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Dust Controls and Monitoring Practices on Australian Longwalls

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Abstract

Fugitive dust on longwalls has always been an issue of concern for production, safety and the health of workers in the underground coal mining industry globally. Longwall personnel can be exposed to harmful dust from multiple dust generation sources. With the increase in production created from the advancement in longwall equipment, dust loads have also increased and this has resulted in an increase in exposure levels to personnel. Control processes in place for the mitigation of dust vary from mine to mine, with each individual mine having a dust mitigation setup that is only effective for that particular mine operation. While the focus in the past has quite correctly been on improving the controls on dust exposure, the future lies in identifying the efficiency of installed controls on operating longwalls, evaluating them through robust and quantitative sampling methods to ensure the most effective controls are in place to prevent occupational disease from occurring.

This paper will examine the current controls for dust mitigation on longwalls and propose a new testing methodology to determine dust mitigation efficiency (DME) of installed controls for both respirable and inhalable dust. The main objective of this proposed sampling method is to identify dust loads at independent sources of dust generation in mg/tonne produced on longwall faces and quantify the efficiency of installed controls for the mitigation of produced dust on longwall faces.

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Keywords: Fugitive dust, longwall mining, dust mitigation, respirable dust, inhalable dust, Dust Mitigation Efficiency;

1. Introduction

Currently in Australia there are 29 operating longwall coal mines. Of these 29, are 18 in NSW and 11 in QLD. NSW longwalls mined a total of 42,745,900 tonnes of coal in 2009 whilst QLD longwalls mined a total of 40,875,500 for the same period. Australia is the fourth largest coal producer and the largest coal exporter in the world.

Fugitive dust on longwalls has always been an issue of concern for production, safety and the health of workers in the underground coal mining industry both in Australia and globally. Longwall personnel

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can be exposed to harmful respirable and inhalable dust from multiple dust generation sources including, but not limited to: intake entry, belt entry, stageloader/crusher, shearer, and shield advance. With the increase in production created from the advancement in longwall equipment, dust loads have also increased and this has resulted in an increase in exposure levels to personnel.

The mining industry's pursuit to achieve statutory dust levels worldwide has produced a number of methods for longwall dust control over the past three decades. These methods include ventilation controls, water sprays mounted on shearer drums, deep cutting, modified cutting sequences, shearer clearer, dust extraction drum, water infusion, use of scrubbers at stage loader/belt transfer points and other methods. The majority of the dust control techniques 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 3.0 m. Longwall mine managements have been partially successful in controlling their operators dust exposure levels by adopting a combination of the above dust control techniques.

Australian longwall mining experience has indicated that the efficiency of some of the existing dust control methods reduces significantly in thick coal seams and under high production environments. As the current trend in the industry is to substantially increase the face production levels and to extract more thick coal seams, there is an urgent need for detailed investigation of various dust control options and development of appropriate dust management strategies.

The industry has been using statutory dust measurements in underground coal mines according to AS2985 for respirable size dust particles [1], and AS3640 for inhalable size dust particles [2]. The majority of dust sampling to date has been carried out with cyclone separation and collection of the sized particles for weighing, generally over the period of a full shift. Although this method provides an accurate measurement for the total dust exposure for the period sampled, it does not always accurately reflect the source, quantity and timing of respirable dust entering the longwall from different sources, hence presents difficulties in determining the relative effectiveness of the different control technologies in use. Tests based on this methodology also have a number of limitations including limited information from the results and the large number of invalid samples due to over-exposure to dust levels.

This paper presents a critical overview of the dust control practices on Australian longwalls, and introduces a new dust monitoring methodology to quantify both respirable and inhalable dust magnitudes generated from different sources. Using gravimetric sampling as per statutory requirements, this new sampling methodology can be used to evaluate current dust controls and their effectiveness at different sources of dust generation, and analyse the most effective control process in place for each dust source at longwall mines in Australia and globally.

2. Sources of Dust Generation

Regardless of dust loads, which are directly proportional to tonnages produced, longwall dust generation at each independent source, produce relatively the same percentage of dust as a proportion of total face dust in each operating longwall. Research from NIOSH [3] indicates that there are, in general, six individual sources of dust generation on an average longwall. Figure 1 below shows the location of each of these independent sources of dust generation. Studies by NIOSH indicate that longwall shearer and chocks are the main dust sources on longwall faces, representing up to 80 per cent of the total dust make [3]. As the longwall shearer travels long the face, a significant portion of dust occurs in the crushing zone around the pick tip of the cutting drum. In general, the leading drum cuts the full drum height and generates the majority of the dust, while the trailing drum produces less dust due to the lower amount of coal being cut; concurrently as longwall chocks lowered and advanced, crushed coal and/or rock can fall from the top of the chock canopy directly into the face ventilation airflow. Most of this dust becomes airborne, and quickly disperses into the walkway.

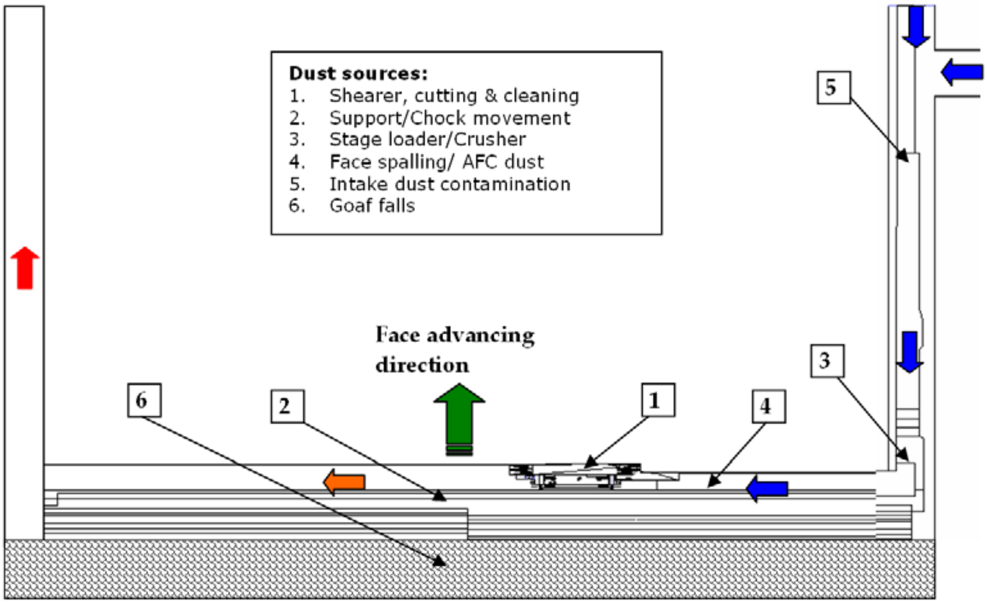


Fig.1. Main sources of dust generation on longwalls

Dust generated due to face spalling ahead of the shearer is a major problem particularly for thick seam longwall faces. Dust can also be lifted up from the AFC by ventilation when the direction of coal transport is against the direction of the airflow. Dust can be generated at all the conveyor transfer points along the intake airways. The movement of any equipment outbye can also cause significant quantities of dust to be raised into the atmosphere. A portion of dust can also be produced following roof caving behind the chocks and sudden goaf falls. A significant part of this goaf dust can be pushed onto the face as the leaked airflow returns to the face along the face support line.

3. Dust Mitigation Controls Used on Longwalls

Ever since respirable dust was identified as the principal agent in the development of a disease known as ‘pneumoconiosis’, there has been a consistent drive from the industry for the development of dust control techniques in coal mines. Allowable dust concentration standards continued this trend, with many dust control methods and operating practices being developed and implemented over the past 30 years to reduce miners’ dust exposure on longwall faces. Although significant progress has been achieved, respirable dust exposure on longwall faces is significantly higher than in other mining environments, and the problem of containing dust concentration to acceptable levels continues to be a challenge for modern longwall mining.

In general, two dust control approaches, namely administrative controls and engineering controls, are adopted for dust management by the industry. Administrative controls or ‘work practices’ are designed to minimise the exposure of individual workers by positioning them in the work area in such a way as to limit the time they are exposed to a particular dust source [4]. Work practices can be effective in protecting some individuals only if followed properly and consistently, and if the environmental exposure remains constant and predictable. Unfortunately, this is not the characteristic of longwall mining in general. Furthermore, the potential for frequent change of location can make it very difficult to identify sources of dust exposure. Engineering controls aim to lower the levels of respirable dust in the mine atmosphere by either reducing dust generation or by suppression, dilution, or capturing and containing the dust. These control measures are usually designed for application to particular conditions. Some are restricted to one operation while others are more general in nature.

While the development of longwall mining has led to high productivity records, the consequent production of high amounts of airborne dust has placed even more stringent demands on dust control. Extensive studies have shown that high dust exposures on longwall mining operations are mainly due to:

- Inadequate air volume and velocity;
- Insufficient water quantity and pressure;
- Poorly designed external water spray systems;
- Lack of dust control at the stage loader and crusher;
- Dust generated during support movement; and
- Cutting sequences that position face workers downwind of the cutting machine.

Face ventilation has always been the primary means to dilute airborne dust and remove from the face quicker by increasing face quantities when production increases. Some mines also employ ventilation curtains and brattice wings to modify the behaviour of the ventilation to reduce the amount of air going passed the maingate chock, over pressurising the goaf and returning somewhere further along the face with contaminated air. Australian longwall face ventilation volume ranges typically from 40m^3/s up to over 100m^3/s, depending up longwall production and gas dilution requirements.

A typical dust control setup on a longwall includes the primary use of sprays as the first point of control. The sprays used vary considerably from mine to mine, however, a typical spray setup would include solid or hollow cone sprays for the BSL discharge and crusher with a water pressure between 12 and 20 bar and a flow rate of up to 35 lpm. The number and positioning of sprays will vary from mine to mine. The shearer will have a series of drum sprays between 45 and 55 dependent on the drum type, usually supplied by the manufacturer, which consist of an orifice of between 1.2 mm and 2 mm, a flow rate of between 90 and 100 lpm and a pressure of 20 to 30 bar. Some mining operations utilise a shearer clearer which consists of a series of up to 10 sprays dependent on desired configuration. These sprays are usually a solid cone with an orifice diameter between 1.2 and 3 mm and an operating flow of between 25 to 30lpm and operating pressure of between 20 and 30 bar. For shield generated dust, solid cone sprays are positioned in the canopy. These sprays usually have up to a 4 mm orifice, using 30lpm at a pressure of between 10 and 20 bar. In most cases the aim of dust mitigation has not been the total suppression of the coal dust, but to reduce the respirable dust from the vicinity of the mine workers.

3.1. Controlling Dust on Intake Roadways

Water application to the mine travel roads is crucial to control respirable dust in the intake roadway. Operators must be diligent in monitoring moisture content of the dust along intake roadways, especially with the increased amount of air travelling toward the face and during winter months. This air amplifies the potential for the roadways to dry out more quickly. The moisture content of the transport road should be approximately 10% [5]. Hydroscopic compounds such as calcium, magnesium chloride, hydrated lime, and sodium silicates increase roadway surface moisture by extracting moisture from the air. Applications of these materials will help maintain the moisture content of the travel road surface [5].

Surfactants such as soaps and detergents dissolve in water and can be beneficial in maintaining the proper moisture content of the intake roadways. Surfactants decrease the surface tension of water, which allows the available moisture to wet more particles per unit volume [6]. Whilst these controls will offer a possible benefit in reducing the amount of respirable and inhalable dust produced from vehicle movement entering the longwall, little data has been collected to quantify the actual amount of dust removed by this form of control.

Application of surfactants can also be restricted by the condition of the road, which in underground coal mining can deteriorate in a very short period of time and requires significant resources to maintain the integrity of the road to allow controls to be continually applied. Another problem with this control is the amount of water, salt or surfactant need to ensure the roadway remains moist. In many underground mining applications, this would be restrictive in terms of cost per tonne to not only purchase the control, but the cost of application will have a significant effect on resources.

3.2. Controlling Dust from the Outbye Belt

Dual intake air from the outbye belt will allow the delivery of more air to the face, providing the potential for better dust and methane dilution. Recent longwall surveys in the USA showed that about 40% of the operations were using belt entry air [7]. Compliance data analysed by MSHA showed that mines using belt air to ventilate work areas did not have significantly different respirable dust levels at the last open cut through when compared to the mines not using belt air [8].

Further, studies conducted by the U.S. Bureau of Mine indicated that any potential addition to dust levels at the longwall face from the belt entry seems to be mitigated as a result of the increased dilution that can be obtained with additional air brought up the belt entry [9]. However, the potential for dust from the belt entry to contaminate the face area has increased in recent years because the quantity of coal being transported by the belt continues to increase.

Current outbye belt controls focus on properly maintaining the belts to keep respirable dust levels low along the belt entry. Missing rollers, belt slippage and worn belts can cause belt misalignment and create spillage. Given the increases in the quantity of coal being transported on the outbye belt, operators must be diligent in their efforts to properly maintain the existing belt entry dust suppression controls to keep fugitive dust from being entrained and carried by the ventilation airstream to the face area.

If the coal is wetted adequately at the face, less dust will be created during transport at the transfer points. However, with the substantial increase in airflow in the belt entry, the moisture may evaporate and rewetting of the coal may be necessary at multiple intervals along the belt. Flat-fan sprays and full-cone nozzles are typically used for coal wetting along the belt. Water application usually ranges from 30 to 45 lpm at operating pressures of between 1000 to 1700 kPa.

Scraping and washing of the belt play an important role in reducing the amount of dust generated by the conveyor belt [10]. Material that adheres to the belt is subject to crushing at the head and tail roller. Often this material dries out and becomes airborne as it passes over the return idlers. The top and bottom of the return belt should be cleaned with spring-loaded or counterweighted scrapers. A low-quantity water spray may be necessary to moisten the belt slightly and complement the belt scrapers. Previous studies have shown that water sprays in conjunction with belt scrapers significantly reduced airborne respirable dust levels [11].

3.3. Crusher and BSL Dust Control

There is no universal dust suppression process or technique in Australian underground coal mines for the BSL and crusher to mitigate produced dust. Rutherford [12] apparently found that dust generation is not considered specifically at the time of the equipment purchase and problems are only detected after operations commence. Modifications are then difficult to make and redesign is expensive and sometimes ineffective and may take many changes to become effective. Rutherford's research also highlighted the poor knowledge by the industry regarding the equipment, the effect on dust of the equipment and differences in operating effectiveness at different mines [12].

Crusher and BSL are fully enclosed, having conveyor belting at the crusher intake, one or two more strips before the hammers and some form of sealing or skirts on the BSL discharge to the outbye belt. Crusher and BSL sprays are typically used at the entrance to the crusher, at the discharge area and at the belt transfer area. Although there are many variations to the spray type used at individual mines, the typical spray is a full cone spray, usually in a row of three inside the crusher, with a row of spray between each of the conveyor skirts. The sprays traditionally use 35-45 lpm each at a pressure of 12 to 20 bar. Some mining applications have sprays on the transfer from the face AFC to the crusher intake and these are usually flat fan sprays designed to stop the dust billowing into the intake air.

3.4. Controlling Shearer Dust

Drum mounted water sprays are the most commonly used first-point dust suppression process on the shearer cutting drum. The sprays are pointed directly at the pick point of coal fracture and add moisture to minimize dust liberation. The pick sprays are also vital for the mitigation of frictional ignition as the pick strikes the coal. Optimum pressure to the sprays is usually 20-30 bar, the sprays are typically full cone or solid stream spray pattern and the number of sprays per drum ranges between 35 -62. It should be noted that drum pressures and flows vary greatly from mine to mine.

Cutting drum maintenance is critical to ensure the minimisation of dust liberation from the cutting pick. Bits with large carbon inserts and a smooth transition between shank and carbide are supposed to reduce dust levels. Replacing damaged, worn or missing bits cannot be over-emphasized as dull bits result in shallow cutting and greatly increases dust generation.

Crescent sprays are another method to potentially reduce shearer generated dust. They are typically located on the top and end of ranging arms with sprays oriented toward face. There are typically 8~10 hollow cone sprays with an operating pressure of between 12~20 bar. The sprays on the end of ranging arm are typically oriented into the face airflow; however these can create turbulence that forces dust toward the walkway.

Shearer mounted sprays are often utilised for dust suppression and may include a shearer clearer designed to induce airflow and dust toward face or spray manifolds positioned between the drum walkway. Both are designed to promote movement of dust-laden air close to the face and prevent migration toward the walkway. They are typically oriented with airflow and positioned on the maingate side of the shearer. Figure 2 shows a typical shearer clearer setup on a maingate arm and a spray manifold positioned on the maingate arm of the longwall shearer.

The latest product development for the mitigation of shearer generated dust is a longwall shearer scrubber which has been jointly developed by CSIRO and the industry [13]. The scrubber is a modular system that can be fitted between the ranging arm and the longwall shearer body. The scrubber includes an intake hood directed into the intake ventilation, a hydraulic-driven fan which sucks the air into an impact filtration system, and a discharge duct which forces the clean air under the shearer body and toward the face. The sides of the intake hood have a series of water sprays to create an agglomeration impact point for the dust/water mixture prior to impact filtration removal. The sprays were also designed to provide positive pressure resistance and create an air curtain to prevent dust from entering the walkway. Clean air is discharged under the shearer ranging arm toward the face. The combined effect of the spray pressure, flow and design contribute to further influence the dust's behavior and improve dust collection. Field trial results indicated that up to 76% of dust can be removed from the shearer operator's position. Figure 3 shows the scrubber installed on a longwall shearer.

(a)Shearer clearer (b) Spray manifold

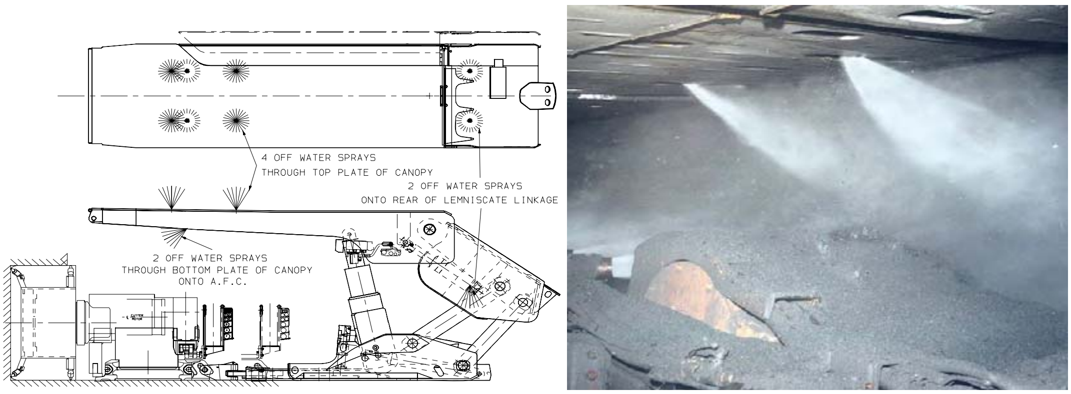
Fig.2. Dust control using shearer clearer and a spray manifold on the longwall shearer

Fig.3. Dust scrubber installed on a longwall shearer

3.5. Controlling Shield Dust

Longwall supports are typically advanced within two or three shields of the trailing shearer drum. As longwall chocks (supports) are lowered and advanced, crushed roof coal and/or rock falls from the top of the chock canopy directly into the face ventilation airflow. Most of this dust becomes airborne, and quickly disperses into the walkway. As a result, chock movement can be a significant source of dust exposure for shearer operators when supports are advanced behind the shearer during maingate to tailgate cuts. To control dust from chock movement, a number of methods have been developed including [3]:

- Canopy-mounted spray systems - A canopy spray system that activates water sprays into the roof material on top of the supports for a short period of time before and during chock movement to wet the material on top of the canopy to lower dust levels during shield advance, as shown in Figure 4.a. Experience in the US and Australia has shown that this type of system is hard to maintain and is not effective in distributing moisture to the material above the canopy.
- Shield sprays under the canopy - These sprays were automatically activated by the position of the shearer to create a moving water curtain in an attempt to contain the dust cloud near the headgate and tailgate drum areas, as shown in Figure 4.b. Proper on/off sequencing of these sprays is critical to supplement the directional spray system. These sprays need to be properly aligned toward the face to enhance the envelope of clean air created by the shearer's directional spray system.



(a) Spray system over canopy (b) Spray system under canopy

Fig.4. Dust control on longwall chocks - water sprays located above and on the underside of the canopy

The above review of the current dust mitigation controls used in underground longwall mining indicates that while controls are in place for the mitigation of produced dust, these controls seem to be installed more in a trial-and-error approach than implemented based on scientific foundations. This is evidenced by no clear approach to what sprays or control perform the best at specific locations, and no clear direction by suppliers of longwall equipment in relation to dust suppression or mitigation. As has been indicated above, little or no thought is given to dust control at the time of scoping up supply of longwall equipment and only after a longwall commences operation, until problems arise relating to high level dust contamination, and a solution is needed to control dust issues. At this time it is very difficult and in many instance expensive to measure control efficiencies, with many mines relying on subjective opinion as to the effectiveness of the installed controls. Little or no scientific research has been undertaken to quantify how effective installed controls are in relation to removing the produced dust on operating longwalls.

4. A New Monitoring Methodology to Determine Dust Mitigation Efficiency (DME)

Questions relating to the validity and subsequent suitability of the current dust sampling methodologies utilised in Australia have recently come under significant scrutiny. The reason for this scrutiny is that there has been a significant increase in Coal Workers' Pneumoconiosis (CWP) in the USA over the last few years despite recorded conformance to exposure level legislation, and the opinion by the underground coal mining industry in Australia that the current testing regime tells them very little about the actual operational production of dust on the longwall face in relation to where it is produced or how to prevent this dust entering the atmosphere.

The current testing regime in Australia provides the mine tested with a single figure for respirable dust exposure levels for five samples taken over a minimum of four hours during a production shift. These figures only provide 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 where the dust has come from 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.

A new testing methodology is proposed utilising 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 longwall faces and quantify the efficiency of installed controls for the mitigation of produced dust. This data will then be used to create a benchmark or signature for each 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.

5. Current Australian Dust Monitoring Practices

Dust sampling in Australian coal mines is carried out with cyclone separation and collection of the sized particles for weighing, generally over the period of a full shift to measure personal exposure levels to airborne contaminants of employees. This testing methodology is described in AS2985 for determination of respirable dust [1] and AS3640 for inhalable dust [2]. Section 6.1 of AS2985 - Workplace atmospheres - method for sampling and gravimetric determination of respirable dust states the essential features of a sampling system are a filter (on which the sample is collected) and a pump for drawing the air through the filter. The filter shall be secured in a holder that prevents air from leaking around the edge of the filter. The filter is preceded by a size-selective sampler. The UK Institute of Occupational Medicine (IMO), Edinburgh has developed a personal sampler for inhalable dust, which embodies a single orifice entry and a filter contained within a special cassette. The cassette and the enclosed filter may be weighed either separately or together. The IOM inhalable dust sampling head is the most commonly used head to collect inhalable dust samples.

According to Coal Services Pty Ltd of NSW, Australia, respirable dust testing analysis, there have been 18,900 respirable dust samples, including re-sampling, taken in the period 1984-2007 [14]. Of these samples, it has been reported that there have been 1200 samples above the exposure limit for respirable dust, which represents less than 6.5% of total samples taken. This testing programme has assisted the industry in achieving outstanding results in the elimination of black lung etc.

5.1. Problems with Current Testing and Reporting In Australia

Whilst these figures are impressive in relation to the amount of failures to the statutory levels and the fact that there are, nor have been, for an extended period of time, any known instances of CWP in Australia, the statutory testing provides very little useful information to the mine operators other than a pass or fail figure. A number of limitations with the existing methodology have been identified, these include large number of failed samples due to contamination; provision of limited useful information that can be linked to specific activities and working environment, and thereafter cannot be used to assess and refine dust controls.

Calls from industry are pushing for a review of the current inhalable and respirable dust sampling methods used in Australia and to investigate alternative sampling methodologies applicable to major underground coal mining tasks, report on their validity within the codes, guidelines and standards and propose a new testing methodology that better identifies atmospheric contamination caused by dust produced during the cutting cycle in longwall mining.

It has been suggested that with changes in the work routines of many Australian miners, the traditional way of sampling is no longer adequate. Further, industry members believe that the current testing process is getting what are believed to be data errors arising from how sampling is being conducted not by over exposure to dust levels. Many samples are being contaminated leading to a failed result. The industry feels that rather than being recorded as a failure to the tested mines these should be deemed as invalid samples and quite rightly retested.

Mining industry members have been investigating alternative ways of placing dust sampling units to eliminate contamination whilst still meeting the strict codes, guidance and standards applied to this area. They also want to identify techniques that more accurately identify what specific work activities lead to specific results which will assist further in managing specific risks. Mining industry members would also like to look at instantaneous measuring devices that may also assist with identification and eventual mitigation of airborne contaminant risks.

It has further been suggested that there is a need to establish a database of best practice dust suppression techniques used by longwalls for the industry to peruse and use along with the management of sampling data. Currently the industry invests a lot of money in the sampling conducted by the regulatory regime but receive very little useful information on how to mitigate airborne contaminants. With the volume of data collected the industry should have a fairly accurate picture and understanding of the underground longwall work environment to help refine installed controls and measure their dust knockdown efficiency, but currently only receive single sample information with details recorded for a 5 sample batch not individual samples. The industry feels it would be better to have information on individual pieces of plant & equipment, tasks and activities and on the practises of crews or individuals. The industry would also like to see a review which will document standards of approach in the areas of dust control efficiencies to capture a definitive benchmark which will allow for a more scientific approach to the management of airborne contaminants.

Finally, it has been suggested by the mining industry that a review of competency requirements for persons undertaking dust sampling be undertaken and that a review of the occupational exposure limit is covered and suggested legislative shift adjustment criteria is recommended specifically in the industry to better reflect the continual changes in the mining environment.

With the support of Australian Coal Research Program (ACARP) and the industry, the University of Wollongong is currently engaged in the development of a new dust monitoring methodology to determine DME.

5.2. Results of the New Testing Methodology

To date, two Australian mines have been tested under the proposed new testing methodology. The results have shown that the first mine, Mine A, had a DME of 40% for respirable dust and a DME of 62% for inhalable dust. Mine B showed a DME of 19% for respirable dust and only a 5% DME for inhalable dust. Table 1 shows a comparison of dust monitoring results between Mine A and Mine B in the mg/tonne produced for respirable and inhalable dust at independent sources of dust generation on the longwall and shows how efficient the installed controls are at removing the produced dust.

Table 1. A comparison of dust monitoring results between Mine A and Mine B

Average mg/tonne	**Mine A**	**DME**	**Mine B**	**DME**
Respirable Dust Controls off	0.000597		0.000623	
Respirable Dust Controls on	0.000356	**-40%**	0.000505	**-19%**
Inhalable Dust Controls off	0.011739		0.0031	
Inhalable Dust Controls on	0.004489	**-62%**	0.00291	**-5%**
Outbye BSL Discharge mg/tonne				
Respirable Dust Controls off	0.000113		0.000182	
Respirable Dust Controls on	7.10E-05	**-37%**		
Inhalable Dust Controls off	0.000301		0.000655	
Inhalable Dust Controls on	0.000503	**67%**	0.000224	**-66%**
Last open Cut Through mg/tonne				
Respirable Dust Controls off	8.95E-05		0.0001	
Respirable Dust Controls on	6.35E-05	**-29%**	7.73E-05	**-23%**
Inhalable Dust Controls off	0.000595		0.000433	
Inhalable Dust Controls on	0.000411	**-31%**	0.000204	**-53%**
Inbye Crusher Discharge mg/tonne				
Respirable Dust Controls off	0.000164		0.000182	
Respirable Dust Controls on	0.00011	**-33%**	0.000132	**-27%**
Inhalable Dust Controls off	0.000503		Void	
Inhalable Dust Controls on	0.003268	**550%**	0.000346667	
Shearer Driver Respirable mg/tonne				
Respirable Dust Controls off	0.000373		0.0007	
Respirable Dust Controls on	0.000271	**-27%**	0.000334667	**-54%**
Maingate mg/tonne				
Respirable Dust Controls off	0.0002		0.0003	
Respirable Dust Controls on	0.000125	**-38%**	0.000148	**-42%**
Inhalable Dust Controls off	0.024554		0.0006	
Inhalable Dust Controls on	0.002693	**-89%**	0.000333333	**-43%**
Chock 20 mg/tonne				
Respirable Dust Controls off	0.000796		0.0005	
Respirable Dust Controls on	0.000352	**-56%**	0.000296	**-45%**
Inhalable Dust Controls off	0.004939		0.003	
Inhalable Dust Controls on	0.004868	**-1%**	0.002834667	**3%**
Chock 40 mg/tonne				
Respirable Dust Controls off	0.000945		0.001	

Respirable Dust Controls on	0.000521	**-45%**	0.000618667	**-43%**
Inhalable Dust Controls off	0.009297		0.003	
Inhalable Dust Controls on	0.002545	**-73%**	0.008150667	**133%**
Chock 60 mg/tonne				
Respirable Dust Controls off	0.001018		0.0007	
Respirable Dust Controls on	0.000543	**-47%**	0.000742667	**14%**
Inhalable Dust Controls off	0.007292		0.003833	
Inhalable Dust Controls on	0.009888	**36%**	0.002773333	**-28%**
Chock 80 mg/tonne				
Respirable Dust Controls off	0.001592		0.001267	
Respirable Dust Controls on	0.000596	**-63%**	0.000802667	**-37%**
Inhalable Dust Controls off	0.005682		0.005167	
Inhalable Dust Controls on	0.003658	**-36%**	0.005244	**1%**
Tailgate mg/tonne				
Respirable Dust Controls off	0.000619		0.001243	
Respirable Dust Controls on	0.000894	**44%**	Void	
Inhalable Dust Controls off	0.012604		0.006573	
Inhalable Dust Controls on	0.015779	**25%**	0.005572	**-15%**

The above monitoring results identify the efficiencies of installed controls at the two mines tested. Mine A has more efficient installed controls on average for both respirable and inhalable dust mitigation. However, Mine B has more efficient installed controls in mitigating inhalable dust in the tailgate. In relation to the rest of the face, Mine A removes 37% of the respirable dust from the outbye area tested with installed controls operating, however, Mine B has an excessively high figure which will need to be retested. At the same point outbye, Mine B removes 66% of the inhalable dust with installed controls operating while Mine A has an increase of 67% of inhalable dust when the controls are turned on. This would indicate that Mine A could increase their DME at this point by installing Mine A's outbye belt controls.

The last open cut through have similar results for both mines while inbye of the crusher discharge shows that Mine A has a huge increase in inhalable dust with the controls on. This should also be retested to confirm readings. Mine B removes twice as much respirable dust from the shearer driver, while similar efficiencies exist for along the face line with the exception of chock 40 where Mine B sees an increase of 133% in inhalable dust and at chock 60 where Mine B sees an increase in respirable dust of 14% with controls on and Mine A sees an increase in inhalable dust of 36% with controls on. The tailgate shows an increase of 44% for respirable dust and 25% for inhalable dust for Mine A which is an area that needs significant attention.

6. Conclusion

Reducing dust exposure level to workers remains a challenge in Australian longwalls in spite of the application of various dust controls. Australia has identified that currently installed controls for the mitigation and removal of harmful coal dust from the underground mining environment have proven to be hard to measure in terms of the success in mitigating airborne contaminants. The need for a more comprehensive testing methodology is considered paramount to allow more information to be made available to mine operators to ensure instances of CWP do not creep back into the mining environment.

From this evaluation of the installed controls in longwall mining and the current testing regimes in Australia, it can be clearly identified that significant measuring problems exist in the control of dust produced during the cutting cycle in longwall mining.

The new testing methodology has the capacity to identify which installed controls work efficiently in mitigating respirable and inhalable dust, and how this information can be easily transferred to other mines to improve their DME. As more mines are tested, clear DME trends will be identified at each independent source of dust generation on an operating longwall, thus allowing the development and implementation of best control practices.

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