational hygiene for the new millennium: from dust to dust. Journal of the Mine Ventilation Society of South Africa, 54(3):73-77, July/September.
3. GUILD, R., EHRLICH, R.I., JOHNSTON, J.R., ROSS, M.H. 2001. SIMRAC Handbook of Occupational Health Practice in the South African Mining Industry. Johannesburg. Creda Communications. 160 p.
4. GUILD, R., EHRLICH, R.I., JOHNSTON, J.R., ROSS, M.H. 2001. SIMRAC Handbook of Occupational Health Practice in the South African Mining Industry. Johannesburg. Creda Communications. 160 p.
5. BURROWS, J., HEMP, R., HOLDING, W., STROH, R.M. 1989. Environmental Engineering in South African Mines. Cape Town. CTP Book Printers. 379 p.
6. SOUTH AFRICA. Department of Minerals and Energy. Mine Health and Safety Inspectorate. Guideline for the compilation of a mandatory code of practice for an occupational health program on personal exposure to Airborne Pollutants. 2002.
7. South African Bureau of Standards. SABS 1424:1987. Standard Specification for Filters for use in air-conditioning and general ventilation. 1987.
8. British Standards Institution. BS EN 779:1993. Particulate air filters for general ventilation - Requirements, testing, marking. 1993.
9. KIELBLOCK, J. 2001. Personal protection as an interim strategy to reduce occupational dust exposure: PPE selection and allocation. (RPE Field Trail developed for AngloGold SA Region). (Unpublished).