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REPORT OF INVESTIGATIONS/1995

Dust Sources and Controls for Multiple-Machine Longwall Faces

UNITED STATES DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES

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UNITED STATES DEPARTMENT OF THE INTERIOR
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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

Metric Units

h	hour	m^3/s	cubic meter per second
m	meter	mg/m^3	milligram per cubic meter
m/min	meter per minute	min	minute
m/s	meter per second		

U.S. Customary Units

cfm	cubic foot per minute	ft	foot
fpm	foot per minute	in	inch

DUST SOURCES AND CONTROLS FOR MULTIPLE-MACHINE LONGWALL FACES

By Jay F. Colinet[1] and Ellsworth R. Spencer[2]

ABSTRACT

Longwall mining in lower seam heights may necessitate the use of single-drum shearers to overcome size constraints associated with standard double-drum shearers. To avoid the operational problem of clearance in the tailgate entry with one single-drum shearer, two single-drum machines can be operated on the same face, with each shearer responsible for mining a predefined portion of the face. However, utilization of two shearers on the same face necessitates the positioning of one shearer operator and a jacksetter in the return air of the upwind shearer, thus complicating respirable dust control on the longwall. In an effort to evaluate the unique dust control problems associated with this type of mining, the U.S. Bureau of Mines conducted dust surveys on two multiple-machine longwall operations. Sampling was done to quantify major sources of respirable dust and to identify potential solutions to problem areas. Sampling results indicate that the cutting sequences utilized on multiple-machine faces may have to be designed to minimize dust exposure, as opposed to optimizing productivity or facilitating operational requirements. Also, state-of-the-art dust control techniques typically found on double-drum shearer longwalls must be employed to help minimize the exposure of all face personnel to traditional dust sources.

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INTRODUCTION

Utilization of two single-drum shearers on the same face was initially implemented for the development of advancing longwall faces in Europe. Information provided by officials of British Coal indicated that the two primary functions of the second shearer on the face were to advance the gate-road entry and to cut a small portion of the face. In the United States where retreat mining is employed, the use of single-drum shearers is limited to longwalls having a lower seam height, where there is not enough clearance under the typical double-drum shearer to transport the coal efficiently. If only one single-drum shearer is used on the face, the shearer body must travel into the tailgate entry to allow the shearer drum to complete the cutout at the tailgate end of the face. However, most tailgate entries require substantial cribbing for roof support and, therefore, do not provide sufficient clearance for the shearer body. As a result, a second single-drum shearer is added to the face to facilitate completion of the cutout at the tailgate.

The use of two single-drum shearers allows for longwall mining in seam heights lower than those possible with standard double-drum shearers and eliminates the problem of machine clearance around roof support in the tailgate entry; single-drum shearers can be used in softer floor conditions than in-web, double-drum shearers and typically offer better horizon control than in-web machines. Another advantage of multiple-machine longwalls is that when one machine shuts down for routine maintenance or for minor breakdowns, production from the face can continue with the second shearer.

Operation of a multiple-machine face does have several disadvantages compared with a single-machine face: The mined material from the tailgate shearer must pass under the frame of the headgate shearer, additional personnel are required to operate the second shearer, maintenance costs are incurred for two shearers, and some workers are positioned downwind of an operating shearer. Also, current Mine Safety and Health Administration (MSHA) policy allows only one shearer to cut at any given time, so that the full cutting potential of both shearers cannot be realized.

In the United States, a typical cutting sequence for multiple-machine faces has each shearer cut approximately one-half of the face. Consequently, the downwind shearer operator and jacksetter are exposed to dust levels produced by cutting and cleaning with the upwind shearer. The potential for aggravated dust control problems associated with this unique type of mining led the U.S. Bureau of Mines (USBM) to investigate dust generation and control relative to multiple-machine longwall mining, as part of its mission to improve mine health and safety.

Underground dust surveys were conducted on two multiple-machine longwall operations to quantify the dust generated by the various sources on these faces and identify the dust control techniques being used. Also, information on the cutting sequences, personnel deployment, and general operating practices was obtained. The information gathered during these surveys is used to compare relative dust levels from multiple-machine operations, identify unique practices and controls used on multiple-machine operations, and suggest ways to minimize worker dust exposure on multiple-machine longwalls.

At the outset of this research program, four multiple-machine faces were operating in the United States. As a result of mine closures, only two multiple-machine faces are operating at present.

DESCRIPTION OF MINES SURVEYED

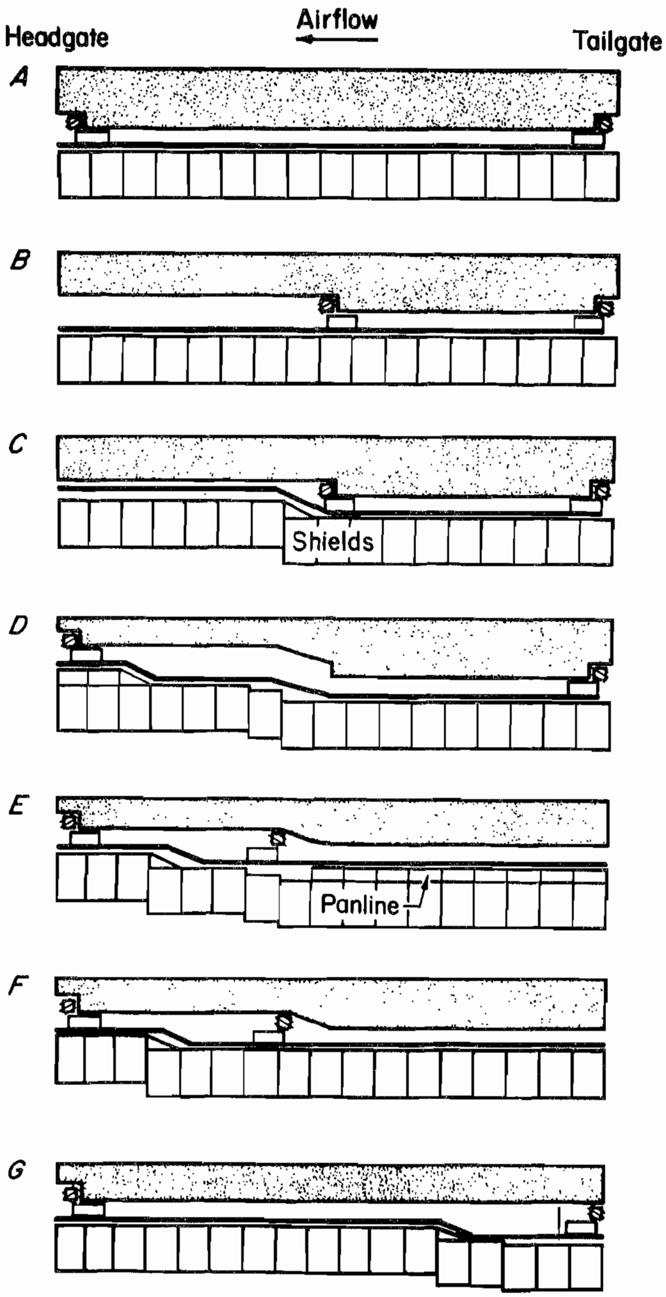
Two multiple-machine longwalls were surveyed, which have been designated as mine A and mine B. Mine A was located in the Midwest, and mine B was located in the East. A description of the general conditions and the cutting sequence is presented for each mine.

MINE A

The longwall panel at mine A was approximately 198 m (650 ft) wide, and the mining height ranged from 1.14 to 1.27 m (45 to 50 in). The web depth of the shearer drums was 0.76 m (30 in), and the average tram rate during cutting was 5.2 m/min (17 fpm). The tailgate entry was used as the intake air entry so that airflow on the face was from tail to head. The two single-drum shearers were equipped with back-face-flushing, full-cone sprays on the drums. External water sprays on the face side of the machines were used to discharge cooling water toward the coal face. Neither shearer was equipped with splitter arms or belting. Each shearer was used to cut approximately one-half of the face with a bidirectional cutting sequence.

Figure 1 illustrates the various stages in the typical cutting sequence observed at mine A. For the baseline position (*A*), the panline has been advanced and both shearers have sumped at their respective ends of the face. At the beginning of the sequence (*B*), the headgate shearer cuts to approximately the midpoint of the coal face. The shields are advanced behind the shearer, and then the panline is advanced (*C*) in preparation for the return cut. The headgate shearer then sumps and cuts to the headgate (*D*), with the shields once again advanced behind the shearer. A portion of the panline is also moved forward. After the headgate shearer has sumped into the coal face at the headgate, the tailgate shearer completes a cut to midface just beyond the sump location of the headgate shearer (*E*). The shields are advanced behind the shearer, and the panline is pushed forward in preparation for the return cut (*F*). As the tailgate shearer cuts to the tailgate, the shields are advanced and the panline is pushed forward (*G*). The tailgate shearer then sumps at the tailgate, and the cut sequence is ready to start again (*A*). Only one shearer was operated at any given time to comply with MSHA policy.

Figure 1



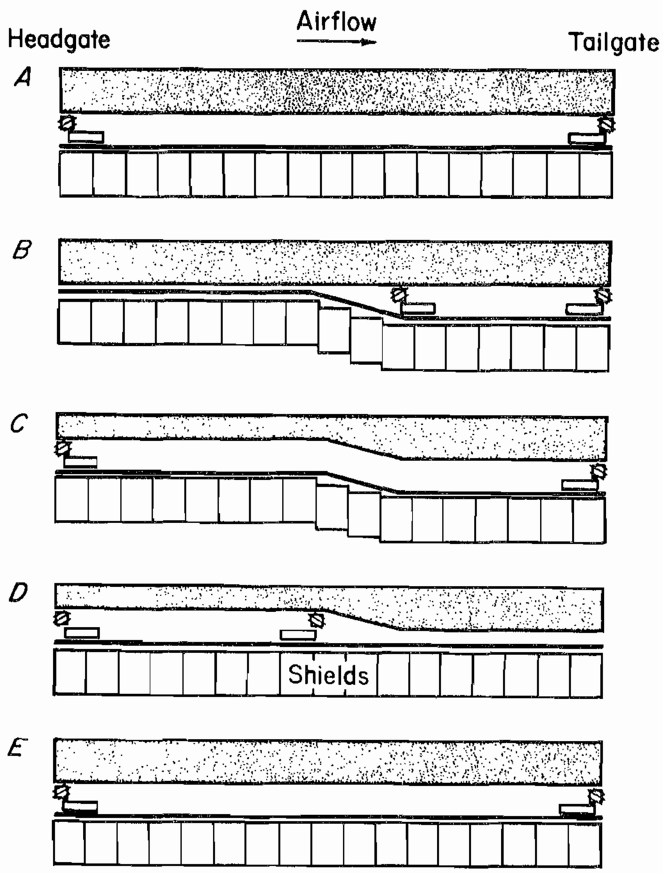
Cutting sequence at mine A.

MINE B

The longwall panel at mine B was approximately 183 m (600 ft) wide, and the mining height ranged from 1.09 to 1.27 m (43 to 50 in). The web depth for the shearers was 0.91 m (36 in), and the average tram rate during cutting and cleaning passes was 5.5 m/min (18 fpm) and 6.1 m/min (20 fpm), respectively. Airflow on the face was from head to tail. Each shearer was equipped with sprays installed in pipe manifolds mounted on the hub of each shearer drum. Four external sprays located on the face side of the machines were used to discharge cooling water toward the coal face. The headgate shearer was also equipped with a splitter arm containing eight sprays. Vertical belting was suspended from the splitter arm. Each shearer on the face was used to cut approximately one-half of the face.

For mine B, a unidirectional cutting sequence was completed by each shearer, which is illustrated in figure 2.

Figure 2



Cutting sequence at mine B.

At the outset of a cycle (*A*), each shearer is positioned at the gate entries. The headgate shearer completes a cleanup pass from the headgate to the midpoint, with the shields and panline advanced behind the shearer (*B*). A cutting pass from midface to the headgate is then completed (*C*). Likewise, the tailgate shearer cleans from the tailgate to midface, with the shields and panline advanced (*D*). The tailgate shearer then completes a midface-to-tailgate cutting pass (*E*). MSHA policy permitted both shearers to be operating at the same time so long as only one shearer was cutting. The second shearer was permitted to clean up or tram as needed while the primary machine continued to cut.

SAMPLING PROCEDURE

The original sampling procedures developed for these surveys utilized gravimetric and instantaneous samplers with stationary and mobile sampling protocol (*1*).[3] Samplers were to be mounted at fixed-point locations and also suspended from each of the shearers. Typically, two gravimetric samplers and one instantaneous sampler were placed at each sampling location. It should be noted that for both mines the sampling duration on any shift did not exceed 5.5 h, and therefore, the gravimetric sampling results do not relate to MSHA compliance sampling. Also, all reported dust concentrations are actual concentrations and are not adjusted to a Mining Research Establishment (MRE) equivalent.

Real-time aerosol monitors (RAM's) were the instantaneous dust samplers used to supplement gravimetric sampling (*2*). RAM samplers utilize light scattering to determine relative dust levels on a real-time basis. These dust levels are recorded on a data logger and can be downloaded onto a computer for analysis. Time study information is collected on the face so that operations of interest (cut, cleanup) can be isolated for analysis. Extended shearer downtimes can also be eliminated so that dust concentrations representing actual mining time can be used for analysis. Because RAM samplers provide a relative dust measurement that can be affected by coal or rock type and airborne moisture, the relative RAM data are adjusted based upon the gravimetric concentrations measured at the same location as the RAM. A ratio determined by dividing the gravimetric concentration by the RAM concentration is used to adjust the relative RAM dust levels.

In addition to dust data, information on the quantity and velocity of face airflow was obtained on a shift-to-shift basis. Spot air velocity readings and/or traverse readings were obtained at multiple locations on the face during each shift.

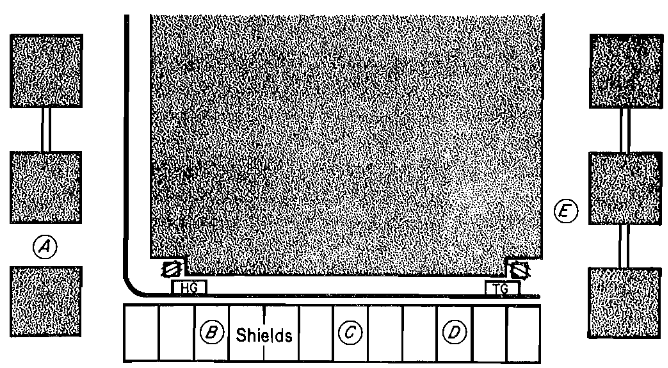
MINE A

The dust-sampling strategy included the use of RAM and gravimetric samplers at four positions on the face. One RAM and two gravimetric samplers were located at each of the following locations (see figure 3): headgate shearer, tailgate shearer, shield 121 (*D*), and shield 10 (*B*). Since the primary intake entry in this mine was at the tailgate, the tailgate shearer was operating upwind of the headgate shearer, with shield 10 representing the return air sampling location. These samplers were started as soon as the sampling crew reached the face and operated for 4- to 5-h sampling periods. Because of loose roof conditions in the tailgate entry (*E*), the intake dust levels were monitored with two gravimetric samplers suspended from shield 121 (*D*). These intake samplers were turned off when the tailgate shearer reached approximately shield 118 on the midface-to-tailgate pass and were not restarted until the tailgate shearer had reached approximately shield 115 on the tail-to-midface pass. Operation of the intake samplers was suspended during this period to prevent contamination of intake dust readings with the dust generated by the cutout and sump at the tailgate.

MINE B

At mine B, gravimetric and instantaneous dust sampling was conducted at mobile and fixed sampling locations along the face. For the mobile sampling conducted during the first shift, one RAM and two gravimetric samplers

Figure 3



Sampling locations for multiple-machine longwall surveys.

[3]Italic numbers in parentheses refer to items in the list of references at the end of this report.

were hung from each of the shearer machines and traveled along the face with each machine. However, when the samples from the first shift were analyzed, it was discovered that both the RAM and gravimetric samplers had been exposed to substantial quantities of water and the RAM data were lost. Consequently, on subsequent sampling days, the shearer mobile sampling was discontinued and fixed-point sampling along the face was increased.

The original fixed sampling locations (see figure 3) included the last open crosscut for the main air intake (*A*), the intake to the face at shield 10 (*B*), and downwind dust levels at shield 112 (*D*). After discontinuing mobile sampling, one RAM and two gravimetric samplers were added at midface (*C*), shield 70, for an additional fixed sampling location.

RESULTS

MINE A

Table 1 contains a summary of the gravimetric dust concentrations sampled at mine A. The averages from the three shifts were combined into an overall average for each sampling location. It should be noted that these dust levels represent the total sampling period, which contains producing and nonproducing time. Surprisingly, the intake dust levels measured at shield 121 are higher than expected, since intake air was brought up the tailgate entry and would not have the opportunity to entrain dust released by the belt, stageloader, crusher, or face conveyor-to-stageloader transfer point. These intake dust levels also exhibit much more variability than is typically measured with paired stationary samples. The unusually large differences between these paired samples suggest that severe dust gradients were present at the sampling locations or that there were problems with one of the samplers. Caution should be exercised when considering the representativeness of these intake measurements.

Table 1.—Summary of gravimetric dust concentrations at mine A, milligrams per cubic meter

	Intake (shield 121)	Tailgate shearer	Headgate shearer	Return (shield 10)
Shift 1:				
Sample 1 ..	2.6	4.9	2.5	2.3
Sample 2 ..	1.6	7.0	2.6	1.7
Average ...	2.1	6.0	2.6	2.0
Shift 2:				
Sample 1 ..	0.7	3.1	1.6	1.9
Sample 2 ..	3.4	2.8	1.6	1.6
Average ...	2.1	3.0	1.6	1.8
Shift 3:				
Sample 1 ..	3.2	4.1	3.0	2.0
Sample 2 ..	1.6	5.4	2.2	2.1
Average ...	2.4	4.8	2.6	2.1
Overall average	2.2	4.6	2.2	1.9

The remaining gravimetric samples show that dust levels measured at the tailgate shearer are higher than those observed at the sampling locations downwind of the shearer. This indicates that high-concentration dust clouds are being generated by the cutting drum and are passing over the dust samplers located near the midpoint of the shearer. As the dust cloud moves down the face, it mixes with the ventilating air and becomes a more dilute, homogeneous cloud as it spreads into the walkway.

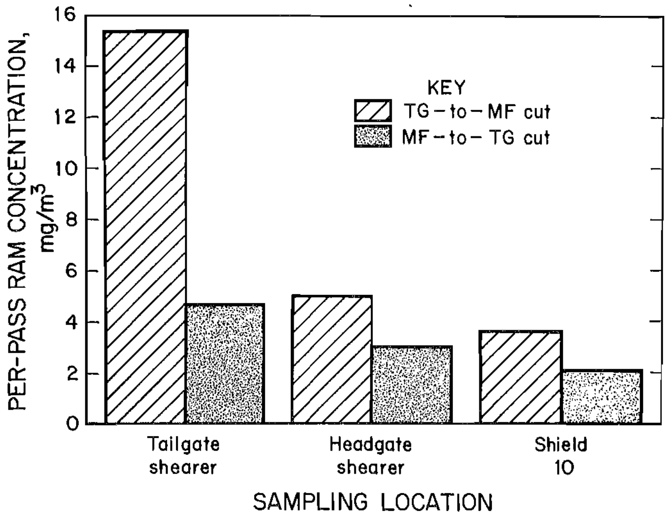
To further examine the dust generation on the face, the RAM data were used to isolate dust levels for shearer cuts in each direction across the face. RAM dust concentrations were calculated on a per-pass basis, with all significant downtimes eliminated from the calculations. Table 2 summarizes the adjusted RAM dust concentrations at three sampling locations for cuts completed with the tailgate and headgate shearers. Figures 4 and 5 illustrate the dust levels calculated for cuts made with the tailgate and headgate shearer, respectively.

Table 2.—Per-pass adjusted RAM concentrations for mine A, milligrams per cubic meter

	Tailgate shearer	Headgate shearer	Shield 10
TAILGATE SHEARER CUTTING			
Tailgate-to-midface cut:			
Shift 1, cut 1	16.4	5.5	4.5
Shift 1, cut 3	21.6	7.4	4.1
Shift 1, cut 5	16.0	3.5	2.8
Shift 2, cut 2	9.1	2.8	2.9
Shift 3, cut 1	14.0	5.8	3.8
Average	15.4	5.0	3.6
Midface-to-tailgate cut:			
Shift 1, cut 2	5.4	3.9	2.2
Shift 1, cut 4	5.7	3.4	1.8
Shift 1, cut 6	4.8	3.2	2.1
Shift 2, cut 1	2.9	1.8	1.8
Shift 2, cut 3	4.9	2.8	2.9
Average	4.7	3.0	2.1
HEADGATE SHEARER CUTTING			
Headgate-to-midface cut:			
Shift 1, cut 1H	NAp	1.3	2.3
Shift 1, cut 3H	NAp	0.9	2.6
Shift 2, cut 1H	NAp	0.8	4.2
Shift 3, cut 1H	NAp	0.9	5.0
Shift 3, cut 3H	NAp	0.9	3.3
Average	NAp	0.9	3.5
Midface-to-headgate cut:			
Shift 1, cut 2H	NAp	1.2	1.7
Shift 2, cut 2H	NAp	1.5	0.7
Shift 3, cut 2H	NAp	0.7	1.3
Average	NAp	1.1	1.3

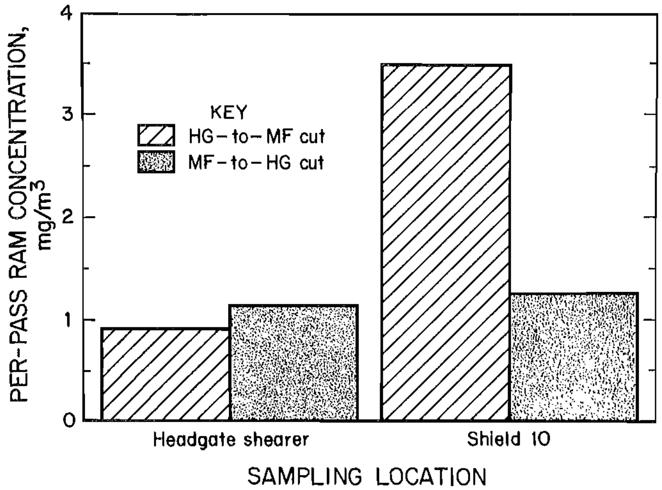
NAp Not applicable.

Figure 4



RAM concentrations for mine A with tailgate (TG) shearer cutting. MF = midface.

Figure 5



Ram concentrations for mine A with headgate (HG) shearer cutting. MF = midface.

The per-pass dust levels shown in figure 4 support the presence of high-concentration dust clouds at the tailgate shearer, which become diluted downstream of this location by mixing with face airflow. Average per-pass dust concentrations at the tailgate shearer are higher than the dust levels at the headgate shearer or at shield 10 for cuts in both directions. Dust levels at the tailgate shearer are much higher for the tailgate-to-midface cuts, which may result from the cutting drum being exposed to the face airflow. Visual observation of the shearer during these cuts indicated that the dust generated by the exposed cutting drum is being carried back against the ventilating airflow by the drum sprays and boiling out into the walkway (*3*). The absence of a splitter arm and passive barriers on the shearer would minimize the ability to confine this dust to the face (*4*).

Adjusted RAM dust concentrations were also obtained for those cuts taken by the headgate shearer. Figure 5 illustrates the per-pass dust concentrations measured at the headgate shearer and at shield 10. These data show that since the cutting drum is downwind of the sampling equipment on the headgate shearer, much lower dust levels were observed at this location for the headgate shearer cuts than for the cuts made by the tailgate shearer. However, downwind dust levels (at shield 10) were similar to those observed for the cuts completed by the tailgate shearer.

Comparison of the per-pass data shows that the cuts made from the gate entries toward midface exhibit higher dust levels than the cuts made from midface to the gate entries. This pattern is observed for both shearers and suggests that the drum design, rotation, cutting, and/or loading is less efficient for the gate-to-midface passes. In any case, adoption of a unidirectional cutting sequence with both machines cutting from the midface toward the gate entries could be used as a means to reduce downwind dust levels.

Face air velocity readings were obtained with two anemometer traverses taken at shield 120 on each sampling shift. One traverse was completed between the panline spillplate and coal face and showed an average velocity of 2.34 m/s (460 fpm). A second traverse was taken between the spillplate and the shield legs and showed an average velocity of 1.74 m/s (343 fpm). Estimates of the area under the shields were used to calculate average air quantity, which was found to be 6.47 m^3/s (13,700 cfm).

MINE B

All of the gravimetric samplers were started and operated on a continuous basis so that the sampling results include both production and downtimes. The average intake dust concentration as measured in the last open crosscut to the longwall was 0.1 mg/m^3, which is low and presents no problems. Table 3 provides a summary of the gravimetric sampling results obtained on the face at mine B. The face intake samples collected at shield 10 show two distinct levels. For shift 1, the average dust concentration is less than 0.7 mg/m^3, but on the next three shifts, all individual concentrations are above 1.1 mg/m^3, with an average of 1.4 mg/m^3 for these shifts. The diversity in these readings may result from a change in sampling location and a change in airflow patterns on the face. During shift 1, the samplers were located at shield 10 and no walkway curtains were hung on the face. For shifts 2 to 4, walkway curtains were hung at several locations along the face, with

Table 3.—Summary of gravimetric dust concentrations at mine B, milligrams per cubic meter

	Intake (shield 10)	Headgate shearer	Midface (shield 70)	Tailgate shearer	Return (shield 112)
Shift 1:					
Sample 1	0.6	6.3	NAp	8.6	5.4
Sample 2	0.8	6.5	NAp	8.4	5.2
Average	0.7	6.4	NAp	8.5	5.3
Shift 2:					
Sample 1	1.6	NAp	3.1	NAp	6.4
Sample 2	1.7	NAp	3.2	NAp	6.6
Average	1.7	NAP	3.2	NAP	6.5
Shift 3:					
Sample 1	1.4	NAp	2.3	NAp	4.8
Sample 2	1.4	NAp	2.4	NAp	5.0
Average	1.4	NAp	2.4	NAp	4.9
Shift 4:					
Sample 1	1.1	NAp	2.9	NAp	4.8
Sample 2	1.3	NAp	2.7	NAp	5.4
Average	1.2	NAp	2.8	NAp	5.1
Shifts 2 to 4:					
Average	1.4	NAp	2.8	NAp	5.5

NAP Not applicable.

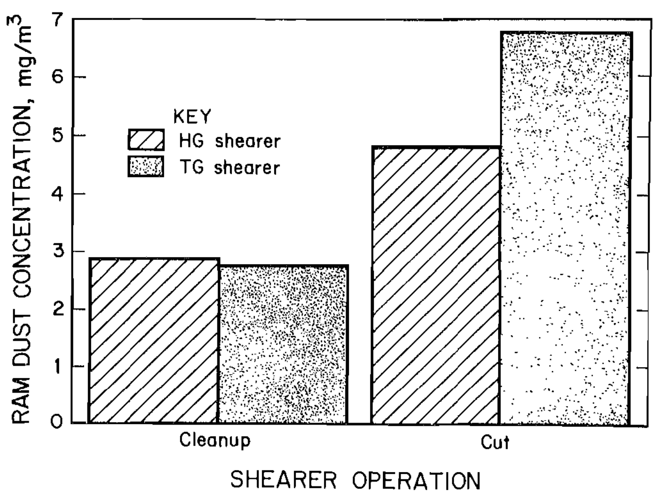
one curtain hung at shield 8. Consequently, the face intake samplers were moved outby the walkway curtain and placed on shield 7. Airflow patterns in the sampling area were affected by this walkway curtain, which could account for the apparent increase in face intake dust levels (*5*) during the last three shifts.

Unidirectional cutting was utilized, and per-pass dust concentrations were calculated with the adjusted RAM data. These data are summarized in table 4. Samples collected at shield 70 were used to calculate dust generation from the headgate shearer, which resulted in an average concentration of 4.8 mg/m³ for the cutting passes and 2.9 mg/m³ for the cleaning passes. In order to determine the dust generation by the tailgate shearer it was necessary to isolate those time periods during which the tailgate shearer was cutting or cleaning. However, during these same time periods the headgate shearer was also operating, so the difference between shield 70 and shield 112 dust levels is used to represent dust generated by the tailgate shearer. The tailgate shearer dust levels were found to be 6.8 mg/m³ for the cutting passes and 2.7 mg/m³ for the cleaning passes. Figure 6 illustrates the dust levels attributed to each shearer. Both shearers are shown to produce nearly identical dust levels during cleaning and higher dust levels during cutting. The large quantity of rock being cut by both shearers would aggravate dust levels generated during the cutting passes.

For the time periods when the headgate shearer was cutting, the average dust concentration at shield 112 was 7.6 mg/m³. The increase in dust level between shield 70 (4.8 mg/m³) and shield 112 reflects the combined operation of the two shearers. While the headgate shearer was cutting, the tailgate shearer was permitted to clean up along its area of the face. Likewise, when the headgate shearer was cleaning, dust levels at shield 70 and 112 were 2.9 and 7.3 mg/m³, respectively. The increase in tailgate dust levels reflects the dust generated from the tailgate shearer, which was cutting during the headgate cleanup. This same trend is observed when the cleanup and cut operations for the tailgate shearer are isolated. When the tailgate shearer was cleaning and cutting, the average "upwind" dust levels measured at shield 70 were 4.3 and 2.6 mg/m³, respectively, which reflects the cutting and cleaning operations of the headgate shearer.

Spot air velocity readings were taken along the face during each shift. The average air velocity for the survey was found to be 1.91 m/s (375 fpm). Measurements were taken to make a rough estimate of the area under the shields, and this area was used to calculate an average face air quantity of 8.73 m³/s (18,500 cfm).

Figure 6



Dust levels produced by each shearer at mine B. HG = headgate; TG = tailgate.

Table 4.—Per-pass adjusted RAM concentrations for mine B, milligrams per cubic meter

	Shield 70	Shield 112	Net difference
HEADGATE SHEARER OPERATING			
Headgate-to-midface cleanup:			
Shift 1, cut 1	NAp	6.4	NAp
Shift 1, cut 3	NAp	4.5	NAp
Shift 2, cut 1	2.1	7.0	5.0
Shift 2, cut 3	4.2	11.4	7.2
Shift 2, cut 5	2.4	5.2	2.9
Shift 2, cut 7	2.7	6.1	3.4
Shift 2, cut 9	2.4	NAp	NAp
Shift 4, cut 2	2.5	4.9	2.4
Shift 4, cut 4	1.2	6.1	4.8
Shift 4, cut 6	2.4	8.2	5.8
Shift 4, cut 8	4.0	10.6	6.6
Shift 4, cut 10	4.8	9.5	4.7
Average	2.9	7.3	4.8
Midface-to-headgate cut:			
Shift 1, cut 2	NAp	11.0	NAp
Shift 1, cut 4	NAp	7.6	NAp
Shift 2, cut 2	4.3	9.8	5.4
Shift 2, cut 4	4.0	7.6	3.5
Shift 2, cut 6	6.7	10.1	3.5
Shift 2, cut 8	5.9	11.2	5.3
Shift 4, cut 1	3.8	5.2	1.4
Shift 4, cut 3	3.1	5.3	2.2
Shift 4, cut 5	4.4	5.5	1.1
Shift 4, cut 7	5.6	4.3	-1.3
Shift 4, cut 9	5.1	6.2	1.1
Average	4.8	7.6	2.5

	Shield 70	Shield 112	Net difference
TAILGATE SHEARER OPERATING			
Tailgate-to-midface cleanup:			
Shift 2, cut 1T	NAp	NAp	NAp
Shift 2, cut 3T	4.6	10.1	5.5
Shift 2, cut 5T	1.8	7.2	5.4
Shift 2, cut 7T	8.1	12.3	4.2
Shift 4, cut 1T	3.6	6.1	2.5
Shift 4, cut 3T	3.2	5.6	2.3
Shift 4, cut 5T	4.8	5.9	1.0
Shift 4, cut 7T	3.0	3.0	0.0
Shift 4, cut 9T	5.4	6.3	1.0
Average	4.3	7.0	2.7
Midface-to-tailgate cut:			
Shift 2, cut 2T	2.0	7.5	5.5
Shift 2, cut 4T	2.8	7.8	5.0
Shift 2, cut 6T	2.6	8.0	5.4
Shift 2, cut 8T	4.3	14.8	10.5
Shift 4, cut 2T	1.3	3.3	2.0
Shift 4, cut 4T	1.8	9.2	7.4
Shift 4, cut 6T	2.9	11.2	8.3
Shift 4, cut 8T	2.6	11.7	9.1
Shift 4, cut 10T	3.1	10.9	7.7
Average	2.6	9.4	6.8

NAP Not applicable.

SUMMARY

Dust surveys were conducted on two longwalls operating with multiple single-drum shearers on the same face. Bidirectional cutting was in practice at mine A, while unidirectional cutting was used at mine B. At both mines, each shearer was used for cutting approximately one-half of the face. At mine A, only one shearer was permitted to operate at any given time, while at mine B, one shearer could clean while the other was cutting.

Dust sampling was conducted to isolate the quantity of dust generated by each shearer for cutting and cleaning passes in each direction along the face. Survey results indicate that the cutting sequences utilized on these longwalls have a significant impact on dust generation and personnel exposure. The following suggested improvements in cutting sequences, based upon observations made in the multiple-machine dust surveys, have the potential to reduce dust exposures for face personnel.

- Modify the cutting sequence so that the downwind shearer is responsible for cutting a greater portion of the face. This minimizes the time spent downwind of an operating shearer and also moves the primary cutting drum downwind of both shearer operators (*6*). The dust levels show that the exposure of the downwind shearer operator to dust is substantially less from his or her own machine than from the upwind machine.
- Design the cutting sequence so that when the upwind shearer is cutting, the downwind shearer is as far away from the upwind shearer as possible. This separation between shearers will maximize the potential for the ventilating air to mix with and dilute the dust cloud generated by the upwind shearer before it reaches the downwind shearer operator.
- Utilize optimum cutting strategies to minimize dust generation. At mine B, a substantial quantity of rock had to be cut to achieve required clearances. Since a unidirectional cutting sequence was in use and the mined height was a little greater than the drum diameter, the roof rock could be undercut during the primary cutting pass and then mined on the return pass in an effort to reduce dust generation.
- Minimize dust boilout and entrainment to reduce the exposure of personnel around the shearer. Boilout typically occurs when drum spray water forces dust toward the walkway and/or when the ventilating air passes freely over the shearer drum and entrains generated dust, carrying this dust toward the walkway and face personnel. Cut direction determines the relative exposure of the cutting

drum to face airflow, and it was found to have a significant impact on downwind dust levels for bidirectional cutting. For cuts made against the airflow, the cutting drum was completely sumped into the coal face and shielded from the ventilation. Also, for these cuts, the drum sprays that were not on the half of the drum in the coal (disengaged) were spraying in a downwind direction. For the cuts made with the airflow, the shearer drum was exposed to face airflow and the disengaged sprays were spraying in an upwind direction. Dust levels for cuts with the airflow were higher than for cuts in the opposite direction, which is attributable to increased boilout and entrainment.

Dust control problems common to double-drum shearer faces (e.g., outby dust sources, cutting with upwind shearer drum) were also found on these multiple-machine faces, making the challenge of maintaining compliance with MSHA regulations that much more difficult. For example, unacceptably high intake dust levels were observed on one face and no external sprays or splitter arms were available to prevent dust boilout over the shearer operator. Outby dust controls (e.g., enclosing the stageloader-crusher and using water sprays) must be applied and maintained to ensure minimal contamination of the intake air reaching the multiple-machine face. Shearer operators should take advantage of remote control (*7*) and maintain positions as far upwind of the shearer cutting drum as possible to minimize exposure to high-concentration dust clouds. Splitter arms and external sprays (*8*) should also be installed to redirect dust away from the shearer operator and down the face. Sampling results made it apparent that these types of state-of-the-art dust controls must also be implemented on the multiple-machine faces to optimize dust control at all sources

Implementation of administrative controls may be explored as a means of reducing the dust exposure of downwind personnel. For example, utilizing multiple operators at the tailgate shearer by having the upwind and downwind shearer operators switch positions after each half-shift would reduce the exposure of any one shearer operator. The same technique could be utilized with jacksetters on the face. However, these types of administrative controls must be approved by MSHA and then be utilized on a consistent basis to have a substantial impact on dust exposure.

Results from these surveys highlight the need to design an optimum cutting sequence to minimize the dust exposure of downwind personnel. In addition, state-of-the-art longwall dust controls must be implemented to assist in protecting all face personnel from traditional dust control problems (e.g., stageloader dust, boilout) found on longwalls.

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