TRENDS IN IMPLEMENTATION OF LONGWALL DUST CONTROLS

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ABSTRACT

During the last ten years, longwall mining systems have undergone many changes. Panel widths and lengths have increased. Longwall faces have become more automated. Average production from individual longwall panels has increased from 1,000 to 3,600 tons per shift. To control the dust generation resulting from the higher production, longwall dust control systems have integrated various dust control techniques.

Systems designed to control dust generated at the crusher/stageloader, shearer, and supports are common to most longwall faces. A survey was made of the dust controls that are currently in place on all the longwalls in the U.S. This survey addressed the types of controls used to reduce dust generated at the crusher/stageloader, shearer and roof support movement. Additionally, information on face ventilation rates, cutting cycle and level of automation was obtained. The purpose of this paper is to review the dust control practices that have been implemented throughout the United States and to identify those controls that are being used on high production longwall faces.

Additionally, a model is used to demonstrate how ventilation and automation affect occupational exposure. Automation of roof support movement can offer some of the greatest reductions in occupational dust exposures. While technically feasible, its full benefit has not been fully realized by the industry. Until technology to fully automate longwall mining systems becomes more reliable, future dust control systems must rely on increased ventilation, application of headgate dust collectors, improved shearer dust controls and improved shield dust suppression systems.

INTRODUCTION

During the last ten years, the number of longwalls in the United States has remained relatively constant. Approximately 80 to 90 longwall faces operate at any given time. However, during this time, longwall mining systems have undergone many changes. Panel widths have doubled. Panel lengths have tripled. Longwall faces have become more automated. Over fifty percent of the faces use a bidirectional mining sequence. Average production from individual longwall panels has increased from 1,000 to 3,600 tons per shift. Approximately 25 percent of the longwall sections have average productions in excess of 4,000 tons per shift.

During the past five years, the coal mining industry has become involved in many issues involving respirable coal mine dust. These issues include among other things sampling, compliance determination, development and implementation of control technology and the plan approval process (U.S. Department of Labor, 1993). While these issues impact the entire mining industry, they are especially important to mines where longwall systems are used to extract coal.

Although dust control technology for room-and-pillar mining sections has not significantly changed, longwall dust control systems have been enhanced to control the dust generation resulting from the higher production. Longwall dust control has become an integration of various systems designed to control dust generated at the crusher/stageloader, shearer, and from roof support movement. However, even with these higher levels of dust controls, longwall sections have historically maintained dust levels just below the applicable dust standard.

A survey of MSHA health specialists was made to identify the dust controls that are currently in place on all the longwalls in the United States. This survey addressed the types of controls used to reduce dust generated at the crusher/stageloader, shearer and supports. Additionally, information on face ventilation rates, cutting cycle and level of automation was obtained.

The purpose of this paper is to review the dust control practices that have been implemented throughout the United States and to address how future longwall developments can affect longwall dust control.

CURRENT DUST CONTROL TECHNOLOGY AND STATUS OF CONTROL TECHNOLOGY IMPLEMENTATION

The U.S. Bureau of Mines has conducted extensive research on longwall dust sources and longwall dust control (Shirey, 1985; Organiscak, 1986; Niewiadomski, 1993; U.S. BuMines, 1985, 1986, 1987, 1989, 1989). Table 1 shows a summary of the dust sources and dust controls which have been demonstrated to be effective. Dust sources include the intake/belt, headgate area, shearer and roof support movement. Dust controls have been divided into two categories: 1st and 2nd Generation.

The 1st generation controls include ventilation, water applications, enclosures and barriers, and shearer remote control. Proper application of these controls have, in most cases, maintained dust levels within acceptable levels for productions below 4,000 tons per shift. When production exceeds 4,000 tons per shift, some of the 2nd generation controls may be required to maintain dust levels below the applicable standard. The 2nd generation controls include: increased ventilation, headgate dust collectors, high pressure water or foam through the shearer drums, and automated supports.

The survey of dust control practices consisted of contacting each of the Health Supervisors in the nine Coal Mine Safety and Health Districts, where longwall sections are operated. Information regarding current types and levels of controls used to reduce occupational exposure was obtained. This information is summarized in Table 2. This information reflects the controls actually in place and not the controls required by the ventilation plan. In many cases, plan requirements are substantially less than the actual parameters in place.

The results of the survey indicated that nearly all of the longwalls utilize the 1st generation dust controls. Most longwall faces have air velocities greater than 400 fpm (2.0 m/s), drum water pressure greater than 100 psi (6900 kPa), external spray pressure greater than 125 psi (8600 kPa), enclosures and sprays on the crusher/stageloader and remote control operation of the shearer.

Approximately 57 percent of the longwall faces utilize a bidirectional cutting sequence. The primary implementation of 2nd generation controls included the use of increased airflow and increased implementation of automation. Approximately 40 percent of the mines have face air velocities greater than 600 fpm (3.0 m/s). When these mines are combined with the high seamed western mines, approximately 62 percent of the longwall sections have face air volumes greater than 36,000 cfm (17.0 m^3/s). Increased ventilation has not had a detrimental effect on longwall dust control (Tomb, 1991).

In western mines with sufficient entry height, dust collectors had been installed on five of the crusher/stageloaders. Approximately 72 percent of the mines have shields equipped with automation features. However, in most cases, the use of automation to advance the shields was not considered reliable. None of the longwall faces utilized shearer drum dust suppression systems such as reverse drum rotation, high pressure drum sprays or foam through the cutting drums.

If sufficient airflow capacity is available in a mine, increased ventilation can provide for a short term solution to dust control problems. Long term dust control improvements can be achieved by increasing ventilation system capacity or by increasing the applications of automation.

The primary proven 2nd generation control is increased dilution and removal of dust through increased ventilation. Automation is a dust control solution that can be designed into future longwall panels. Increased ventilation is a dust control that can be applied to existing longwall panels.

Recently, the U.S. Bureau of Mines and the Mine Safety and Health Administration have entered into a number of joint research projects. One of these projects will provide for installation and evaluation of state-of-the-art dust controls on a single longwall face. The controls will be installed in two phases. The first phase will include the installation and evaluation of a crusher/stageloader dust collector; "designer" surfactants; and reverse rotation of the cutting drums (U.S. BuMines, 1987). The second phase will include the installation and evaluation of a crusher/stageloader dust collector; "designer" surfactants; and either high pressure drum sprays or a drum foam system (U.S. BuMines, 1989, 1989). Results of this study will provide information on the full capabilities of 2nd generation longwall dust controls.

EFFECTS OF INCREASED VENTILATION

The effect of increased ventilation and improved automation on longwall dust control were assessed by mathematically applying these controls to the various dust sources on a longwall face.

Longwall dust sources include the intake/belt, the crusher/stageloader, the shearer, and support movement. Table 3 gives the factors that can be applied to longwall dust sources for changes in ventilation. Ventilation changes are based on dilution.

Changes in ventilation affect each of the longwall dust sources through dilution. Consequently, a change in ventilation would be reflected by a proportionate change in dust exposure. The resulting dust concentration (C_2) can be obtained by multiplying the existing dust concentration (C_1) by the initial airflow (Q_1) then dividing by the new airflow (Q_2).

$$(C_2) = (C_1) * (Q_1) / (Q_2)$$

The primary reason for increased dust generation is increased production. Controlling this increased dust generation through increased ventilation requires between 5 and 20 cfm per ton (0.0025 and 0.010 m^3/s per ton) of coal mined during a production shift (Haney, 1993). This ventilation value depends on the specific geology of the coalbed and the effectiveness of the other dust controls in place.

Figure 1 shows the ventilation versus production relationship to maintain the dust concentration at 2.0 mg/m^3 for a 10 cfm per ton (0.005 m^3/s per ton) airflow-to-tons ratio. As production increases, the required airflow would also increase. The velocities are based on an area along the face of 60 square feet (5.5 m^2).

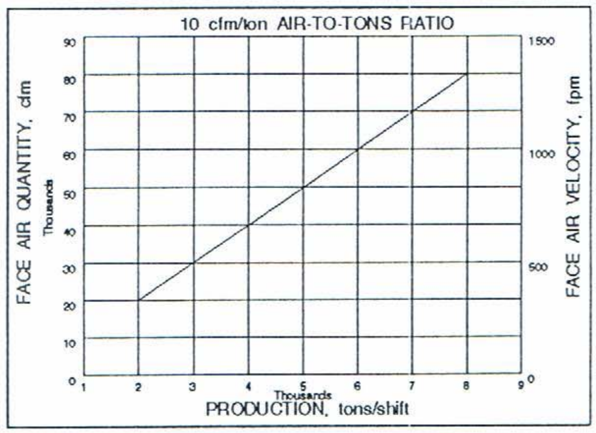

Figure 1. Relationship of airflow and production to maintain a 2.0 mg/m^3 dust concentration.

EFFECTS OF AUTOMATION

During a panel discussion held at Longwall USA in June, 1994, industry representatives indicated that they would prefer to invest in automation rather than risk downtime associated with initial installation of the 2nd generation shearer drum dust controls. The specific type of automation desired by the industry is shearer actuated support advance. Radio remote operation of the shearer is currently available.

In addition to the dust level changes based on ventilation, Table 3 gives percentage reductions for various levels of automation. These reductions are based on exposure time and worker position (Haney, 1988). For the unidirectional system, supports are advanced upwind of the shearer. In this system, workers would be exposed to approximately 25 percent of the shearer generated dust and 100 percent of the support dust. For the bidirectional system with shearer remote control, workers are required to work downwind of the shearer half of the time. As a result, workers would be exposed to approximately 50 percent of the shearer dust and 50 percent of the support dust. For the bidirectional system with full automation, workers remain up wind of the shearer. As a result, workers would be exposed to approximately 25 percent of the shearer dust and 50 percent of the support dust.

Table 4 shows how various levels of automation would effect dust exposure on a longwall face. As indicated by the first line in the table, the total dust generated is unaffected by automation. The total dust generated is the sum of the individual sources. The occupational exposure depends on the magnitude of each dust source and the level of automation. The exposure is the sum of the contribution of each source. The contribution was found by multiplying the source by the factor for the various levels of automation given in Table 3. The following equations were used to calculate the total dust generation and exposure, respectively, Shown in Table 4.

DUST GENERATION = INTAKE + HEADGATE + SHEARER + SUPPORTS

DUST EXPOSURE = SUM [DUST SOURCES X AUTOMATION FACTOR]

As indicated by the values in Table 4, the cutting cycle in combination with the level of automation can result in either an increase or decrease in occupational exposure. If the shearer is a larger dust source than the support movement, changing from a unidirectional cut sequence to a bidirectional cut sequence will increase occupational exposures. However, if the support movement is the larger dust source, the change to bidirectional cutting will result in a reduction of occupational exposure. Implementation of bidirectional cutting with fully automated support movement provides for the lowest occupational exposures. In this system all workers can remain upwind of the shearer.

Automation of support movement can offer some of the greatest reductions in occupational dust exposures. While technically feasible, its full benefit has not been fully realized by the industry. Many of the automation problems encountered with supports are related to the adverse conditions of the underground environment. Water and humidity on the longwall face can cause malfunctions in the electronic controls. Shields can get stuck in the top or bottom, requiring manual advance. Mechanical failures such as broken hoses can also require manual advance of the shields. Until technology to fully automate longwall mining systems becomes more reliable, future dust control systems must rely on increased ventilation, application of headgate dust collectors, improved shearer dust controls and improved shield dust suppression systems.

Current automation practices have no effect on the dust generated by the crusher/stageloader. For longwall faces where the crusher/stageloader represents a major dust source, the application of a dust collector to capture the dust generated inside the crusher/stageloader enclosure would be appropriate.

CONCLUSIONS

1. A review of longwall dust control and operational practices indicate that the current industry trends to control occupational exposure to respirable dust include increased ventilation and increased use of automation.

2. If sufficient airflow capacity is available, increased ventilation can provide both short and long term solutions to dust control problems.

3. Long term dust control improvements can be achieved by increasing ventilation system capacity or by increasing the applications of automation.

4. Bidirectional cutting without full automation can cause occupational dust levels to either increase or decrease depending on the magnitude of the specific dust sources.

5. Headgate dust sources can be a significant contributor to occupational exposure. Headgate dust sources are not effected by automation.

6. Prior to instituting a change in mining cycle, a dust source and exposure analysis should be conducted to assess the impact on occupational dust levels.

TABLE 1. Summary of Longwall Dust Controls

	1ST GENERATION	2ND GENERATION
MINING CYCLE	UNIDIRECTIONAL	BIDIRECTIONAL
VENTILATION CONTROLS	400 fpm VELOCITY GOB & CUT OUT CURTAINS	10 x PRODUCTION (cfm)
SHEARER DRUM	1 SPRAY PER BIT @ 80 psi BIT DESIGN	HIGH PRESSURE SPRAYS FOAM THROUGH DRUM VENTILATED DRUM REVERSE DRUM ROTATION
SHEARER BODY	SHEARER CLEARER @ 125 psi	
CRUSHER/ STAGELOADER	ENCLOSURE- SPRAYS @ 80 psi	ENCLOSURE- DUST COLLECTOR @ 5,000 (cfm)
SHIELDS	MANUAL WASHDOWN	SHIELD MOUNTED SPRAYS
AUTOMATION	SHEARER REMOTE CONTROL	ELECTRO-HYDRAULIC SHIELDS
BARRIERS	BELTING ON MACHINE	FACE CURTAINS WATER CURTAINS

TABLE 2. Summary of Longwall Dust Control Implementation - June, 1994.

		NUMBER	PERCENT	COMMENTS
CONTROL/OPERATIONS		86		
CYCLE	UNIDIRECTIONAL	37	43	
	BIDIRECTIONAL	49	57	
VENTILATION	400 fpm	52	60	- 21 WESTERN
	>600 fpm	34	40	
DRUM SPRAYS	50 psi	12	14	
	100 psi	74	86	
	HP, ETC	0	0	
EXTERNAL SPRAYS	50 psi	12	14	
	>125 psi	74	86	
CRUSHER	NOT ENC	5	6	
	ENCLOSED	81	94	
	DUST COLL	5	6	- ALL WESTERN
SHIELDS	NO SPRAYS	69	80	
	SPRAYS	17	17	- AT FACE
REMOTE	SHEARER	80	93	
	SHIELDS	62	72	
BARRIERS	SHEARER	20	23	
	FACE	7	20	
	INFUSION	5	6	
SURFACTANTS		12	14	

TABLE 3. Effect of Ventilation and Mining Cycle on Exposure to Longwall Dust Sources.

SOURCE CYCLE/ CONTROL	INTAKE	HEADGATE	SHEARER	SUPPORTS
VENTI- LATION	Q1/Q2	Q1/Q2	Q1/Q2	Q1/Q2
UNIDI REMOTE SHEARER	100%	100%	25%	100%
BIDI REMOTE SHEARER	100%	100%	50%	50%
BIDI FULL REMOTE	100%	100%	25%	50%

TABLE 4. Contributions of Longwall Dust Sources to Dust Exposure (mg/m^3).

SOURCE/ CYCLE	INTAKE	HEADGATE	SHEARER	SUPPORTS	TOTAL
SOURCE	0.2	0.6	2.0	0.6	3.2
UNIDI REMOTE SHEARER	0.2	0.6	0.5	0.6	1.9
BIDI REMOTE SHEARER	0.2	0.6	1.0	0.3	2.1
BIDI FULL REMOTE	0.2	0.6	0.5	0.3	1.6

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