Update on face-ventilation research for improved longwall-dust control

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Introduction

Longwall mining equipment and operational practices have improved dramatically from the early 1980s through the mid-1990s. Longwall mining now accounts for approximately 50% of the coal produced underground in the United States. Average shift production has increased from approximately 1.36 kt/shift (1,500 st/shift) in 1983 to more than 2.9 kt/shift (3,200 st/shift) in 1994. Historically, longwall mining operations have had difficulty in maintaining compliance with mandatory federal dust standards. In the early 1980s, 31% of the compliance samples collected by the US Mine Safety and Health Administration (MSHA) exceeded the 2 mg/m^3 respirable dust standard. For fiscal year 1994, 20% of MSHA-collected samples exceeded the standard. Although significant gains in longwall dust control have been made, these have been overshadowed by the significant increases in coal extraction rates. The increase in coal extraction rates has been accompanied by a continuing effort to maintain compliance with the respirable dust standard. However, as more coal is mined, more dust is generated (Webster, 1990). The increase in longwall coal-extraction rates has meant that far more dust is being produced, which means that more dust must be controlled. Approximately 25% of longwalls today are capable of extracting in excess of 5.44 kt/shift (6,000 st/shift), with several capable of extraction rates in excess of 9 kt/shift (10,000 st/shift).

As with all mining methods, ventilation is the primary means to control dust and methane in longwall operations. Improved ventilation techniques for room-and-pillar mining have been well documented by both industry and government research. However, detailed scientific study of longwall face ventilation has often been overlooked. Only recently have face-ventilation parameters for longwall mining systems been studied and characterized. The Dust and Toxic Substances Control Branch, National Institute for Occupational Safety and Health, Pittsburgh Research Laboratory (NIOSH-PRL-DTSCB) recently completed a 10-year effort to identify and document the effectiveness of certain improved face-ventilation techniques for longwall operations. This has allowed for a thorough documentation of the changes that have taken place in longwall face-ven-

Abstract

Although the number of operating longwall mining systems has remained relatively constant, longwall production levels during the last five years have increased significantly. In the United States, longwall mining now accounts for approximately 50% of all underground coal production. While longwalls are highly productive and offer other advantages, operations employing this method of mining continue to experience dust-compliance problems. This increased longwall productivity has meant that far more dust is being produced. An improved understanding of the longwall face-ventilation system and the advancement of face-ventilation technologies are necessary to ensure all face personnel are allowed to work in an environment that is free of excessive levels of airborne respirable coal mine dust. The Dust and Toxic Substances Control Branch, National Institute for Occupational Safety and Health, Pittsburgh Research Laboratory, examined several basic principles of the longwall face-ventilation system and has evaluated the effectiveness of numerous improved face-ventilation techniques for longwall mining systems. These include identifying improved techniques for measuring face-ventilation parameters on longwall mining sections and investigating the fundamental relationship between face airflow and the entrainment and dilution of respirable coal mine dust. Studies have been completed to determine the impact on face dust levels of using belt entry air to ventilate the longwall. Novel methods have been identified to increase the face airflow and to manage face airflow to effectively minimize dust exposure to face workers. Unique systems of auxiliary face ventilation have been developed and evaluated at full-scale, simulated longwall test facilities. The theoretical and applied aspects of each of these principles and technologies are discussed. Application of these results throughout the longwall mining industry, as documented from surveys conducted in the early 1980s and 1990s, have reduced the health hazard associated with excessive exposure to respirable coal mine dust.

FIGURE 1

Longwall dust sources in the 1980s.

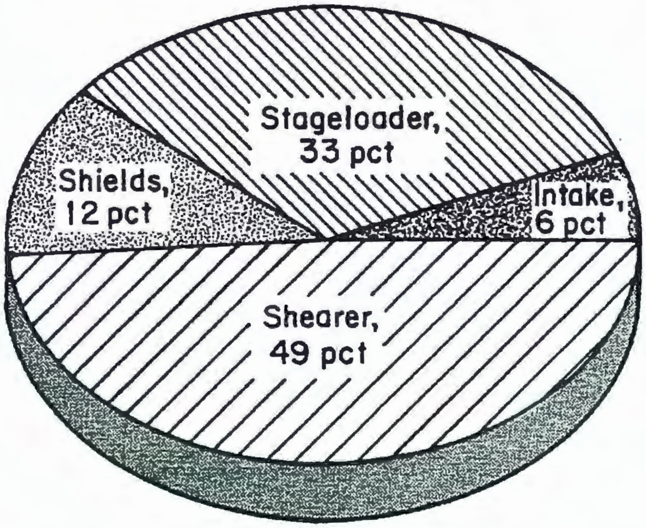
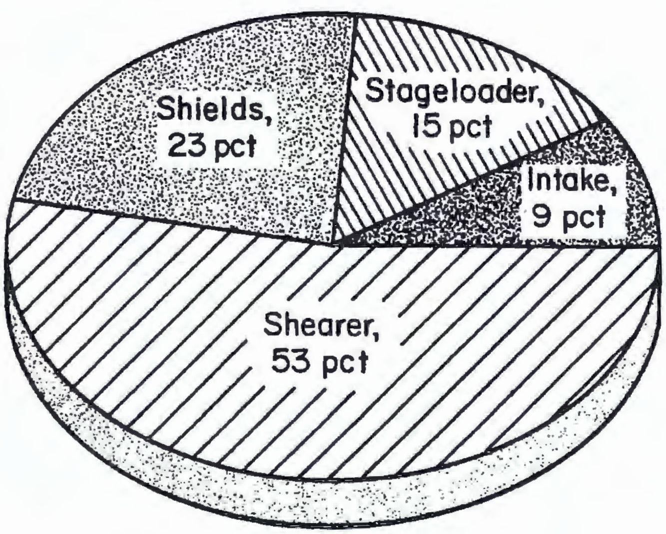


FIGURE 2

Longwall dust sources in the 1990s.



tilation practices and has allowed for an evaluation of its impact on face dust levels.

The issue of respirable dust control at longwall operations could present a major limitation on the application and extraction potential of this advanced mining technique, unless new and improved methods of face ventilation are developed and implemented. Consequently, greater operator commitment is being made toward reducing dust levels at existing operations through the application and maintenance of state-of-the-art face-ventilation technologies. Additionally, NIOSH is pursuing the advancement of ventilation technologies for dust control on future longwalls, to enable all face personnel to work in an environment that is free of excessive levels of respirable coal mine dust.

Longwall dust sources

To identify the sources and levels of respirable dust and to study the ventilation practices applicable to typical longwall faces, research was conducted in cooperation with the longwall mining industry in the 1980s (Jankowski and Organiscak, 1983) and again in the 1990s (Colinet and Jankowski, 1997). In both surveys, the cutting action of the shearer was identified as the primary source of respirable dust. Ventilating air quantity has been shown to impact respirable dust levels downwind of the shearer. Because the shearer is the largest dust source on the longwall, increasing the quantity of air supplied to the longwall is one of the most important changes that a longwall operator can make to improve dust levels. However, the contribution of dust from coal transport through the stage loader/crusher and the contribution of dust liberated during support advance are now found to be significant (Figs. 1 and 2). During the 1983 study, the open design of the crusher and modest levels of water application to the coal product allowed high levels of respirable dust to be generated and released into the primary airstream. By 1994, levels of water applied to the mined product had increased by 200%, and most stage loader/crushers were completely enclosed. However, face lengths and shearer tram speeds almost doubled. This required rapid and constant support advance with associated increasing levels of dust liberation. The impact of ventilation on support dust liberation has not been established.

Ventilation procedures developed and implemented to minimize dust levels

As with all mining methods, ventilation is the primary means for controlling dust on longwall operations. Providing adequate amounts of air to dilute and carry the airborne dust down the face and prevent its migration to the walkway has presented unique challenges for the longwall mining industry. At first glance, the ventilation of a longwall face appears deceptively simple: air comes in on one side, courses over the face and then exits. If workers are to be kept out of the dust, they are simply kept upwind of the dust sources. Unfortunately, there can be high-intake dust levels, air that leaks back behind the shields (especially near the shearer) and operators that need to see the downwind drum. All of these can place personnel in areas of high dust concentrations. Researchers in cooperation with the longwall mining industry have identified and documented the effectiveness of certain improved face-ventilation techniques for longwall operations. These studies have shown that assessment of the primary intake alone is not sufficient. The direction and utilization of the primary airflow is critical for dust control. Substantial improvements can be obtained through application of these advanced techniques.

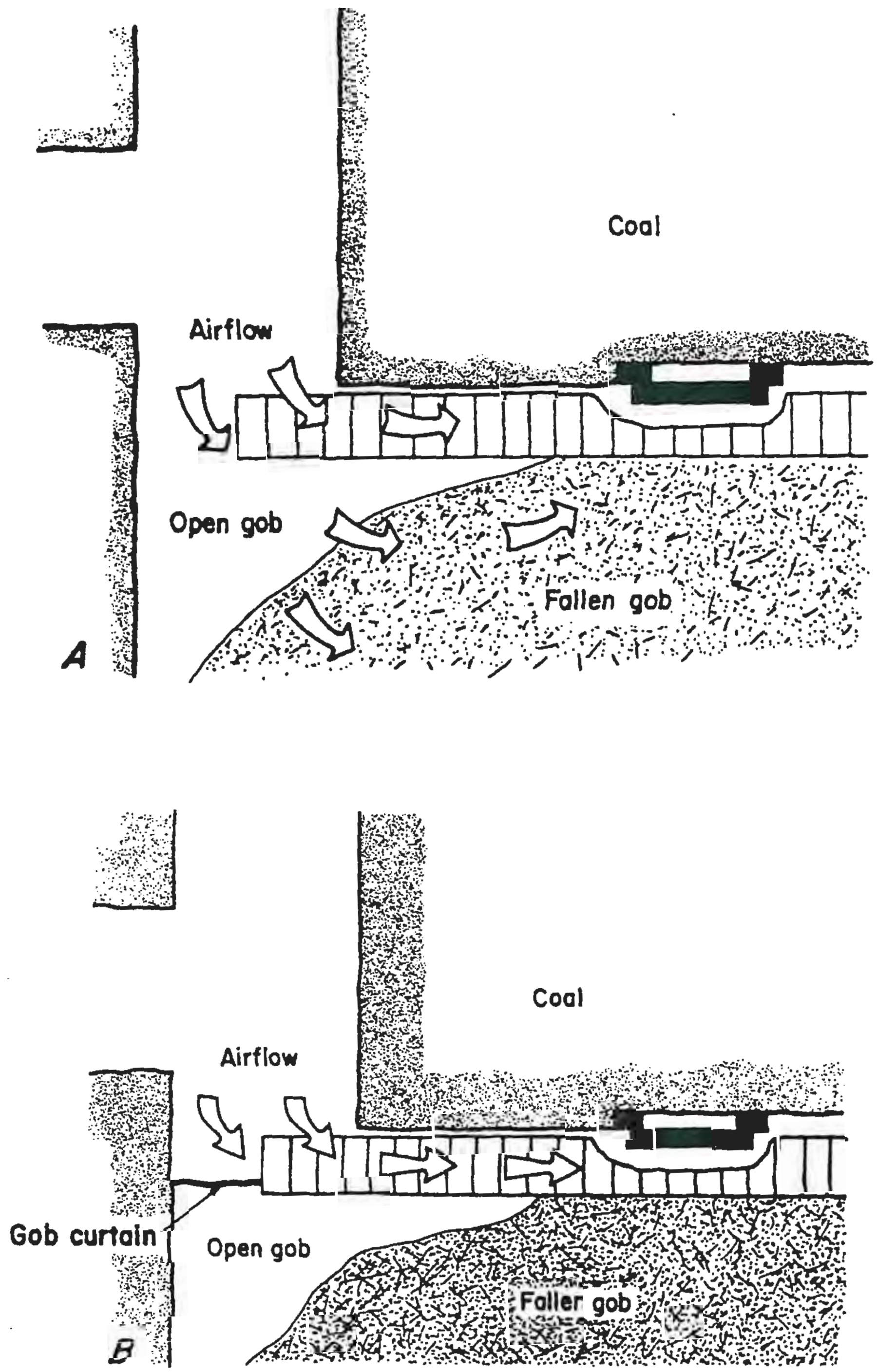
Higher air quantities and volumes help control airborne dust. In most longwall operations, the face airflow is usually measured at the crosscut in the headgate entry. Although this intake quantity often exceeds 14.2 m^3/sec (30,000 cfm), this measurement is often not representative of face airflow. Ventilation measurements should be taken at every tenth support. The resulting profile can be used to determine the "average" face airflow, the effective utilization of the primary intake and the air loss to the gob. Airflow along the face is seldom uniform. A measurement at any single location may not be representative of the average face airflow. With a ventilation profile, the mine operator can discover problem areas and more accurately determine the specific ventilation parameters on a given longwall face.

Face air velocities of at least 2 to 2.3 m/sec (400 to 450 fpm) appear to be the minimum appropriate for dust control (Mundell et al., 1979). Once again, these values are for the average face-velocity profile and should be maintained for the entire face length. With optimum air utilization, these values would equal minimum average intake-air quantities of 9.4 m^3/sec (20,000 cfm) for a 1.5-m (5-ft) coal seam and 14.2 m^3/sec (30,000 cfm) for a 2.1-m (7-ft) seam. In the past, air velocities above 3.3 m/sec (650 fpm) were thought to cause entrainment of dust from coal transport and dust liberation during support movement. Recent studies by MSHA (Tomb et al., 1992) now show that, as face air quantities increase, even beyond 6.1 m/sec (1,200 fpm), respirable dust levels due to dust generated along the face decrease. NIOSH is now attempting to identify a cooperative mine site at which to conduct further studies of the impact of air velocity increases on dust entrainment along the face.

Minimum average face air velocities of 2 to 2.3 m/sec (400 to 450 fpm) help to control respirable dust in three ways. The higher air velocities provide greater air quantities for better dilution of intake dust as well as dust generated during support movement. Higher velocities over the shearer help to confine the dust to the face area and lower contamination in the walkway. Finally, these higher velocities improve diffusion of dust from stagnant areas in the headgate and along the support line.

FIGURE 3

Location of gob curtain at longwall headgate.



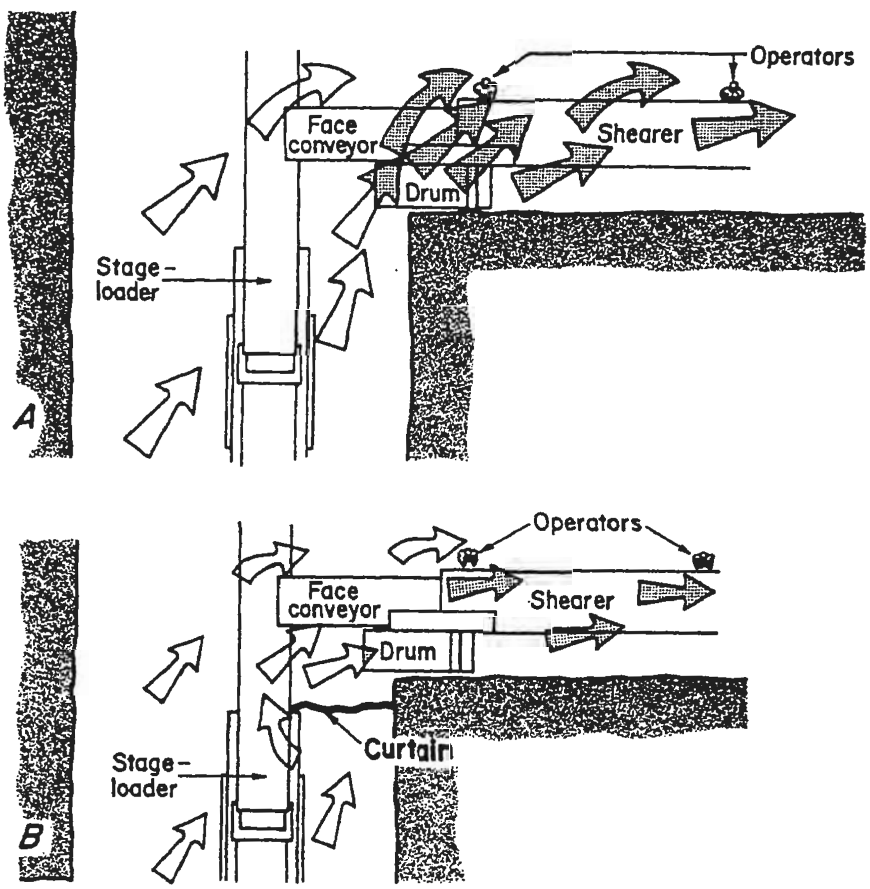
Curtains in headgate provide better direction of primary airflow. Often, loss of air into the gob in the headgate area prevents the maximum utilization of the air available to ventilate the longwall face. The gob behind the first few supports remains open owing to the roof bolts in the headgate entry, and a large gap usually exists between the first support and the entry rib. As a result, a substantial portion of the ventilation air from the headgate entry leaks back into the gob, lowering the airflow along the face. Moreover, this air laden with dust generated during gob falls may reenter the face area, compounding the dust problem.

A gob curtain installed between the first support and the rib in the headgate entry can force the ventilation airstream to make a 90° turn, staying on the face side of the supports rather than leaking into the gob. The curtain is suspended from the roof to the floor and advanced with the supports at each pass.

Previous researchers (Jankowski and Organiscak, 1983) collected extensive face air-velocity data with and without the gob curtain in use. The average face air velocity with the curtain installed was approximately 35% greater than without the curtain. The biggest improve-

FIGURE 4

Location of cutout curtain at longwall headgate.



ment due to this curtain is seen at the first 25 to 30 supports, where the increased air volume lowers dust concentrations through dilution. The gob curtain is easy to use, install and maintain. And it is fabricated from material that is readily available in all mines (Fig. 3).

In many longwall operations, misapplication of the primary airflow may actually contribute to increased dust levels. One source of extreme concentrations of respirable dust for longwall shearer operators is the headgate shearer drum as it cuts through into the headgate entry. As the drum cuts into the entry, it is exposed to the primary ventilation airstream. The high-velocity air passes through and over the drum, picking up large quantities of dust. This dust is carried into the walkway and over the shearer operators. Although this operation is usually of short duration, the resulting dust levels are extremely high. Concentrations ranging from 20 to 30 mg/m^3 have been measured at several mines using instantaneous dust monitors at the operator position. Thus, the cumulative effect on full-shift exposure levels can be significant, particularly on high-production faces where this operation may be performed six to eight times a shift.

To overcome this problem, some coal mine operators use a "cutout" curtain in the headgate to shield the lead drum from the ventilation airstream as it cuts out into the headgate. The curtain redirects the primary air so that it flows out and around the drum. The curtain is usually located 1.2 to 1.8 m (4 to 6 ft) back from the corner of the face, so that maximum shielding is provided without interference with the drum. The curtain is suspended from the roof between the panel side rib and the stageloader. It only needs to be in place during the actual cutout operation and is advanced every other pass (Fig. 4).

Previous researchers (Jankowski, 1986) conducted underground evaluations to document the improvements achieved through installation of a cutout curtain. Dust levels at the operator positions were monitored using instantaneous dust monitors. Concentrations monitored with and without the curtain indicated that the curtain can reduce the exposure of the tailgate shearer drum operator by 50% to 60% during this phase of the mining cycle. To achieve these improvements, the curtain must be installed tightly against the mine roof and it must extend sufficiently into the headgate entry.

Impact of belt entry air. An increasing number of mines are either using or petitioning to use belt entry air to ventilate active longwall face areas. Using the belt entry as an intake entry may allow delivery of more air to the face, providing better dust and methane dilution. NIOSH, as part of its goal to improve the health of miners, recently conducted underground dust surveys to further explore this topic (Potts and Jankowski, 1992). Results of these studies have shown that a 300-m (1,000-ft) increase in belt entry length or a 181- to 453-t/shift (200- to 500-st/shift) increase in production resulted in roughly a 0.1-mg/m^3 increase in dust. Dust levels inby the belthead appeared to be independent of belt entry airflow over the range of airflow observed during the surveys. During the 1993 study, six of the operations surveyed were using belt air to ventilate the longwall face. The average dust level in the belt entry just outby the stage loader was 0.6 mg/m^3, while the average intake concentration was 0.5 mg/m^3. Any potential increase in face intake dust levels appears to be negated by the potential for increased dilution that can be obtained with additional air brought up the belt entry.

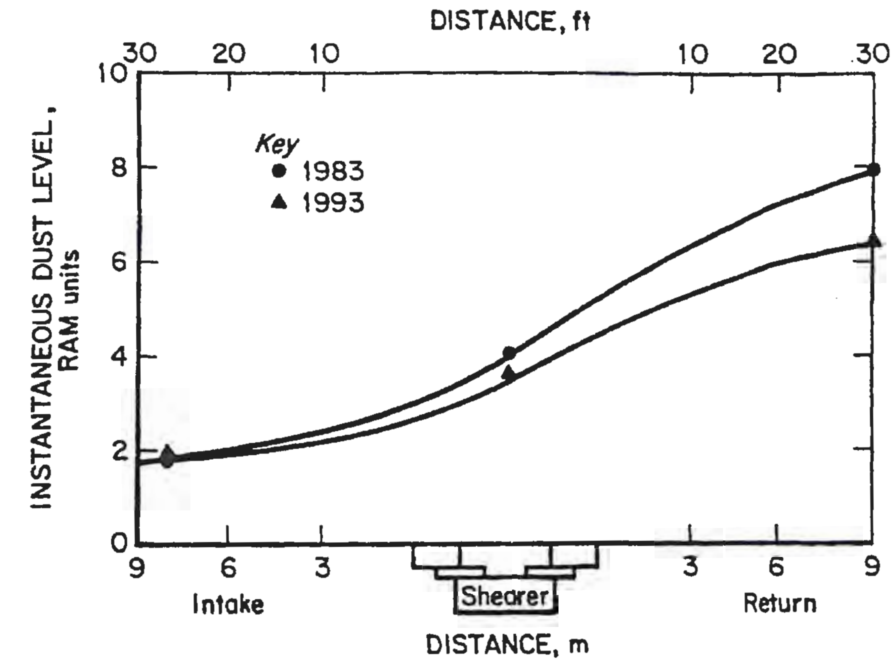
Compliance data analyzed by MSHA (1989) indicated that mines using belt entry air to ventilate work areas did not have significantly different respirable dust levels at the designated occupation than mines not using belt air. According to MSHA, in one district, mines using belt entry air had a significantly lower mean dust concentration than mines not using belt air. From a theoretical standpoint, applying the dilution formula shows that, if belt entry air represents additional air brought to the face and if belt entry dust levels, including those at the stage-loader and crusher, can be maintained below the

,average dust level measured at the designated occupation, it is beneficial from a dust-compliance perspective for the mine to use belt entry air to ventilate work areas.

Using the belt entry as an additional source of intake air results in an increased number of outby dust sources. The conveyor belt itself is a source of dust and the stageloader and crusher are always in intake air if the belt entry is used to ventilate the face. Researchers conducted extensive research and have demonstrated effective technology to control dust from these sources (Organiscak, 1982).

FIGURE 5

Directional water-spray systems augment primary face airflow.



Impact of water-spray systems on face-ventilation effectiveness

Design and operational parameters of the shearer water-spray system can have a significant impact on face-ventilation effectiveness. Water sprays oriented perpendicular to or upwind into the primary ventilation can cause high levels of dust to be transported away from the face area and into the primary airstream. Water sprays are very efficient air movers and, if applied properly, can be used to augment the primary airflow and reduce the amount of shearer-generated dust that is transported into the face walkway.

Operating spray pressure. All shearer cutting drums in operation since the late 1970s have been equipped with drum-mounted water sprays. The purpose is to apply water for dust suppression directly at the point of coal fracture and to add moisture to the product to minimize dust liberation during coal transport off the longwall face. Once respirable dust becomes airborne and is released into the primary airstream, it remains airborne the entire length of the longwall face. Although very effective at minimizing dust generation at the point of coal fracture, shearer drum water sprays can actually increase airborne respirable dust levels if operated at too high a water pressure. Instead of suppressing dust generation, these sprays force the dust out away from the cutting drum, and allow it to mix with the primary airflow, where it is then carried throughout the entire cross-sectional volume of the longwall face. Studies (Piemental et al., 1984) have shown that increasing shearer drum water-spray pressures above 700 kPa (100 psi) can increase the shearer operators dust exposure by 25%. At operating pressures exceeding this level, the drum sprays force dust out away from the face and overwhelm the dilution capacity of the primary ventilation. The optimum operating drum spray pressure appears to be between 480 to 700 kPa (70 to 100 psi). Water flow rate should be increased by increasing the nozzle orifice size rather than the operating spray pressure.

Air-directional water-spray systems. Water sprays are very effective air-moving devices. Water sprays mounted on the shearer body act very much like small fans, moving air and entrained dust in the direction of their orientation. Poorly designed shearer-mounted spray systems with nozzles directed upwind at the cutting drum actually carry the dust away from the face and upstream of the drum, where it mixes with the clean intake air and is carried out into the walkway over the shearer operators.

Researchers have devised a novel shearer-spray system, called the shearer clearer (Jayaraman et al., 1985). The system takes advantage of the air moving capabilities of water sprays. It consists of several shearer-mounted water sprays oriented downwind to augment the primary ventilation airflow. And it consists of one or more passive barriers that split the airflow around the shearer into clean and contaminated air splits. The air split is initiated by a splitter arm, extending from the gob-side corner of the shearer body, from which conveyor belting hangs down to the panline.

Spray manifolds mounted on the splitter-arm confine the dust cloud generated by the cutting drum, further enhancing the air split. The dust-laden air is drawn over the shearer body and is held against the face by two spray manifolds positioned between the drums. The air is then directed around the downwind drum by a set of sprays located on a downwind splitter arm. Operating pressure must be approximately 1.03 MPa (150 psi), measured at the nozzle, to assure effective air movement.

In underground tests, the shearer clearer has reduced operator exposure from shearer-generated dust by approximately 50% when cutting against face ventilation and by 30% when cutting with ventilation. Although a properly installed and operated shearer-clearer system controls dust at the operator's position more effectively than does a conventional spray system, it cannot com-

TABLE 1

Summary of longwall operating parameters and dust levels for mines A through L*.

	A	B	C	D	E	F	Avg.
Headgate dust level, mg/m³							
1983	1.1	1.2	1.8	1.6	1.8	1.2	1.5
1993	1.4	1.0	1.8	2.1	1.2	0.6	1.4
Tailgate dust level, mg/m³							
1983	5.4	5.1	5.5	8.4	6.1	1.8	5.9
1993	2.7	2.9	5.6	3.0	3.0	1.0	3.2
Face velocity, m/sec							
1983	1.7	2.0	1.2	2.4	0.6	3.3	1.9
1993	1.9	1.5	1.1	3.0	2.7	3.8	2.3
Face length, m							
1983	190	147	176	161	163	163	166
1983	238	168	176	224	212	224	207
Extraction rate, t/min							
1983	15.8	8.2	11.9	9.5	15.5	10.1	11.8
1993	23.1	18.9	31.5	21.0	26.6	11.3	20.1
Belt air used to ventilate, yes or no							
1993	No	No	No	Yes	Yes	Yes	–

	G	H	I	J	K	L	Avg.
1983 data							
Headgate dust level, mg/m³	1.6	1.2	1.0	1.6	1.3	2.6	1.6
Tailgate dust level, mg/m³	10.9	7.2	4.2	8.2	4.3	8.4	7.2
Face velocity, m/sec	1.8	1.2	1.8	1.4	1.0	1.3	1.4
Face length, m	127	138	138	138	148	127	135
Extraction rate, t/min	8.8	8.0	8.5	10.0	5.2	9.2	8.3

	G	H	I	J	K	L	Avg.
1993 data*							
Headgate dust level, mg/m³	0.9	0.8	1.1	1.4	0.4	1.0	0.9
Tailgate dust level, mg/m³	1.7	3.2	2.1	3.3	2.2	10.0	3.8
Face velocity, m/sec	1.9	2.5	1.5	1.8	2.3	1.6	1.9
Face length, m	184	260	240	193	284	176	224
Extraction rate, t/min	12.4	30.6	21.7	35.4	24.2	14.3	23.1

*Mines A through F represent the same mines sampled in both 1983 and 1993. For Mines G through L, the 1993 data represent different mining operations but similar mining regions across the United States and were only used to identify generalities drawn from analyses between these data sets.

pensate for insufficient primary ventilation nor can it reduce operators exposure from other dust sources.

Shearer cooling water has historically been discharged through spray nozzles oriented against the primary airflow or directed into the face, causing dust to be carried back into the walkway. An alternative for discharging cooling water is panline spray manifolds mounted at both ends of the shearer and aimed down onto the panline. This minimizes turbulence caused by face side sprays. Respirable dust reductions of up to 35% at the shearer operators location can result (Jayaraman et al., 1985).

Assessment of changes in face-ventilation practices

As previously stated, researchers at NIOSH's Pittsburgh Research Laboratory conducted extensive in-mine surveys that can be used to obtain insight into the changes that have taken place in longwall face-ventilation practices. As part of this research, NIOSH conducted an evaluation of the impact of these changes on face dust levels at operating longwalls from the early 1980s to 1990s. Twelve longwalls representing eastern, midwestern and western US coal mining regions were surveyed during each time period. The longwalls surveyed represent a cross section of conditions existing during each period. Several generalities can be drawn from analysis of these data sets, and certain specifics can be obtained from six mines that were surveyed during both surveillance periods.

Based on MSHA compliance records (Niewiadomski and Jankowski, 1993) for all longwalls operating in the early 1980s, 31% of the longwall designated occupation (DO) samples exceeded the respirable dust standard, with an average value of 2.3 mg/m³. For fiscal year 1994, 20% of MSHA-collected DO samples exceeded the respirable dust standard with an average value of 1.7 mg/m³ (Niewiadomski, 1996), for a typical dust reduction of 26%. As previously stated, during the same time period, coal-extraction rates increased from approximately 1.36 to 2.95 kt/shift (1,500 to 3,250 st/shift), for an average increase of 117%.

Tables 1 and 2 list a summary and averages of longwall ventilation parameters and dust levels from the 12 operations surveyed during the two surveillance periods. In general, these values are in good agreement with national averages reported yearly and with results of a 1995 survey of high-production longwall mining sections (Jankowski et al., 1994). On average, results of this study indicate that the average face air velocity has increased by approximately 27%, from 1.7 m/sec (327 fpm) in 1983 to 2.1 m/sec (415 fpm) in 1993. When comparing only the six longwalls surveyed during both periods of surveillance, average face air velocity has increased by 20%, from 1.9 m/sec (374 fpm) in 1983 to 2.3 m/sec (453 fpm) in 1993. Results of a similar study showed the average face air velocity on longwalls increased by 0.5 m/sec (100 fpm) during the same time period. During the same time period, longwall panel face lengths increased by approximately 40%. This means that, on average, longwall mine operators were delivering about 4.7 m^3/sec (10,000 cfm) more air to the longwall panel in 1993 than was being delivered in 1983.

When comparing changes in dust levels during the same time period, average dust levels at the tailgate location decreased by approximately 47%, from 6.6 mg/m^3 in 1983 to 3.5 mg/m^3 in 1993. Similar dust reductions (46%) are observed when comparing only the six longwalls surveyed during both surveillance periods. Headgate dust levels decreased approximately 25%.

A comparison of these statistics makes it apparent that significant gains have been achieved in the area of longwall dust control. However, applying a simple dilution formula for ventilation cannot explain the magnitude of dust-level reductions observed. Coal extraction rates have increased approximately 120%. As stated above, when more coal is mined, more dust is generated. There are a number of factors in addition to ventilation that have allowed the longwall industry to advance extraction rates while continuing to reduce respirable dust levels along the longwall face.

Obviously, the increases in face air velocity and quantity have contributed, as have the changes in machine design, increases in water application and the use of remote control. However, the longwall mining industry has adopted and implemented a broader, more scientific approach to longwall face ventilation, based on results of the research conducted during the past decade. Face air velocities in the range of 2 to 2.5 m/sec (400 to 500 fpm), as observed during the surveys conducted in the 1990s, appear to be most appropriate for dust control. As noted previously, these higher air velocities provide greater air quantities for better dilution of intake dust as well as dust generated during support movement. Higher velocities over the shearer help to confine the dust to the face area and lower contamination in the walkway. And, finally, these higher velocities improve diffusion of dust from stagnant areas in the headgate and along the support line.

Projections from recent surveys suggest that half of the longwalls in operation today use the belt entry to bring intake air to the longwall face. Doing so results in an average face air quantity of approximately 25.8 m^3/sec (55,000 cfm). More than 90% of the longwall faces in operation today use headgate curtains to assist in directing the primary intake onto the face, avoiding air loss to the gob in the headgate area. Average face air velocities can be significantly improved through the installation of headgate curtains.

TABLE 2

Percent change from 1983 to 1993 for longwall operating parameters.

Parameter	All mines surveyed	Six mines surveyed
Average headgate dust level, mg/m^3		
1983	1.6	1.5
1993	1.2	1.4
Change	25%	7%
Average tailgate dust level, mg/m^3		
1983	6.6	5.9
1993	3.5	3.2
Change	47%	46%
Average face velocity, m/sec		
1983	1.7	1.9
1993	2.1	2.3
Change	27%	20%
Average face length, m		
1983	150	165
1993	215	207
Change	43%	25%
Average extraction rate, t/min		
1983	10.1	11.8
1993	21.6	20.1
Change	114%	70%

As previously stated, design and operational parameters of the shearer water-spray system can have a significant impact on face ventilation effectiveness. Results of this study have shown that the longwall mining industry has thoroughly embraced this development. More than 95% of the longwalls in operation today have implemented some type of air-directional water-spray system on the shearer to augment the primary face airflow, to confine shearer-generated dust to the face area and to lower dust levels in the face walkway. This concept and its acceptance and application by the industry is illustrated in Fig. 5. The average respirable dust profiles around the shearer are shown for the six mines that were surveyed during both surveillance periods. The average respirable dust level 6 m (20 ft) on the intake-air side of the shearer remain unchanged and are not impacted significantly by the air-directional water-spray system on the shearer body. However, the respirable dust level at the midpoint of the shearer and 12-m (40-ft) downwind of the shearer have been reduced by 20% to 25%.

Summary

During the early 1980s, many longwall mining operations did not optimize the application and utilization of the primary face airflow as a method to reduce respirable dust levels along the face. During the past decade, considerable research has been conducted to identify and document the effectiveness of several improved face-ventilation techniques, and the longwall mining industry has aggressively applied results of these research developments. Providing adequate amounts of air to dilute and carry the airborne dust down the face and prevent its migration to the walkway has presented unique challenges for the longwall mining industry. NIOSH, in cooperation with the longwall mining industry, has identified and documented the effectiveness of certain improved face-ventilation techniques for longwall operations. Researchers at NIOSH's Pittsburgh Research Laboratory conducted extensive in-mine surveys that can be used to obtain insight into the changes that have taken place in longwall face-ventilation practices. An evaluation of the impact of these changes on face dust levels at operating longwalls from the early 1980s to 1990s was also conducted.

Face air velocities of at least 2 to 2.3 m/sec (400 to 450 fpm) appear to be the minimum appropriate for dust control. Minimum average face air velocities in this range help to control respirable dust in three ways. The higher air velocities provide greater air quantities for better dilution of intake dust as well as dust generated during support movement. Higher velocities over the shearer help to confine the dust to the face area and lower contamination in the walkway. Finally, these higher velocities improve diffusion of dust from stagnant areas in the headgate and along the support line. Average face air velocity has increased by approximately 27%, from 1.7 m/sec (327 fpm) in 1983 to 2.1 m/sec (415 fpm) in 1993. Longwall mine operators are delivering approximately 0.5 m^3/sec (10,000 cfm) of additional air to the longwall panel in 1993 than was being delivered in 1983. Often, loss of air into the gob in the headgate area prevents maximum utilization of the air available to ventilate the longwall face. A substantial portion of the ventilation air from the headgate entry leaks back into the gob, lowering the airflow along the face. A gob curtain installed between the first support and the rib in the headgate entry can force the ventilation airstream to make a 90° turn, staying on the face side of the supports, rather than leaking into the gob. An increasing number of mines are using belt entry air to ventilate active longwall face areas. Using the belt entry as an intake entry may allow delivery of more air to the face, providing better dust and methane dilution.

Design and operational parameters of the shearer water-spray system can have a significant impact on face-ventilation effectiveness. Water sprays are very effective air-moving devices. Water sprays mounted on the shearer body act very much like small fans, moving air and entrained dust in the direction of their orientation. A typical shearer-clearer system design consists of several shearer-mounted water sprays oriented downwind and one or more passive barriers to divide the airflow around the shearer into clean and contaminated air splits. Results of this study have shown that the longwall mining industry has thoroughly embraced this development. Respirable dust levels at the midpoint of the shearer, and 12 m (40 ft) downwind of the shearer have been reduced by 20% to 25%.

These statistics make it apparent that significant gains have been achieved in the area of longwall dust control. Average dust levels at the tailgate location have decreased by approximately 47%, from 6.6 mg/m^3 in 1983 to 3.5 mg/m^3 in 1993. The longwall mining industry has adopted and implemented a broad scientific approach to longwall face ventilation based on results of the research conducted during the past decade. Continuing joint research efforts are under way that should represent the next generation of longwall face-ventilation technology and enable all face personnel to work in an environment that is free of excessive levels of respirable coal mine dust. ■

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