Development and quantification of a dust reduction program in longwall mining at metropolitan colliery — a case study

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ABSTRACT

Harmful respirable dust produced during longwall mining is a major concern for production, safety and the health of workers in the underground coal mining sector both in Australia and globally, Longwall personnel are exposed to harmful dust from multiple dust generation sources including, but not limited to intake entry, belt entry, stageloader/cnisher, shearer, shield advance and dust ingress from falling goal or over pressurisation of the goal th the increase in production created from the advancement in longwall equipment, dust loads have significantly increased and this has resulted in a potentially greater exposure level to personnel. Metropolitan Colliery, located at Helensburgli in NSW, Australia, in conjunction with the University of Wollongong, P11/1[1]6 Laboratories and EnviroCon, has implemented a dust reduction program Utilising a recently developed Dust Mitigation Efficiency Model to quantify dust loads produced during the cutting *cycle.* With the quantification of.this benchmark dust load production along with the quantification of installed control efficiencies at independent sources of dust generation, Metropolitan CollierY, with the installation of the latest shearer scrubber technology has successfully reduced the respirable dust levels in excess of 70% of benchmark levels on their operating Iongwali This reduction will have a significant and immediate positive effebt on employees, production and operating costs which will be maintained throughout the life of the mine:

1:` Introduction

Metropolitan Colliery is an underground mine located 30 km north of Wollongong near the township of Helensburgh, winch produces coking coal for export and domestic markets. Metropolitan is owned and operated by a subsidiary of Peabody and has a workforce of approximately 320 and extracts up to 2 million tonnes (t) per annum (Mtpa) of hard and semi hard coking coal product and operates seven days per week, 24 hours per day. The majority of product coal (approximately 90%) is transported by train to the Port Kembla Terminal for shipping to domestic and overseas customers. Overseas customers include Japan, India, South America and Europe. A minor portion of the product coal is transported by truck to the Corrimal and Coalcliff Coke works for domestic use. Longwall mining of the Bull Seam commenced in 1995 with Longwall 22 currently mined, with underground mining operations supported by surface facilities which include administration buildings, workshops, bath houses, ablution facilities, haul roads, access roads, fuel and consumables storages, hardstand areas, a Coal Handling and Preparation Plant (CHPP), stockpiles (including Run of Mine [ROM] coal, product coal and coal reject stockpiles), underground coal emplacement plant, and associated coal handling infrastructure including conveyors, transfer points and buffer bins [1].

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At Metropolitan Colliery, evaluation of a workplace is primarily undertaken to establish if the workplace environment is safe for employees to perform their normal duties. Occupational hygiene has been an integral part of mining operators for centuries; however its importance has grown with developments in mechanisation and rising community expectations for better occupational health and safety of employees [6].

Production from longwall mining in Australia has increased remarkably over recent years. This increased productivity has meant that more dust is being produced and controlling respirable dust continues to present the greatest ongoing challenge for coal mine operators. A report by the director of mine safety operations branch of Industry and investment NSW has found that there is an increasing level of dust being ingested by coal miners in New South Wales, potentially leading to long-term health problems [2]. This increased exposure level for underground workers can be directly attributed to the increase in coal production and the continued development of medium and thick seam mines in Australia which allow the installation of bigger and more productive longwall equipment [3].

Studies by the National Institute of Occupational Health and Safety (NIOSH) in the USA have shown that prolonged exposure to excessive levels of airborne respirable coal dust can lead to Coal Workers' Pneumoconiosis (CWP), Progressive Massive Fibrosis (PMF), and Chronic Obstructive Pulmonary Disease (COPD). These diseases are irreversible and can be debilitating, progressive, and potentially fatal [4]. The continued occurrence of CWP in underground coal mine workers and the magnitude of respirable dust overexposures in Iongwall mining occupations illustrates the need for mining operators to improve existing dust control technology on longwalls, not only in the USA, brit also in Australia, to prevent the incidence of lung diseases from occurring [5].

As a direct result and understanding of this potentially fatal disease, Metropolitan Colliery, in a joint venture project with the University of Wollongong, PM10 Laboratories and EnviroCon, have undertaken comprehensive dust testing that has quantified benchniark dust loads produced from outbye belts and last open cut-through, ESL discharge, crusher, shearer and shields and analysed this to data collected at the same points of dust generation with installed controls operating.

The Dust Mitigation Efficiency (DME) Model identifies respirable (PM2.5) and inhalable (PM10) dust loads produced at independent sources of dust generation, represented in mg/tOnne of coal cut, on an operating longwall, for both benchmark dust production and installed control efficiency. The utilisation of this robust and peer reviewed testing procedure at Metropolitan Colliery has allowed, for the first time, the quantifiable analysis of installed engineering controls against collected benchmark .data. The comparative analysis of the data preVides a dust mitigation efficiency, represented as a percentage change, from the dust loads with no controls operating, to the dust loads with installed controls operating. For the purpose of this paper, only the respirable fraction has been analysed and discussed.

2. Dust Mitigation Efficiency (DME) model

The DME Model was developed with comprehensive consultation with the University of Wollongong, Coal Services, the Department of Investment and Industry and the CFMEU, to determine installed control efficiency and dust load production for both respirable and inhalable dust in 2010. The DME Model retains gravimetric collection for dust load sampling to ensure uniformity of the collection process, validity of the collected data and quantification of the analysed results. Also, the DME Model has been designed to ensure the collected data is deemed quantifiable to satisfy the requirements of scientific validity and for reference in potential future projects. The objective of the DME Model is to identify dust loads at independent sources of dust generation on longwall faces and quantify the efficiency of installed controls for the mitigation of dust generation. This data will then be used to create a benchmark or signature for the longwall mine in relation to dust loads from different sources of generation. Once this signature is established, quantifiable testing can be undertaken on new or improved controls to ensure maximum efficiency in removing respirable and inhalable dusts.

The DME Model data collection process locates monitors on each of the independent sources of dust generation. In each location, separate monitors and heads are placed to sample both respirable and inhalable dust loads. Fig. 1 below details monitor and head placement along Metropolitan Collieries longwall face. The amount of dust produced at each individual source of dust generation was measured. This required the mine to turn off the controls at these individual locations during a sampling period of 1 to 2 shears, to allow produced dust to be measured accurately.

This was not an issue for the controls on outbye conveyors, travel roads, ESL discharge, crusher and shield sprays; however, drum sprays had to remain operating as these are used more for frictional ignition : suppression than dust mitigation. Additional sprays, such as chock sprays were turned off for the period of the testing.

Controls were turned back on and sampling heads changed to remeasure dust loads with controls operating. The collected samples were taken to the University lab and re-weighed. These final filter weights were analysed in comparison to the initial filter weights and the resulting difference applied to the DME formula. The final percentage change quantified the efficiency of the installed controls on the Metropolitan longwall.

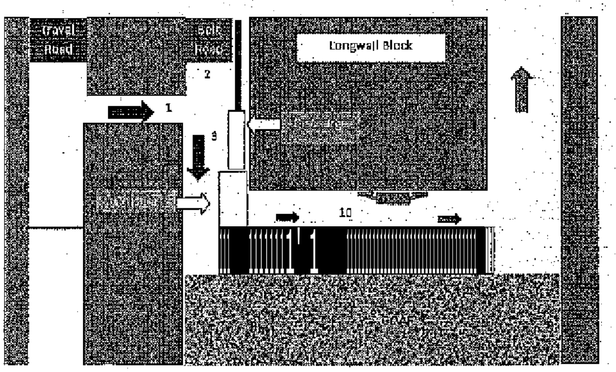

Fig. 1. Location of monitors and heads for data collection [7].

3. DME testing performed

A total of 120 gravinmetrie samples wee taken during 5 separate DME tests over a 3 year period commencing in 2010. Of these samples, 60 were in the PM2.5, or respirable dust fraction size. The sampling was conducted as a benchmark establishment process, as detailed above, which was then compared to an operational performance of installed engineering controls under normal operating parameters. These results were analysed and reported.

The first of these tests was the measurement of the benclunark dust production collected and analysed to determine the DME of the current installed controls, The standard installed engineering controls at Metropolitan Colliery are detailed in Table 1.

The second test was a repeat of the first set of data collected to prove the robustness of the methodology.

The third and fourth set of tests incorporated the introduction of venturi sprays situated at the maingate corner spraying into the BSL crusher and venturi sprays placed in chock #5 facing at approximately 45° toward the tailgate aiming at the face.

Tablel
Metropolitan Colliery installed engineering controls [7].

BSL discharge	
Number of sprays in BSL discharge	3
Type: Solid, Hollow cone, Flat, V	Hollow Cone
Spray Diameter	6mm
Water Pressure	I5Bar
Water Flow	NA
BSL Sprays	
Number of sprays	12
Type: Solid, Hollow cone, Flat, V	Hollow Cone
Spray Diameter	6mm
Water Pressure	15Bar
Water Flow	NA
BSL crusher	
Number of sprays	12
Type: Solid, Hollow cone, Flat, V	Hollow Cone
Spray Diameter	6mm
Water Pressure	15Bar
Water Flow	NA
Shearer	
Number of sprays	64
Type: Solid, Hollow cone, Flat, V	Solid Cone
Spray Diameter	1.2mm
Water Pressure	65Bar
Water Flow	475lpm
Types of Picks	Radial
Shearer Clearer	None
Chock Sprays	
Number of sprays	2 per chock
Type: Solid, Hollow cone, Flat, V	Hollow Cone
Spray Diameter	1.2mm
Water Pressure	60Bar
Water Flow	1001om
Other Dust Controls Used?	BSL Scrubber
Shearer drum speed	30rpm
Shearer Speed	5-8m/minute
Av. Shears per Shift	4
Av. Tonnes per Shear	650
Scrubber	Yes. On BSL Discharge

Fig. 2 shows the location of the venturi spray at the maingate corner facing toward the crusher and Fig. 3 shows the set of venturi sprays located at chock #5 for the testing.

The fifth test collected data relating to the DME of a surfactant injected into the longwall spray system.

The final set of collected date relates to the DUE of the installed shearer scrubber, with an additional 40 respirable samples collected. This data was collected at 1500, 2000, 2500 and 3000 RPM for both day and afternoon shifts over the period of a week.

Figs. 4 and 5 show photos of the installed EnviroCon shearer scrubber prior to testing commencement.

Table 2 details the average mg/tonne of respirable dust produced during the cutting cycle with no engineering controls operating at each of the known sources of dust generation on the longwall face. The average mg/tonne at each independent source of duct generation, and the longwall average dust load, was calculated by adding together each of the collected samples and dividing the number by the amount of samples collected.

Table 3 details the average mg/to tune of respirable dust produced during the cutting cycle with no engineering controls operating at each of the known sources of dust generation on the longwall face. The average mg/tonne at each independent source of duct generation, and the longwall average dust load, was calculated by adding together each of the collected samples and dividing the number by the amount of samples collected.

Table 4 provides an analysis of the efficiency of the installed controls on the Metropolitan Colliery longwall during the cutting cycle. The last open cut through shows an increase in the respirable particle fraction as does the belt road and the BSL discharge. This would indicate that outbye activities during the cutting cycle are having a significant effect on the inbye dust loads.

The maingate shows a 30% decrease in respirable dust with corresponding decreases evident rnidface and at the tailgate. The average respirable dust mitigation was measured at 5%, with the two standard control configurations and the surfactant having the most success in mitigating the respirable dust

For the shearer scrubber testing, a new benchmark was established which represented the respirable dust loads in mg/torme produced at chocks #5, 25, 50, 75 and 90. These locations were deemed as representative of the dust produced primarily by the shearer and the chock movements during the cutting cycle.

Testing has shown that the shearer scrubber mitigates significantly more respirable dust from the Metropolitan operating longwall than any other control configuration measured. Table 5 shows that the shearer scrubber effectively removes between 34 and 36% of the respirable dust at 1500rpm, between 39 and 41% at 2000rpm, between 54 and 55% at 2500rpm and between 68 and 71% at 3000rpm. This is significantly greater than the average of only 5% respirable dust mitigation with all other measured installed control configurations.

4. Conclusions

The DME model has successfully identified that the shearer scrubber is the most efficient installed engineering control operating for respirable dust production at individual sources of generation on Metropolitan Collieries longwall. By continued use of the shearer scrubber as the principal engineering control, Metropolitan Colliery is in a significantly better position to ensure compliance with regulatory standards for exposure levels and most importantly, they are ensuring minimum risk to worker health by reducing the most respirable dust possible from the mining environment.

The DME model has proven to be reliable, robust, flexible and sensitive. Reliability has been proven by the benchmark results over a multitude of samples being very similar, the robustness is shown by the continued gathering of reliable and useful data, the flexibility is demonstrated by its ability to adapt to a required or designed testing methodology and its sensitivity is seen by the results identifying significant differences between a number of controls selected to mitigate harmful respirable dust from the mining environment at Metropolitan Colliery.

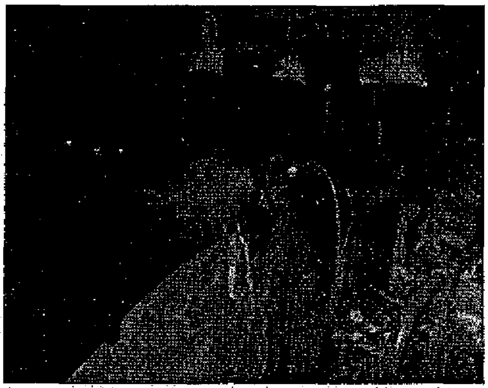

Fig. 2. Venturi spray at the Maingate [7].

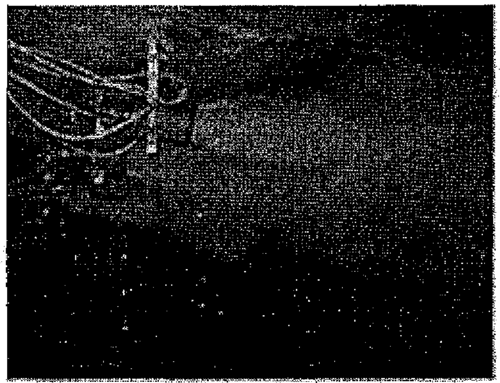

Fig. 3. Venturi spray on chock #5 [7].

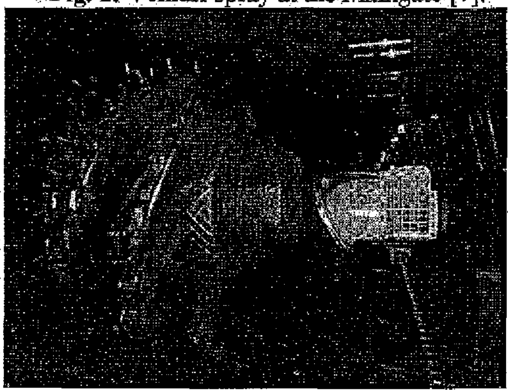

Fig. 4. Installed shearer scrubber.

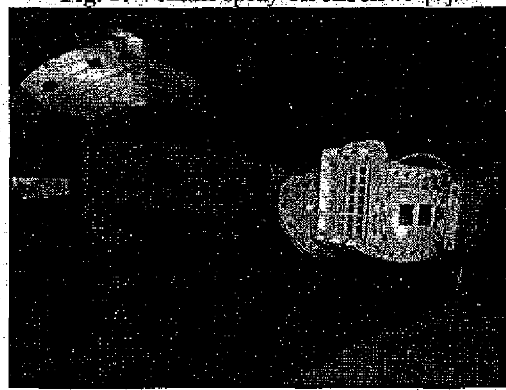

Fig. 5. Installed shearer scrubber.

Table 2
Respirable dust benchmark production test results.

[redacted]		Respirable Dust Benchmark				[redacted]	
		Testin t Anal sis					
[redacted]	LOC	Belt. Road	Discharge	Maingate	Midface	Tailgate	Average m tonne
[redacted]	0.0001	0.0002	0.0002	0.0006	0,0009	0.0012	0.0005
Test 2	0.0002.	0.0001	0.0002	0.0006	0.0009	.0.0012	0.0005
[redacted]	0.0002	0.0001	0,0002	0.0007	0.0009	0.0016	0.0006
Test 4	0.0002	0.0001	0,0002	0.0007	0.0009	0.0016.	0.0006
Test 5	0.0001	0,0000	0.0001	0.0004	0.0010	0.0016	0.0006
Average m tonne	0.0003	0.0002	0.0003	0.0006	0.0011	0.0018	0.0007

Table 3
Respirable dust control efficiency.

		Respirable DME Analysis					
	LOC	Belt Road	11SL Discharge	Maingate	Midface	Tailgate	Average mg/tonne
Test 1-Standard	0,0001	0.0001	0.0001	0,0001	0,0006	0.0013	0.0004
Test 2-Standard	0.0002	0.0002	0.0002	0,0002	0.0006	0.0013	0.0005
Test 3-Venturi	0.0002	0.0002	0.0002	0.0007	0.0012	0.0017	0.0007
Test 4-Venturi	0.0002	0.0002	0.0002	0.0007	0.0013	0.0014	0.0007
Test 5-Surfactant	0.0001	0.0001	0.0001	0.0003	0,0008	0.0013	0.0005
Average mg/tonne	0.0003	0.0002	0.0003	0.0004	0.0011	0.0018	0.0007

Table 4
Metropolitan control efficiency analysis.

	Metropolitm Colliery Average Benchmark and Efficiency Analysis						
	LOC	Belt Road	BSL Discharge	Maingate	Midface	Tailgate	Average
Average Benchmark Respirable mg/tonne	0.0003	0,0002	0.0003	0.0006	0.0011	0.0018	0.0007
Average Efficiency Respirable mg/tonne	0.0003	0.0002	0.0003	0.0004	0.0011	0.0018	0.0007
	8%	5%	1%	-29%	-1%	-3%	-5%

Table 5
Shearer scrubber efficiency analysis.

Metropolitan Colliery Average Benchmark and Efficiency Analysis with Shearer Scrubber Installed							
	Chock 5	Chock 25	Chock 50	Chock 75	Chock 90	Average	Efficiency
Respirable Benchmark for all tests	0.0004	0.0006	0.0011	0.0017	0.0016	0.0011	
1500rprn D/S	0,0002	0.0004	0.0008	0.0011	0.0010	0.0007	-34%
1500rpm A/S	0.0003	0.0004	0.0007	0.0011	0.0011	0.0007	-36%
2000xpin D/S	0.0002	0.0004	0.0007	0.0011	**0.0010**	0.0007	-39%
2000rpm A/S	0.0002	0.0004	0.0007	0.0010	0,0010	0.0006	-41%
2500rprn D/S	0.0002	0.0003	0.0005	0.0008	0.0001	0.0005	-54%
2500rpniA/S	0.0002	0,0003	0.0006	0.0008	0.0007	0.0005	-55%
3000rpm D/S	0.0001	0.0002	0.0003	0.0006	0.0005	0.0004	-68%
3000rpm A/S	0.0001	0.0002	0,0003	0.0005	0.0005	0.0003	-71%

More importantly, the DME model has quantified the dust reduction program implemented at Metropolitan Colliery. Initial results clearly indicate that traditional forms of installed engineering controls, eg, sprays, have little effect on mitigating the respirable dust. Additional engineering controls that have been touted as exceptional dust control products have proven to be mediocre at best. The shearer scrubber has been shown to consistently mitigate significant amounts of respirable dust. The continued use of the shearer scrubber will ensure significantly improved working conditions for longwall workers at Metropolitan Colliery now and into the future.

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