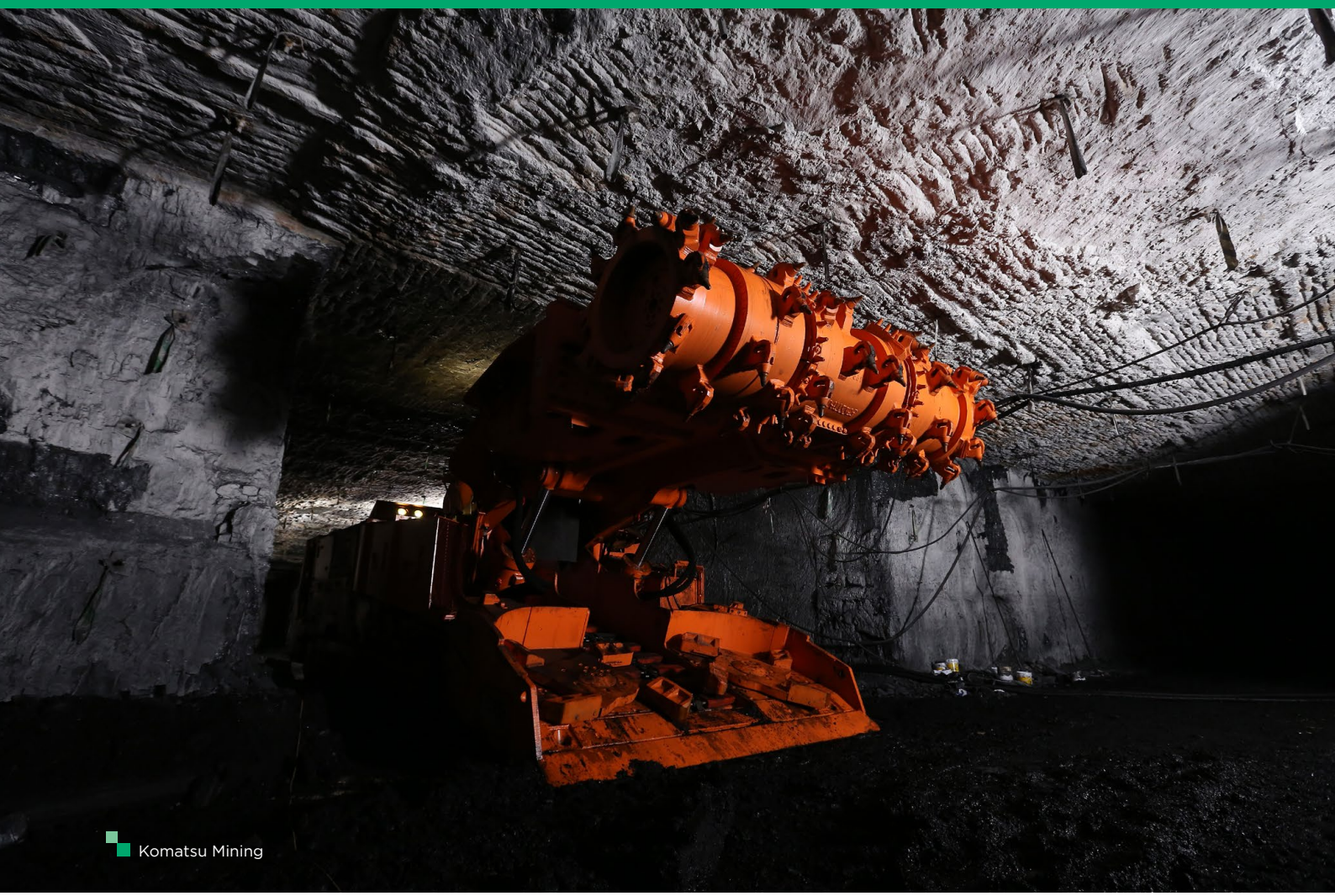
MINING INDUSTRY
OCCUPATIONAL
SAFETY & HEALTH

MINERALS COUNCIL
SOUTH AFRICA

REAL TIME DUST MONITORING ON CONTINUOUS MINER

LEADING PRACTICE ADOPTION GUIDE



EXECUTIVE SUMMARY

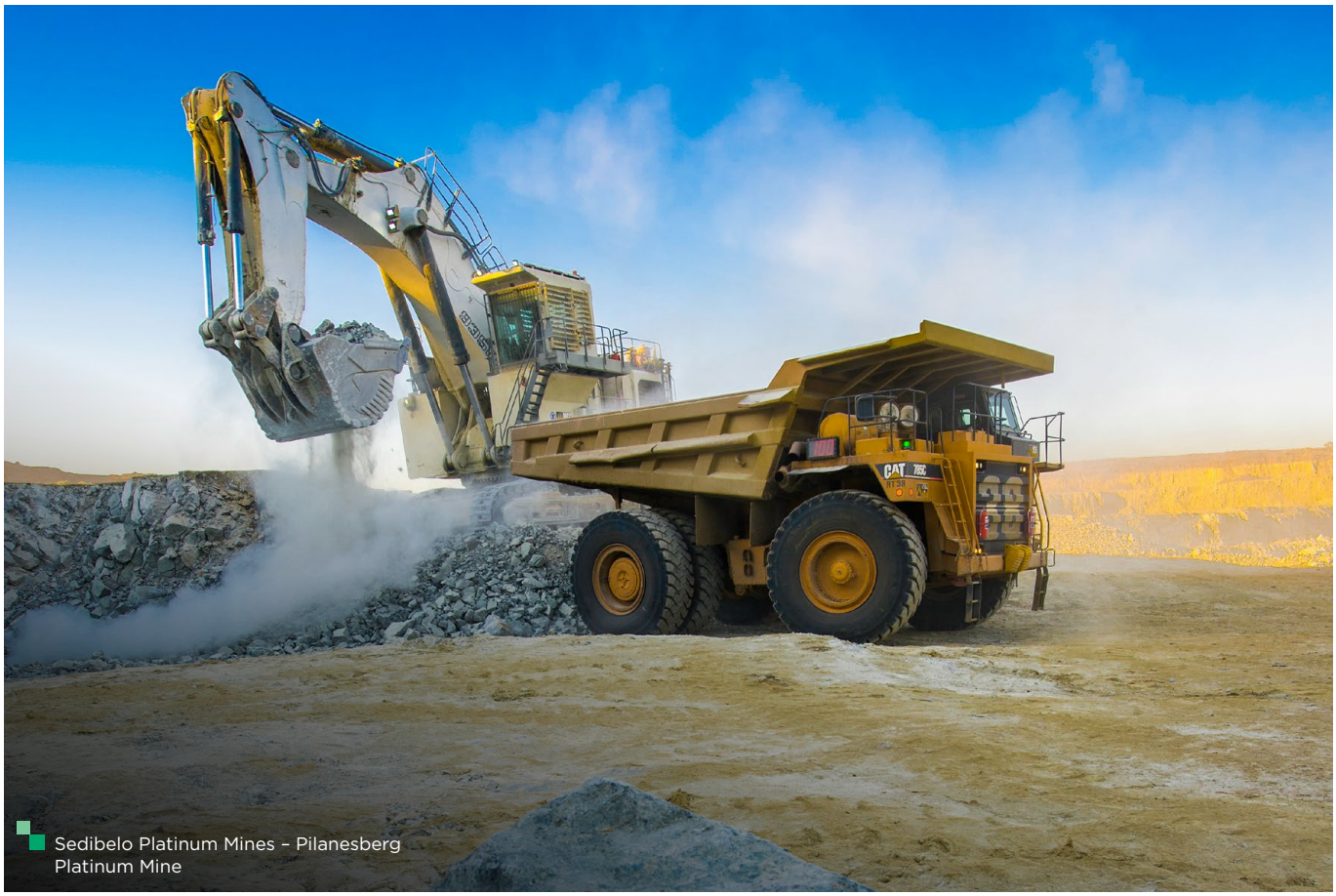
The risk of Occupational Lung Diseases (OLD) within the South African Coal Mining sector remains a challenge. This sector continues to record high levels of coal dust exposures reported quarterly to the Department of Mineral Resources and Energy (DMRE) and the Minerals Council South Africa's "HealthSource" portal, a portal used for reporting progress on the achievement of 2024 occupational health milestones as set by the South African Mining Industry.

As the coal mining sector continues to intensify efforts focused at reducing employee coal dust exposure, by targeting dust generation at source, continuous real-time monitoring of coal dust levels has been identified as one of the leading indicators in mitigating the risk of exposure.

Through the MOSH leading practice adoption system, a best practice on real time monitoring of coal dust concentrations during coal cutting activities was identified by the Collieries Dust Working Group as the next potential leading practice for the South African coal mining sector. The practice was introduced at the source mine during the Coaltech and Latona Consulting pilot projects. The practice was in conjunction with other related projects on dust and flammable gas control. The practice has yielded significant results at the source mine in terms of improving the turnaround time for daily coal dust measurements on the Continuous Miner (CM), whereby the results thereof are obtained two to three days after being sent for laboratory analysis. This waiting period has always been a challenge in terms of identifying or investigating causes of high coal dust exposure, but also in identifying and addressing critical control failures timeously.

The real time monitoring of coal dust on the CM, during cutting operations, has enabled the source mine to proactively manage the risk as they are now able to analyse the data on a real-time basis thereby enabling employees, especially the CM and the shuttle car operators, to make effective and prompt decisions to prevent further employee exposure to coal dust, but also to better monitor the effectiveness and performance of critical controls for coal dust at the point of generation or liberation (during coal cutting).

Continuous real-time monitoring of coal dust levels has been identified as one of the leading indicators in mitigating the risk of exposure



Sedibelo Platinum Mines – Pilanesberg Platinum Mine

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"In 2020, the Minerals Council CEO Zero Harm Leadership Forum (CEOZHF) identified a need to raise the bar on the elimination of workplace exposures, as occupational diseases and fatalities may emanate from airborne pollutant exposures. As a result, it recommended that the key occupational health performance indicators be adopted to track industry progress on the elimination of workplace exposures."

Glencore Coal – Goedgevonden Colliery

PART 1
STRATEGIC CONTEXT

In reference to the Brady Heywood report *"Review of all fatal accidents in Queensland mines and quarries from 2000 to 2019"*, recommendation 5 highlights that *"the industry needs to focus on ensuring the effectiveness and enforcement of controls to manage hazards"*. It is recommended that all the Minerals Council members should; adopt Continuous Real Time Monitoring (CRTM) of the identified significant occupational health hazards, monitor the performance and effectiveness of the critical controls implemented (to minimise exposure to such hazards) and align on the reporting thereof. *"By adopting intelligent technology, businesses can improve safety (and health) at their facilities while increasing productivity"* – Glyn Jones.

At the Leadership Tripartite Summit held in 2014, the mining industry stakeholders agreed on the milestone targets that needed to be achieved by 2024 to improve the performance of Occupational Health and Safety to achieve Zero Harm.

The CRTM of airborne pollutants will therefore serve as an early indicator of potential exposures as it will provide data and information related to workplace environmental conditions in real-time (or almost real-time) with data logging. It will provide a workplace exposure profile over a period of time.

The CRTM should therefore ideally be linked to the mine's identified electronic communication/internal risk management systems and key indicators be monitored and reported to the risk/control owners and/or the person directly exposed to the hazard.

In addition to the deliberations of the CEOZHF, the Section 11 of the Mine Health South Africa Act (MHSA) requires the employer to assess and respond to the risk, determine all measures, including changing the organisation of work and the design of a safe system of work necessary to eliminate the risk.

2014 OCCUPATIONAL HEALTH MILESTONES

Elimination of occupational lung diseases:

- By December 2024, 95% of all exposure measurement results will be below the milestone level for respirable *crystalline silica* of 0.05 mg/m³ (these results are individual readings and not average results).
- By December 2024, 95% of all exposure measurement results will be below the milestone level for platinum dust respirable particulate of 1.5 mg/m³ (<5% crystalline silica) (these results are individual readings and not average results).
- By December 2024, 95% of all exposure measurement results will be below the milestone level for *coal dust respirable particulate of* 1.5 mg/m³ (<5% crystalline silica) (these results are individual readings and not average results).
- Using present diagnostic techniques, no new cases of pneumoconiosis, silicosis, coal worker's pneumoconiosis will occur amongst previously unexposed individuals.

(*"Previously unexposed individual" are those unexposed to mining dust prior to December 2008 i.e. equivalent to new persons who entered the industry in 2009*).

THE PROBLEM ADDRESSED
A case for change

Cable handler, CM driver and General worker dust result averages for 5 days

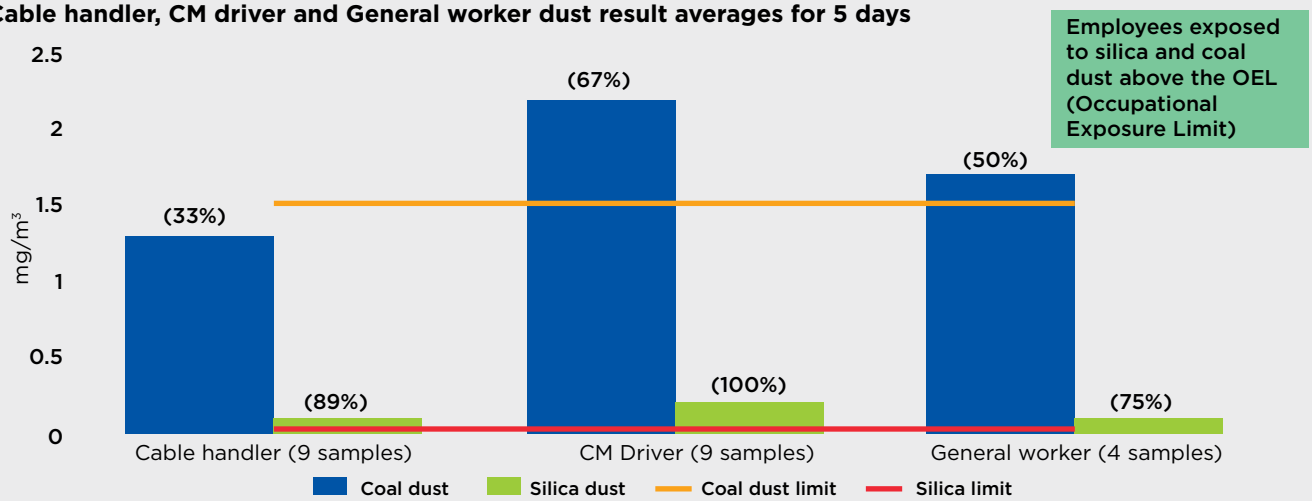


Figure 1: A graph indicating employees who are exposed to dust levels above the OEL (Silica and coal dust). Source Mine Report, 2019. (Occupations exposed to silica and coal dust at the source mine)

HIGH RISK OCCUPATIONS

The occupations as depicted in figure 1, are of employees who work in the production sections. The personal monitoring sampling results conducted by the source mine shows that these occupations are over-exposed to both pollutants (coal dust and silica) and a higher Air Quality Index (AQI). The graph indicates that these production employees are exposed between 75.0% and 100.0% of the Occupational Exposure Limit (OEL) for silica. Also, between 89% to 100% of the sampled population were exposed to an AQI above 1.

OEL EXCEEDANCE

While the industry strives for Zero Harm and the elimination of occupational lung disease, the reality is that more than 10% of the employees in the coal mining sector are continuously exposed to airborne pollutants exceeding the regulated OEL(s). This presents a challenge to achieving the South African Mining Industry's milestone towards the elimination of occupational lung diseases. (See Figure 2: Percentage exposure to airborne pollutants per classification band per commodity)

CM DUST SAMPLING

The monitoring of coal dust levels on the CM is a statutory directive from the Department of Minerals and Energy (DMRE) (B7 Directive,1994), thus every colliery is expected to monitor coal dust levels on the CM and report to the DMRE. According to the directive, CM dust levels must be kept below respirable coal dust level of 5.0 mg/m^3.

The real time dust monitor performs the function of the gravimetric pump, largely known as "Ikati", (a device which is manually placed and retrieved on the CM by the miner at the start and end of each shift). The retrieved samples are then sent to the laboratory for analysis, and the results thereof are communicated back to the mine for reporting and risk management purposes. This process may take two to three days, resulting in delayed dust management action or response from either the CM operator, shuttle car operator or mine management. This has made the investigations of high dust levels on the CM complicated and reactive.

Percentage exposure to airborne pollutants per classification band per commodity

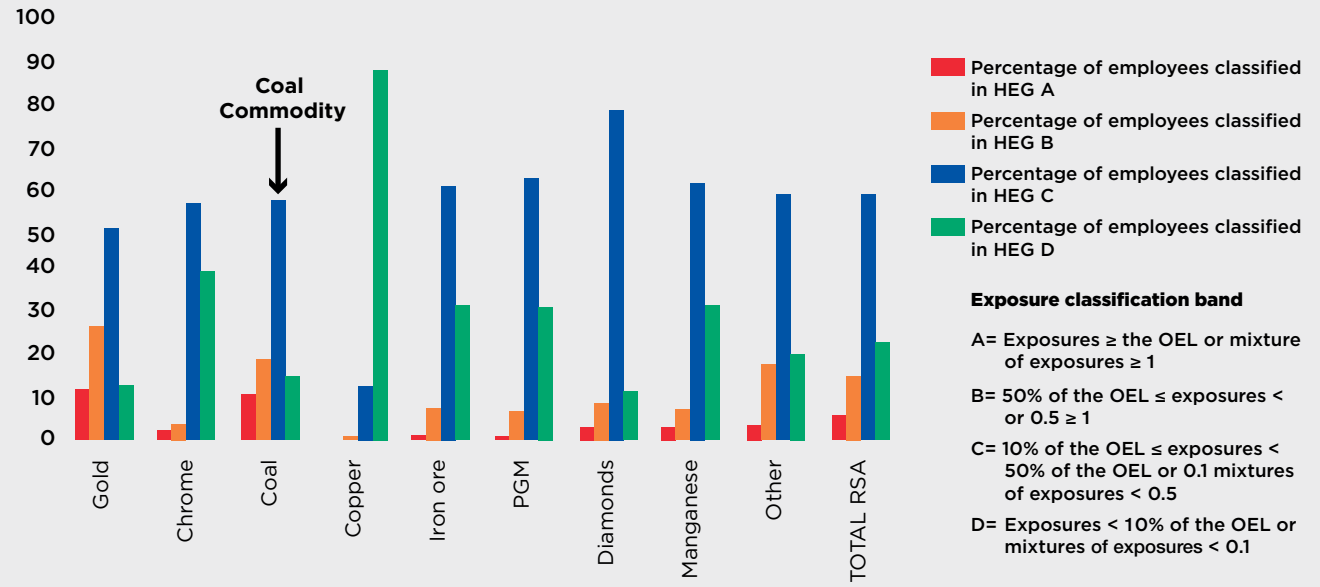


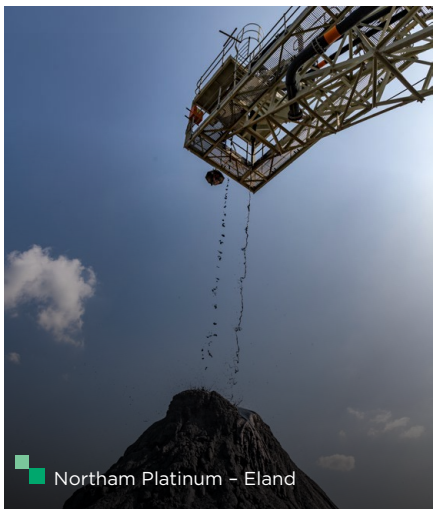
Figure 2: Percentage exposure to airborne pollutants per classification band per commodity. Source: DMRE

SUMMARY DESCRIPTION OF THE PRACTICE

The real time dust monitor is fitted on the CM in a coal winning heading to continuously measure the levels of dust in real time with all dust critical controls in place.

Various dust controls are installed on the CM for dust management, hence monitoring the performance thereof is critical. This practice ensures that the performance of these controls is continuously monitored, and that any control failure can be attended to as soon as possible. The CM operator is empowered to take informative decisions and actions through the early warning nature (audio/visual warning) of this practice, to prevent adverse exposure to coal dust. (See Figure 3: A sketch indicating the current dust controls on a continuous miner at the source mine).

The CM is also fitted with a display monitor to warn the operator when excessive coal dust is generated during coal cutting. Various actions are required from the CM operator to prevent excessive coal dust generation at source, thus preventing dust exposure of other employees downstream of the ventilating air.


Northam Platinum – Eland

Components of the integrated dust suppression system on continuous miner

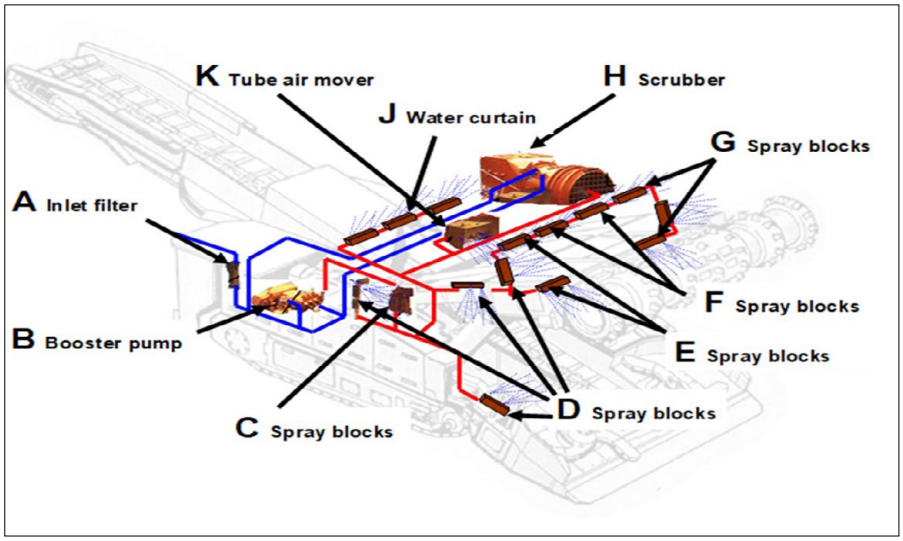


Figure 3: A sketch indicating the current dust controls on a continuous miner at the source mine.

The real time dust monitor offers a wide range of opportunities in terms of managing the coal dust risk and the development of critical controls to suppress the coal dust at the source. The real time dust monitor also plays a critical role in ensuring control availability, effectiveness, and continuous performance monitoring of dust controls on the CM.

Real time dust measurement on the CM can be monitored from a centralised point for example; control rooms and other mobile devices. An analysis report of all dust measurements can be generated at the end of each shift and forwarded, via email, to the Ventilation and Occupational Hygiene Engineering (VOHE) department. This department then facilitates communication of the report to all relevant persons and initiates high dust incident investigation(s) where necessary.

SUMMARY OF DOCUMENTED PERFORMANCE AND IMPACTS

The introduction of the real time dust monitor on the CM has contributed to lower dust levels at the face through effective dust critical control management. Figure 4 shows the improvement documented at the source mine.

"Real time dust measurement on the CM can be monitored from a centralised point for example; control rooms and other mobile devices."


Tshipi é Ntle Manganese Mining – Tshipi Borwa mine

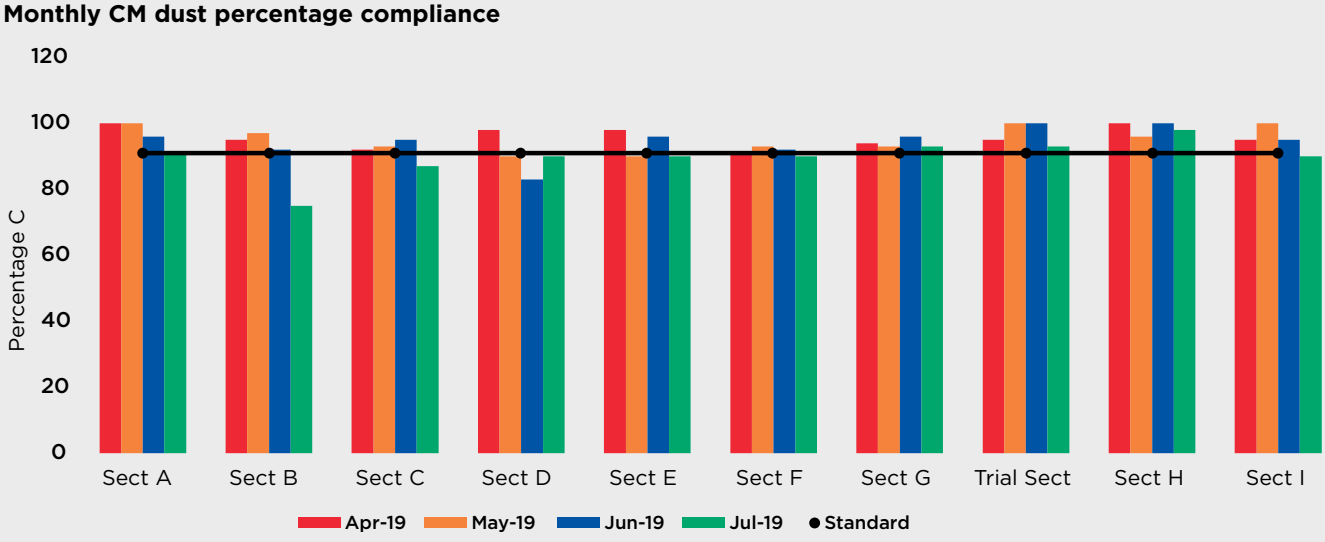


Figure 4: Monthly CM dust percentage compliance. Source: Source mine

GENERIC VALUE CASE

Table 1 outlines the guide for determining the value case to enhance the decision making for adoption of real time dust monitoring on CM Leading Practice.

Table 1: A guideline for establishing a value case for adoption of real time dust monitoring on continuous miner leading practice.

Risk management	**Early warning systems**	Empowerment of the CM and shuttle car operators to minimise exposure to coal dust, but also to proactively protect the health and safety of others downstream.
	Critical control management	Performance, availability and failure of critical controls can be monitored and attended to by the CM Operator or the engineering department immediately, to ensure that the CM operate within permissible dust limits.
	Incident investigation	Investigation of coal dust exceedances can be conducted immediately by line supervision, and findings actioned (maintenance) and communicated to the next shift.
Health and Safety	**OHS benefit**	Risk of occupational lung diseases to underground employees will be significantly reduced. This is of real value to both the employees and employer.
	Progress towards Zero Harm	Death from Coal Workers Pneumoconiosis (CWP) and other occupational lung diseases caused by excessive exposure to coal dust. Reducing this risk to underground employees most at risk will constitute a significant step towards achieving the goal of Zero Harm.
Governance	**Legal compliance**	The installation and use of continuous real time dust monitor on board CM units will assist in monitoring and ensuring that the regulated permissible coal dust exposure levels are achieved. It will also be a good case of management doing what is reasonably practicable to provide and maintain a working environment that is safe and without risk to the health of all underground employees.
	Reduced compensation	In the longer term, the mining industry, including the source mine, stand to benefit from a reduction in compensation and other costs associated with occupational lung diseases.
Stakeholder relations	**Improved working relationships**	Implementation of the behavioral communication and leadership behavior plans has the potential to significantly improve the operational working relationship between supervisors and their staff.
	Buy-in and support	The mine-wide intervention in the interest of protecting the health of those most at risk will help engender buy-in and support for the intervention, from employees and relevant stakeholders.
	Improved investor relations	A positive outlook on the mine's commitment towards elimination of OLD.

MCMining – Vele

PART 2
DETAILS OF THE LEADING PRACTICE

Principle of operation

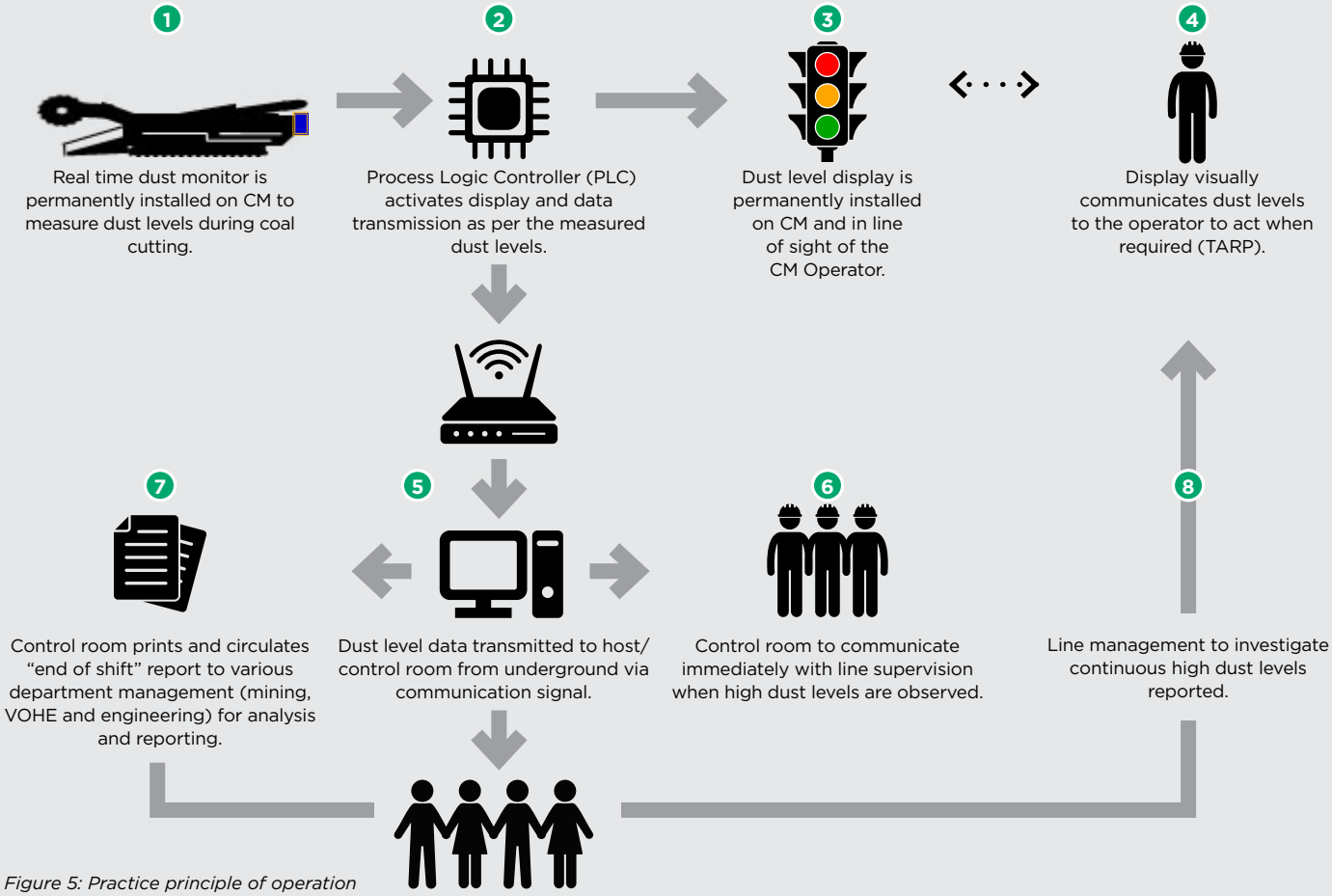


Figure 5: Practice principle of operation

Source mine benefits

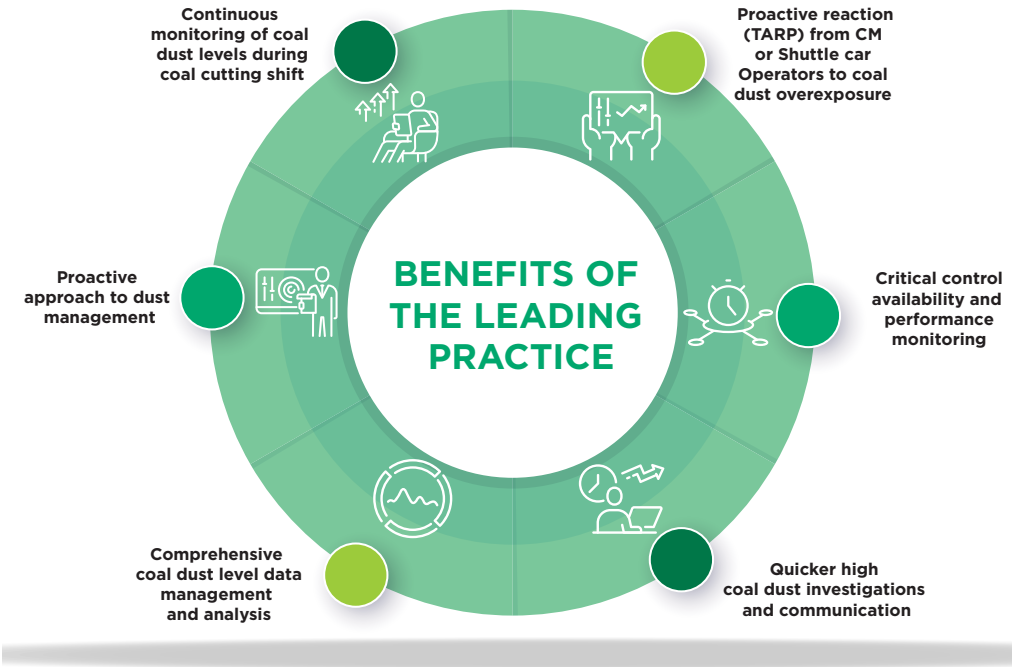


Figure 6: Documented benefits of real time dust monitoring on CM leading practice

Additional benefits at source mine

- Comparative tool for gravimetric sampling results
- Dust liberation analysis vs cutter drum activity
- Improved coal dust reporting systems
- Improved controls functionality (keeping controls honest)

Unintended consequences

- Production loss due to CM cut offs (CM interlocked with dust monitor)
- Practice used to replace the current DMRE B7 directive on gravimetric sampling

Critical success factors for adoption

- Top management buy-in and support
- Appropriate technical equipment (dust monitors, SCADA) selection
- Adequate underground communication systems (Wi-Fi, leaky feeder)
- Compatibility of dust monitoring system to the CM data management system
- Credible technical equipment (real time dust monitors) OEM/supplier and support
- A credible adoption champion with adequate time and support
- Proper identification, briefing and training of key stakeholders
- A well designed and executed adoption roll-out plan

Practice elements to be adopted

Equipment function specifications

a) unit's specs to simulate the gravimetric pump and respirable coal dust collection i.e.
   - flow rate,
   - particle size to represent respirable portion,
   - unit of measurement i.e. PPM vs mg/m^3,

b) Minimum required capacity of network architecture for operating all systems adequately, audio/visual signal).

Trigger action response plan

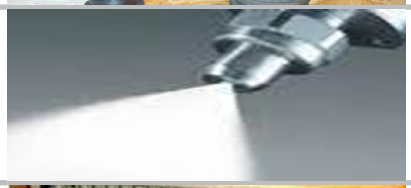
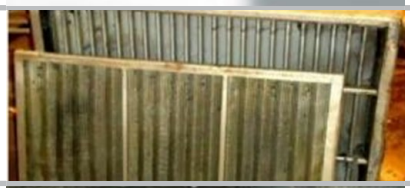
When high levels of coal dust are generated and subsequently measured or reported by the real time monitoring unit in a coal winning heading, all responsible persons, including the CM Operator, are required to ensure that all critical dust controls are in place and in working order. Table 2 shows the defined trigger action levels and the action to be taken. Table 3, the actual checks for each critical dust control are specified.

Table 2: Dust trigger action and response plan displaying the action to be taken by the responsible persons.

Trigger levels	Main display	Action required	Responsible person
Normal conditions Shift average dust reading below 3mg/m^3		**No action required** – maintain dust controls	CM Operator
Level 1 Shift average dust reading above 3mg/m^3 but below 4mg/m^3		Check condition of all dust critical controls i.e., CM scrubber, water sprays, ventilation controls, condition of picks and pick sleeves.	CM Operator
Level 2 Shift average dust reading above 4mg/m^3		**Stop and check condition** of all dust critical controls i.e., CM scrubber, water sprays, ventilation controls, condition of picks and pick sleeves.	CM Operator, Faceboss, Artisan, Shiftboss & Engineering Foreman)
Level 3 Shift average dust reading above 5mg/m^3 **– trip settings activated**		CM will not operate, check all dust critical controls i.e., CM scrubber, water sprays, ventilation controls, condition of picks and pick sleeves.	CM Operator, Faceboss, Artisan, Shiftboss, Engineering Foreman, General Engineering Supervisor, Mine Overseer and VOHE Officer

"All real time data measurements must be transmitted to surface where the daily analysis report will be generated, flagging incidents of high dust."

Table 3: Continuous miner dust critical controls

Critical control		Checks to be conducted
Picks and sleeves	 	Check the condition of the cutter picks and sleeves, replace any blunt, broken picks and damaged or missing sleeves.
Water sprays		Check the condition and replace any blocked or missing water sprays
Scrubber screens		Clean all loose coal on scrubber fan intake. Scrubber water sprays must always be working. Clean or replace scrubber filter.
Ventilation controls		Ensure that the condition of the applicable ventilation controls (scoop brattice, jet fan, force ducting etc.) is to the mine standard and effective.

Data management and reporting

All measurement data must be automatically logged on the data logger, which communicates through the network architecture system on surface to enable data-logging and subsequently generate reports. The system should allow for dust to be sampled in one second intervals and averaged over one minute. The system must be capable of logging data of up to fourteen twelve hour shifts log in one minute average intervals. In the event of a power failure, the one minute average data should be retained so that average calculations will resume when power returns.

All real time data measurements must be transmitted to surface where the daily analysis report will be generated, flagging incidents of high dust. The measurement data analysis report must be generated at the end of every shift and forwarded, via email, to the VOHE department. The VOHE department must then facilitate the communication of this report to all relevant persons and initiate investigation(s) of high dust incidents where necessary. Opportunity to access this report on other personal computers of those affected exist and can be done with outmost ease. Implementing this will enable efficient use of the real time dust data.

High coal dust incident investigation

The real time dust monitor continuously measures the dust levels on a coal winning heading to measure the performance of all the dust controls on a CM. The DMRE B7 directive states that the dust level must be kept below the respirable coal dust level of 5mg/m^3 and reported to the DMRE monthly. The gravimetric pump dust sampling method presented challenges in that dust results are only available after two to three days, to accommodate the process of collection, transportation and analysis of dust filters. Conducting investigations for high dust defeated the objective of dust sampling due to the reactive nature of this process.

The real time dust monitor allows the different stakeholders (i.e. CM Operator, cable handler, Faceboss, Shiftboss, VOHE, and engineering personnel) to view dust results in real time so interventions can be taken immediately in case of high dust. The source mine developed a standard operating procedure on “Intensive care protocol for dust in mechanical sections”. The procedure outlines the responsibilities and actions to be taken by the relevant persons i.e. the process to be followed.

“The gravimetric dust pump sampling method presented challenges in that dust results are only available after two to three days, to accommodate the process of collection, transportation and analysis of dust filters.”

Installation

The real time dust monitor should be mounted on the rear right-hand side of the CM, which is the same position of the gravimetric dust pump (ikati). This position is informed by the DMRE B7 directive. The unit used at the source mine is manufactured and supplied by an independent client, components of their systems are sourced from various third-party OEMs and suppliers (i.e. sensors, display, etc). Since the real time dust monitor can be installed on CMs by various OEMs. A bilateral agreement needs to be in place between the dust monitor supplier and the CM OEM to fit the units on the CM equipment, but also to integrate the dust data management into the CM data logging and reporting system (e.g. JOY).

However, to maintain the dust monitor for day-to-day operation, it is recommended that basic maintenance on the unit be conducted during the maintenance where the housing, fan, and analyser lens can be cleaned.

Figure 7: Position of a real time dust monitor on a CM. Source: Sasol Shondoni Colliery

Dust critical control verification and over-inspection

The real time dust monitoring on CM leading practice assists in ensuring that the performance of dust critical controls for CM cutting operations are continuously monitored, and that any control failure can be attended to as soon as possible. Operations must develop a critical control verification checklist, example supplied in Figure 10, to be completed by the Faceboss at the beginning of each shift as a means for verifying the availability and status of defined dust critical controls. Over-inspection of the critical control verification checklist must be conducted by the Shiftboss during their daily routine inspections.

CCV – Exposure to airborne dust (January 2021)				
Operation:			**Date:**	
Section:			**Shift:**	
Inspector:			**Team:**	
Verification checks	**Yes**	**No**	**N/A**	**Comments**
Mechanical miner dust suppression system				
Are the scrubber screens clean?				
Is there water pressure at least 15-20 bar?				
Is the water flow rate in the pump between 90 and 135 litres per minute?				
Are the spray nozzles free from blockages (not more than 6 sprayers blocked)				
Is the Venturi spray system installed on the mechanical miner?				
Chemical treatment of travelling ways				
Is there physical evidence that chemical treatment was applied to the travelling way? (No powdery road surface or loose duff)				
Is the dust concentration measured by the real-time dust monitors in the travelling road less o.5mg/m^3?			X	Not yet installed
Comments				

Figure 8: Dust Critical Control Verification (CCV) checklist to be completed by Faceboss and over-inspected by the Shiftboss. Source: Sasol Shondoni Colliery

Behavioural communication

The mine is to establish platforms to communicate important messages or to further educate employees on a healthy and safe working environment. It is during these platforms where all employees are mobilised to join the fight against silicosis and coal workers pneumoconiosis and other occupational lung diseases. This can only be achieved if employees understand the dangers of coal dust and that it can potentially cause coal workers pneumoconiosis, and therefore current controls and initiatives to prevent silicosis are explained.

Leadership behaviour

The commitment of the mine's senior management, including the organised labour and other relevant stakeholders, is key to the success and sustainability of adoption of this leading practice and the elimination of occupational lung diseases. The ideal leadership should include the following:

- Measurement, assessment, and corrective actions where necessary.
- Development and continuous improvement of critical controls of airborne pollutants at the source and elsewhere.
- Training and education of employees.
- Initiate awareness campaigns.
- Establish communication platforms.
- Enforcement of dust control. procedures.
- To live their commitment to the eradication of Occupational Lung Diseases (OLD).

Training

The following departments will be impacted by adoption of the real time dust monitor on CM:

- Engineering department – the team will assume full responsibility of the maintenance and operation of the system in the case of the OEM handing it over.
- VOHE department – assessing the integrity of the dust monitor by comparing acquired results against the average shift CM gravimetric dust results from the lab, analysing the data from the dust monitor to establish the dust critical control effectiveness, performance, and availability, compiling, and communicating shift dust results to all relevant parties for action and investigation where necessary.
- Mining production personnel (i.e. CM Operator, Faceboss, Shiftboss, Mine Overseer and Mining Manager) – conducting pre-use inspections (critical control verification checklist), undertaking corrective actions when the various dust levels are encountered and conducting investigations for high dust exceedances.

It is pivotal that mines identify key personnel to be trained at their Operations. The training of CM operators on real time dust monitoring must form part of their formal training programme to ensure that aspects of continuous learning and evaluation are addressed and that all licensed CM Operators have covered the relevant training. Five key areas from the Knowledge transfer framework were identified as relevant in providing guidance for mining operations on the key considerations for a successful training analysis. Table 4 gives guidance on the elements to be considered.

KNOWLEDGE TRANSFER FRAMEWORK

Table 4: Key areas to be considered for a successful training analysis.

Knowledge and skills	
Elements	• Experience • Qualification • Capability and competence
Legal and regulatory	
Elements	• Legal liability
Work practices and processes	
Elements	• Planned, unplanned and ad-hoc work • Maintenance and installation practices • Ways of working, working culture
Upskilling, training and development	
Elements	• Training plans and matrices • Accreditations • Cross/Multi-skilling
Operations	
Elements	• Installation outcomes • Base equipment repair • Spares and replacements • Equipment testing • Calibration

PART 3
ADOPTION GUIDANCE

The MOSH dust team will assist any mine or operation that is adopting the leading practice and ensure the correct use and understanding of the Leading Practice Adoption Guide (LPAG).

ADOPTION STEPS

The following adoption steps need to be followed to ensure successful adoption of the real-time dust monitoring on CM leading practice.

Main step	Sub tasks required to enable successful completion of each step
Step 1 **Secure support for adoption**	• **Task 1** – Facilitate/ or confirm mine leading practice related risks and controls / verify whether the leading practice is applicable to the mine. (persuade/ tool for mine of value case "site specific context") • **Task 2** – Senior mine management/ Manco session and orientation presentation • **Task 3** – Engage organised labour (adopting mine GM or ATM/ adoption champion) • **Task 4** – Issue mine wide communication • **Task 5** – COPA sign up and attendance of COPA (full leading practice) and other interest groups (simple leading practice) • **Task 6** – Conduct adoption readiness review
Step 2 **Establish mine adoption team**	• **Task 1** – Identify functional groups involved in the adoption process • **Task 2** – Attend MOSH "Competence/ capability/ awareness program"
Step 3 **Confirm mine Socio-Technical System (STS) elements to be addressed**	• **Task 1** – Review the Leading Practice Adoption Guide (LPAG) and generic adoption plan of source/demo mine to familiarise the operation with potential STS aspects • **Task 2** – Confirm mine processes and documentation defining the operation's STS aspects (as listed in the Mine Adoption Readiness review)
Step 4 **Establish mine adoption plan**	• **Task 1** – Decide on pilot site/area • **Task 2** – Update adoption plan • **Task 3** – Develop leading practice monitoring plan
Step 5 **Review, update and monitor operational processes and documentation**	• **Task 1** – Develop and/or update existing COPs and procedures • **Task 2** – Develop and/or update training material • **Task 3** – Introduce monitoring mechanisms • **Task 4** – Develop change communication plan and material/update existing material, to communicate the impact and operational changes effectively
Step 6 **Execute leading practice adoption and implementation in pilot site/area**	• **Task 1** – Pilot site/area Leading Practice adoption • **Task 2** – Monitoring of Leading Practice execution based on developed monitoring metrics (step 5 – task 3)
Step 7 **Roll out the leading practice to the rest of the organisation/ mine**	• **Task 1** – Facilitate effective roll-out and duplication of adoption process as undertaken/developed during pilot process • **Task 2** – Provide ongoing feedback and reports on adoption to mosh learning hub

Figure 9: Adoption steps to be followed to ensure successful adoption of the real-time dust monitoring on CM leading practice.

PART 4
SUPPORTING DOCUMENTS

- RISK REVIEW AND ADOPTION
- APPOINTMENT OF MINE ADOPTION CHAMPION
- APPOINTMENT OF MINE ADOPTION TEAM
- MINE WIDE ADOPTION BRIEF