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A scientific approach to quantifying the efficiency and efficacy of dust curtains on a Sandvik mb650 continuous miner at kestrel colliery whilst mining a full face of roof stone during an overcast construction

Brian Plush

Bradley Watson

Clinton Daly

Timothy Gooch

Charlie Spence

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A SCIENTIFIC APPROACH TO QUANTIFYING THE EFFICIENCY AND EFFICACY OF DUST CURTAINS ON A SANDVIK MB650 CONTINUOUS MINER AT KESTREL COLLIERY WHILST MINING A FULL FACE OF ROOF STONE DURING AN OVERCAST CONSTRUCTION

Brian Plush[1], Bradley Watson, Clinton Day, Timothy Gooch, Charlie Spence

ABSTRACT: With the correct identification and continued increase in CWP and related occupational lung disease in the Australian coal mining industry since May 2015, the industry's focus has been directed at mining operations achieving statutory respirable dust level compliance to AS2985. The majority of dust control techniques currently installed and operational in Australian coal mines have been developed in the USA, UK and other western countries and their application is more suited to low to medium coal seam heights up to 3m. The Australian mining experience has indicated that the efficiency of some of the existing respirable dust control methods reduce significantly in thick coal seams, under high production environments and when mining roof stone. As the current trend in the industry is to substantially increase production levels, there is an urgent need for detailed investigation of various dust control options and development of appropriate dust management strategies based on quantifying the efficiency and efficacy of installed controls to mitigate respirable dust from the working environment. This paper details the approach taken to quantify the efficiency and efficacy of installed face curtains for respirable dust mitigation on a Sandvik MB650 continuous miner whilst mining a full face of roof stone cutting an overcast in the mains at Kestrel Colliery. Results of the project have shown that the installed face curtains are not suitable as a dust mitigation control.

INTRODUCTION

Coal Workers Pneumoconiosis (CWP) or Black Lung, is an insidious disease that is totally preventable. Questions relating to the validity and subsequent suitability of the current respirable dust sampling methodologies utilised in Australia have come under significant scrutiny, as they have failed to mitigate the exposure risk to Coal Mine Workers (CMW's) to as low as reasonably achievable, evidenced by the confirmed 87 cases of Coal Workers Pneumoconiosis (CWP or black lung) and other Mine Dust Lung Diseases (MDLD) since 1984 (DNRM website accessed 22/11/2018)

It is well understood that the measurement of respirable dust at the source of generation is a difficult task and that the current process for measuring exposure levels for respirable dust has significant limitations (Plush, *et al* 2012). Recognised Standard 14 acknowledges that assessing and managing the risk of respirable dust exposure is complex and may require the use of specific risk assessment techniques (Recognised Standard 14). Further, section 3 (2) notes that in order to ensure the risk of black lung, or other disease created from exposure to

[1] *Corresponding Author:* brian.plush@bigpond.com

respirable dust is at an acceptable level, the sampling regime must be appropriate, statistically robust and professional judgement undertaken by a competent person at data interpretation (Recognised Standard 14).

The limitation to Recognised Standard 14 and AS2985 – 2004, *Workplace atmospheres—Method for sampling and gravimetric determination of respirable dust*, lays in the fact that the existing statutory testing regime only monitors the exposure level of the worker to the hazard. If an exceedance occurs, the monitoring process does not indicate why the exposure occurred, where the source of the exposure originated from, nor if the currently installed engineering controls are working effectively (Plush et.al; 2012). This has created an industry strategy of removing the person from the hazard through task rotation or operator positioning, which is an administrative control under the Hierarchy of Controls for risk management. According to Recognised Standard 15, sections 5.2 and 7.8, an administrative control such as task rotation and operator positioning requires monitoring and review, does not control dust generation and requires compliance to s.89 of the Regulation.

Dust measurement not dust monitoring is required to eliminate dust at the source of generation. Simply monitoring how much dust is in the air, as previously noted, has limited value. Removing the person from the hazard does nothing to remove the hazard from the air, and only provides a temporary administrative control, the second lowest point on the Hierarchy of Controls. Benchmarks are required to understand how much dust is produced at independent sources of dust generation, then measured again with installed controls operating to determine the efficiency of the installed control at mitigating the risk. Elimination is the highest point of the Hierarchy of Controls and is achievable if the efficiency and efficacy of installed controls is measured and quantified. Exposure level testing will never provide a basis for dust elimination.

Section 5.3.2.2 of Recognised Standard 15 relates to the requirement that, when equipment is selected for purchase, where maintenance is undertaken on equipment and during equipment overhauls, "….all equipment purchases shall be considered in terms of the hierarchy of controls.." and that "…equipment purchase and specification requires input from persons with the relevant expertise in the area of engineering control of dust generation…" (Recognised Standard 15).

Further, Appendix B of Recognised Standard 15 sets a requirement that "Equipment specifications shall include requirements for commissioning plans that confirm the supplied equipment meets the specification requirements for dust control, and *include a plan to establish baseline effectiveness of the dust control equipment*….."

In relation to the Sandvik MB650 used for mains and gateroad development at Kestrel Colliery, the above requirements from the equipment supplier have not been provided. Kestrel identified that not much progress over the last year had been achieved in reducing the risk profile for respirable dust throughout the underground and surface operations of the mine. Kestrel has a Dust Committee and individuals assigned to different areas but without a baseline the pit does not know where to focus or which controls are the most effective and those which should be focused on to lower the risk to as low as reasonably achievable.

TESTING METHODOLOGY TO QUANTIFY THE EFFICIENCY AND EFFICACY OF MB650 FRONT CURTAINS

Planned engineering control efficiency testing was undertaken in the Mains area of Kestrel Colliery where recent personal sampling results have recorded exceedances in silica dust during cutting high drivage excavations involving grading into and out of the roof stone. The area tested was "A" heading 59-60ct as shown in the flight plan in Figure 1.

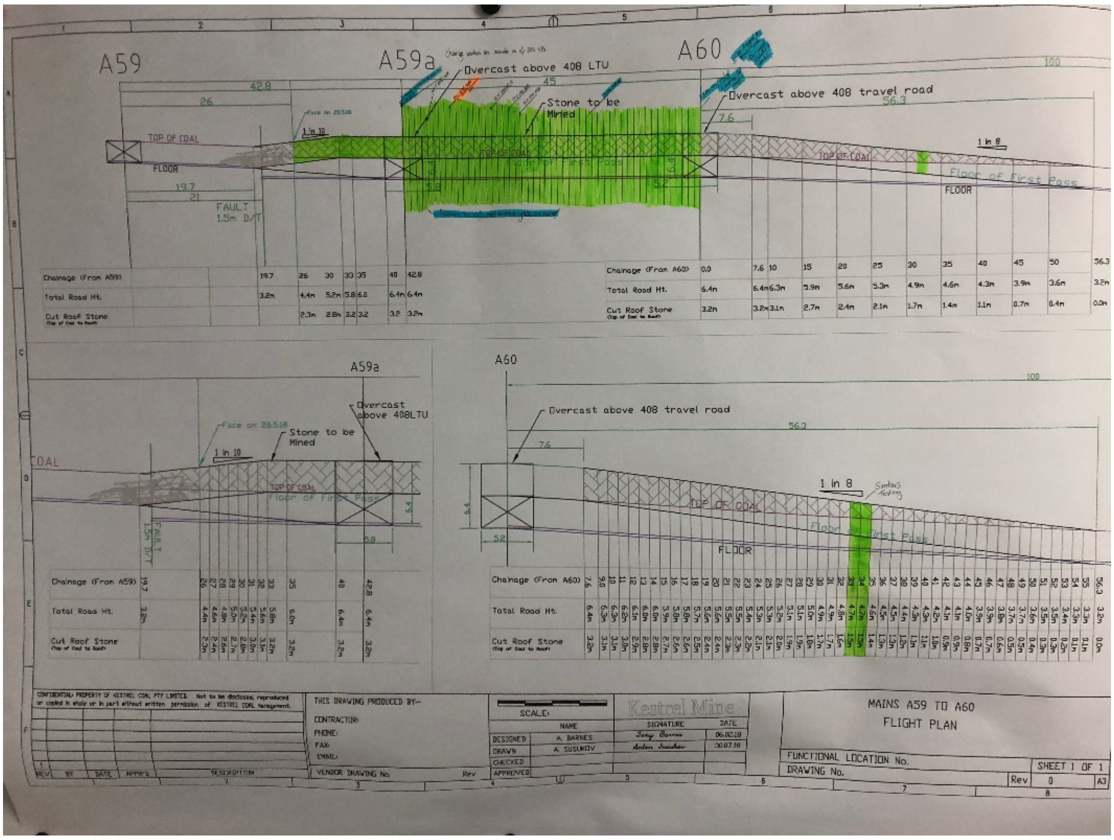

Figure 1: Flight plan of mains testing position

Data collection involved cutting 1m of advancement for the baseline establishment, ie, with no controls operable excluding pick sprays for frictional ignition compliance, and another meter with each of the installed engineering controls operable and working as designed. The 1m cut was undertaken as 2 x 500 mm cuts due to the amount of stone in the face. Testing was continued until the completion of the second cut which took the overall advancement to 1m. At the completion of the first 1m cut, the pumps and heads were turned off and removed to allow the operators back on the miner to install necessary roof controls. During this process, all water was turned back on and any float dust hosed down. After roof controls were installed, the pumps and new set of heads were reinstalled at the same locations, the water to the miner was turned on and the second set of testing commenced. This process was repeated every meter until the completion of the tests.

Table 1 below summarises how each of the tests was performed. The collected data quantified the efficiencies of the installed engineering controls at respirable dust mitigation based on the establishment of a baseline dust production at each of the sources sampled.

Table 1: Sampling summary

	Pick Sprays	Face Curtain	Side Curtains	Sprays
Test 1	On	Retracted	Retracted	Off
Test 2	On	Operable	Retracted	Off
Test 3	On	Operable	Operable	Off
Test 4	On	Operable	Operable	On

QUANTIFYING ENGINEERING CONTROL EFFICIENCIES

The current testing regime in Australia, AS2985, provides the mine tested with a single figure for respirable dust exposure levels during a production shift. This figure only provides information relating to the exposure levels of the person sampled, relative to the 300 mm breathing zone described in AS2985 and does not provide any feedback on the effectiveness of installed engineering controls or any other information that would allow the mine site to implement improvements in mitigation procedures should a non-compliance, or failure to Statutory regulations occur.

The testing methodology for this efficiency testing project utilises dust loads as opposed to exposure levels. The objective of this sampling methodology is to identify dust loads at independent sources of dust generation on the continuous miner and quantify the efficiency of installed controls for the mitigation of produced dust. This data will be used to create a benchmark or signature in relation to dust loads from different sources of generation on the continuous miner. Once this signature is established, quantifiable testing can be undertaken on installed controls to ensure maximum efficiency in removing respirable dust is achieved.

The samples are collected as per AS2985 Gravimetric sampling process; however, the collected data is analysed as a raw weight taken for the benchmark with no controls operating and as a raw weight taken with controls operating. The difference between the two raw weights is the efficiency of the installed control at mitigating respirable dust.

An important aspect for the scientific robustness and repeatability of this sampling process is that the raw weights are analysed compared to tonnes cut as opposed to sampling time as a Time Weighted Average, (TWA), ensuring that the efficiency sampling of installed controls can be confidently repeated.

Figure 2 below shows the face curtains and throat curtains in normal operating conditions. The throat curtains are down, and the face curtains are down.

Figure 2: Face and throat curtains

DETERMINE SAMPLER LOCATION

In each location, as discussed above, a pump and respirable head was used to sample dust loads produced during the cutting cycle to establish a baseline dust production and the efficiency of the installed engineering controls.

Pumps and respirable heads were placed on all continuous miners tested as detailed in Figure 3. These positions are:

- Pump 1 was placed on the left-hand inside side bolter controls to measure dust that is bypassing the front curtains and rolling back over the miner.
- Pump 2 was placed on the left-hand side outside bolter to measure dust that is bypassing the front curtains and rolling back over the miner.
- Pump 3 was placed on the left-hand side of the bolting cassette to measure the amount of dust generated through the throat and out onto the miner platform.
- Pump 4 was placed on the left-hand side rear hand rail to measure what dust is being brought back in with the ventilation from loading the shuttle car.
- Pump 5 was placed on the right-hand inside side bolter controls to measure dust that is bypassing the front curtains and rolling back over the miner.
- Pump 6 was placed on the right-hand side outside bolter to measure dust that is bypassing the front curtains and rolling back over the miner.
- Pump 7 was placed on the right-hand side bolting cassette to measure the amount of dust generated through the throat and out onto the miner platform.
- Pump 8 was placed on the right-hand side rear hand rail to measure what dust is being brought back in with the ventilation from loading the shuttle car.

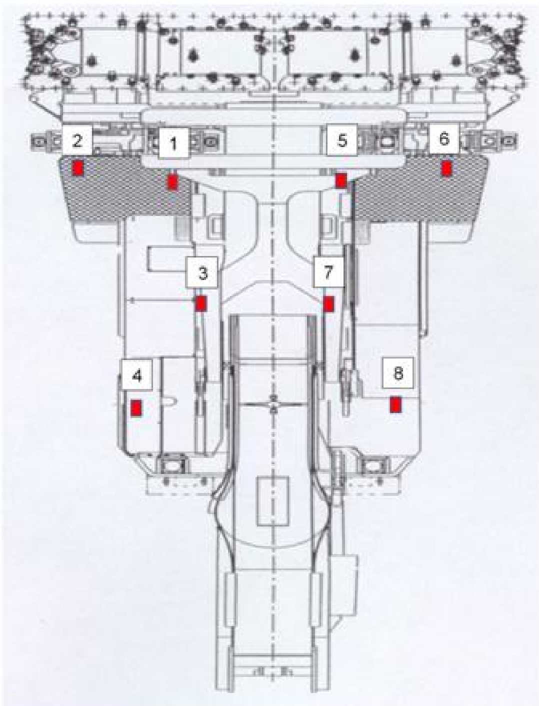

Figure 3: Pump and head placement on MB650

EFFICIENCY TESTING PROCEDURE

The first set of tests were undertaken without the dust suppression sprays operating and other installed dust controls inoperable. This allowed the measurement of the dust load produced during the cutting cycle.

Note:

- Pick sprays remained on for frictional ignition control.
- Miner driver wore a Clean Space during the testing process.

- All other coal mine workers were removed from the hazard to a location of known fresh air.

The controls were made inoperable or turned off as follows:

- The front curtains were rolled up as high as possible and down as low as possible to allow the produced dust to bypass them. This was achieved by chain blocking the curtains up as high as possible and then securing them as required for the testing. This process was repeated to pull down the curtains to the roof. Figure 4 shows a photo of the retracted curtains.
- The side curtains will be rolled up and cable tied securely on either side securing them as required for the testing.
- All sprays, excluding pick sprays, were turned off. It was anticipated that the other sprays would be disconnected at the back of the sprays to allow the water to flow through the cooling circuit and dump to ground.

Figure 4: Retracted curtains

The second set of tests were undertaken as follows:

- The front curtains were replaced to their original position and made operable as per their design.
- The side curtains remained rolled up and cable tied securely on either side securing them as required for the testing.
- All sprays, excluding pick sprays, were turned off. It was anticipated that the other sprays would be disconnected at the back of the sprays to allow the water to flow through the cooling circuit and dump to ground.

The third set of tests were undertaken as follows:

- The front curtains were replaced to their original position and made operable as per their design.
- The side curtains were rolled down to their original position and made operable as per their design.

- All sprays, excluding pick sprays, were turned off. It was anticipated that the other sprays would be disconnected at the back of the sprays to allow the water to flow through the cooling circuit and dump to ground.

The fourth set of tests was undertaken as follows:

- The front curtains were replaced in their original position and made operable as per their design.
- The side curtains were rolled down to their original position and made operable as per their design.
- All sprays were turned back on and made operable as per their design.

RESULTS

During the establishment of the benchmark, it was found that the installed curtains were creating more dust and forcing it to migrate down the platform when they were down as designed. The visible and measured respirable dust was significantly higher with the curtains down as designed compared to when the curtains were rolled up and inoperable. Figure 5 shows the respirable dust being forced around the curtains on the RHS of the continuous Miner (CM) and almost to the rear of the operator's platform with the curtains down as designed. The produced respirable dust remained against the face when the curtains were rolled up.

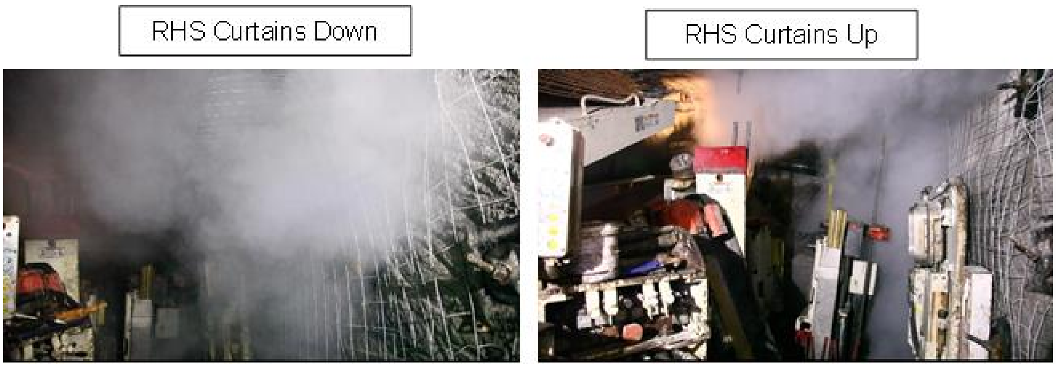

Figure 5: RHS curtains down and curtains up dust migration

Figure 6 shows the respirable dust being forced around the curtains on the LHS of the CM and down the platform with the curtains down as designed. The produced respirable dust remained against the face when the curtains were rolled up.

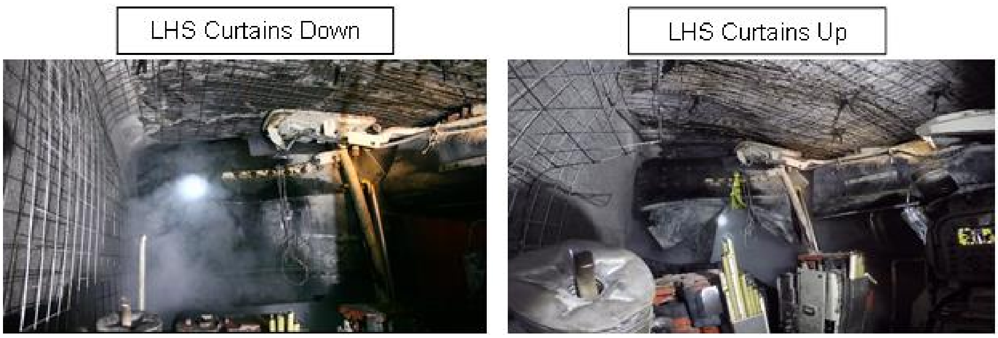

Figure 6: LHS curtains down and curtains up dust migration

The obtained results indicate that with the front curtains down and operating as designed, throat curtains off, and all sprays operating as designed, significantly more respirable dust is produced and migrates down the operator's platform of the CM. Significant respirable dust mitigation was measured with the front curtains rolled up and inoperable, quantifying that the front curtains are not suitable as a dust mitigation control.

Table 2 shows the results achieved by removing the front curtains and leaving the throat curtains and sprays operating as designed.

Table 2: Results achieved by removing the front curtains

			Front Curtains Down	Front Curtains Up	
			Throat Curtains Off	Throat Curtains Off	Control
Date	Location	Location On CM	Sprays On	Sprays On	Efficiency
22-Jun	Mains	LHS Inside Bolter	0.0678	0.0008	-99%
22-Jun	Mains	LHS Outside Bolter	0.0589	0.0016	-97%
22-Jun	Mains	LHS Mid Platform	0.0054	0.0008	-85%
22-Jun	Mains	RHS Inside Bolter	0.1572	0.0047	-97%
22-Jun	Mains	RHS Outside Bolter	0.1869	0.0024	-99%
22-Jun	Mains	RHS Mid Platform	0.0062	0.0034	-45%
22-Jun	Mains	Miner Driver	0.0186	0.0013	-93%
22-Jun	Mains	LHS Rear Platform	0.0042	0.0001	-98%
22-Jun	Mains	RHS Rear Platform	0.0058	0.0002	-97%

Figure 7 is a graphical representation of the obtained results.

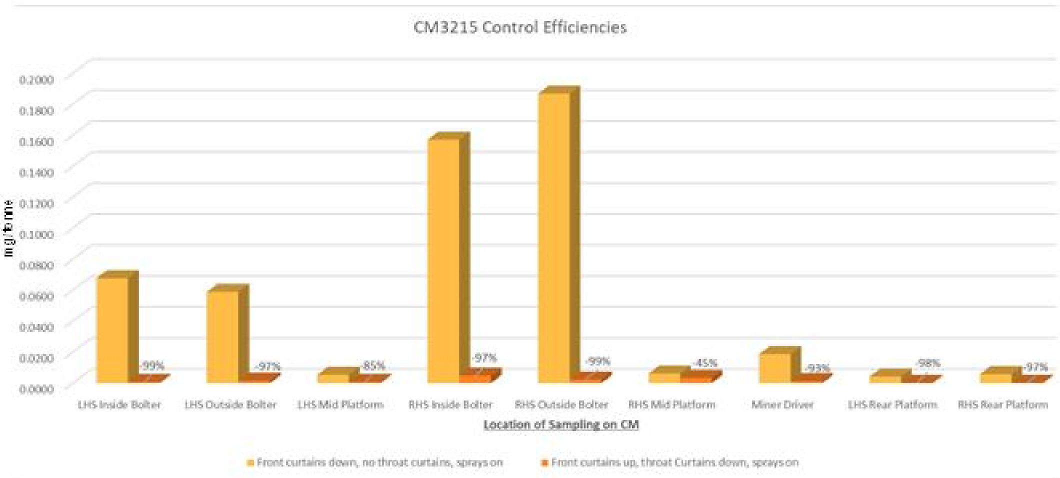

Figure 7: Graph of the respirable dust reduction achieved by removing the front curtains

Figure 8 shows the reduction in respirable dust at different positions on the CM.

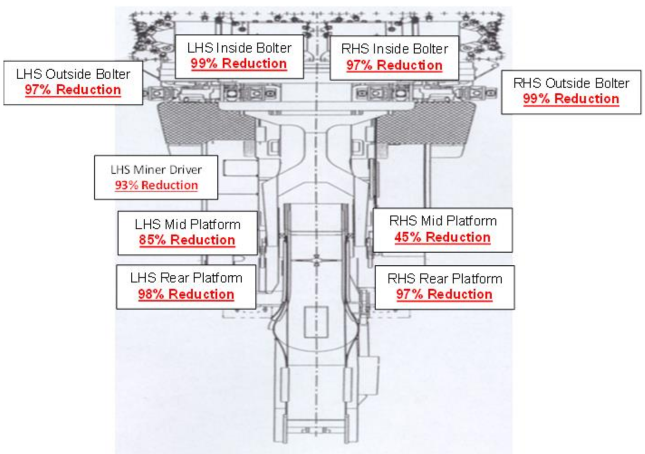

Figure 8 – Respirable dust reduction achieved by removing the front curtains

CONCLUSIONS

Based on the above results it can be quantified that the front curtains installed on the MB650 Continuous Miners are not suitable for dust control. Further, mining a full face of roof stone on CM3215 at Kestrel Colliery has occurred under the following parameters:

- Removal of front curtains to allow face pressure to hold the produced respirable dust against the face allowing the whale's mouth to remove it;
- Throat curtains installed and operating as designed;
- All installed sprays operating as designed;
- The miner driver is to be no closer to the face than at the operators' screen;
- All other personnel are to be back behind the miner driver or off the miner during the cutting cycle, with the exception of dust technicians to take videos and photos during the sampling process;
- Ventilation behind the miner should be no lower than 0.4m/s and 0.5m/s on either side of the miner mid platform;

Continued sampling will be undertaken to further quantify the efficiency and efficacy of the installed throat curtains, throat sprays, tail sprays, apron sprays and Temporary Roof Support (TRS) sprays which will create a best practice engineering control setup for cutting stone with continuous miners, allowing cutting and bolting simultaneously, whilst ensuring the respirable dust risk potential is as low as reasonably achievable.

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