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VARIATIONS IN DUST LEVELS WITH CONTINUOUS MINER POSITION

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ABSTRACT

Little knowledge is available that considers the effects of continuous miner position on the possible respirable dust exposure of the remote mining machine operator. Such information could be very useful for increasing the awareness of the remote operator as to those parts of an extended cut that generate higher levels of respirable dust. This data could be used to develop guidelines for positioning the remote operator to reduce his potential exposure. This work details the effects of continuous miner position on dust levels measured on the machine and at the remote continuous miner operator location.

INTRODUCTION

Considerable work has focused on the use of machine-mounted scrubbers or sprayfan ventilation systems for controlling dust in extended cutting situations (Foster Miller, 1985, 1986; Jayaraman et al, 1987, Volkwein et al, 1986). Extended cutting is defined as mining beyond the standard cut depth of 6.1 meters (20 feet). A much smaller body of work has examined dust levels on a sump or slab cut basis (Colinet and Jankowski, 1996; Bhaskar et al, 1990).

In the literature, however, little data considers the effects of continuous miner position on dust levels measured at the remote operator location. Field work conducted by NIOSH (National Institute for Occupational Safety and Health) personnel showed that dust rollback off the cutting head varied with position of the continuous miner at the face. This suggests that any outby personnel, such as the mining machine operator, could be exposed to higher levels of respirable dust depending upon the position of the continuous miner at the face.

Determining the effects of continuous miner position on potential exposure of the remote operator is necessary. Such information could increase the awareness of remote operators about those parts of an extended cut that may generate higher levels of respirable dust. This could be one means of controlling exposures for the remote operator. Also, this information could provide general guidelines for positioning the remote continuous miner operator to reduce personal exposure. NIOSH has recommended a reduction in the respirable dust standard to 1.0 mg/m^3 (NIOSH, 1995). Identification and control of these higher exposure machine positions may become one means for maintaining compliance with a new dust standard.

This work evaluates the effects of continuous miner position on dust levels measured at several mining operations. One operation used a blowing curtain face ventilation scheme with a machine-mounted scrubber. The other operation used an exhaust curtain with a machine-mounted scrubber. This operation then switched to an exhaust curtain with a sprayfan system. This provided an opportunity to assess variations in measured dust levels with different ventilation schemes.

Dust levels were measured on the left rear corner and right rear corner of the continuous miner. Concentrations measured at these two locations are viewed as indicators of dust rollback from the cutting head. Dust levels also were measured in the return airway and at the remote operator location.

ANALYZES OF DUST LEVELS

Mine A

Mine A is located in the eastern coalfields. A blowing curtain hung along the right rib provided section ventilation at this operation. Curtain quantity averaged roughly 3.1 m^3/sec (6000 cfm). Extended cuts, 12.1 meters (40 feet) in depth, were taken with a radio-remote continuous miner equipped with a flooded bed scrubber. Scrubber flow was rated at 3.1 m^3/sec (6500 cfm). Entries were 6.1 meters (20 feet) wide and 2.4 meters (8 feet) high. This operation used a 4-step arrangement for extracting the 12.1-meter (40-foot) cut (figure 1). For this extraction sequence, lifts 1 and 3 were located on the off-curtain side of the entry, while lifts 2 and 4 were located on the

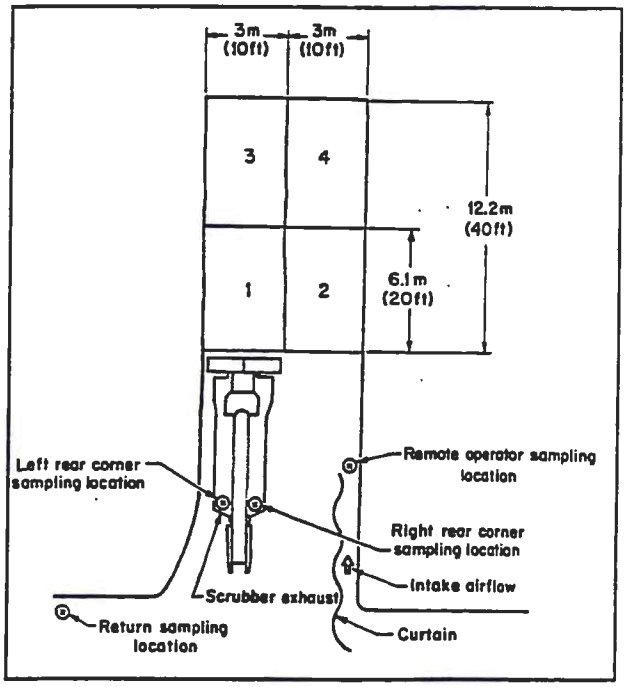

Figure 1. Four-step Arrangement Used at Mine A.

curtain side. The initial sump cut was taken on the off-curtain side of the entry.

For this study, dust levels at all sampling locations were measured using gravimetric samplers and instantaneous monitors. The gravimetric samplers operated at 2 liters/min. These samplers used 10-mm nylon Dorr-Oliver cyclones as preseparators to deposit the respirable dust fraction onto pre-weighed 37-mm filters. All filters were subsequently weighed and the respirable dust concentration calculated. Sets of 2 gravimetric samplers were used at all gravimetric sampling locations. The gravimetric concentration at each location was calculated using the average of each set.

The instantaneous samplers were the RAM-1 devices. These units pulled dust-laden air through a 10-mm Dorr-Oliver cyclone preseparator at a rate of 2 liters/min. This mixture passed through a light source and the amount of light deflection was representative of the dust concentration.

As stated previously, sampling was conducted at the remote operator location, at the left and right rear corners of the continuous miner, and in the return airway location. The dust monitors on the left and right rear corners of the continuous miner were located on top of the continuous miner frame roughly 7.6 meters (25 feet) from the cutting bits. At the remote operator sampling location, two sets of gravimetric samplers were used. One set of samplers measured operator exposure with the continuous miner cutting on the off-curtain side of the face only (lifts 1 and 3). The second set measured remote operator exposure with the continuous miner cutting on the curtain side of the face (lifts 2 and 4).

Due to the number of samplers used at the remote operator location, carrying this equipment was not feasible for the operator. Therefore, a member of the sampling team carried the gravimetric samplers and RAM device. During the study, this person stayed as close to the remote operator as possible without interfering with the operator.

Gravimetric dust levels were calculated at each of the four sampling locations. However, this study required lift-by-lift detail on dust levels measured at each location. Such values were not directly available from the gravimetric data. Instead, these adjusted dust levels were calculated by using the readings of the RAM instantaneous monitors at the various sampling locations.

Dividing the gravimetric dust concentration at each sampling location by the corresponding RAM dust concentration led to a gravimetric to RAM ratio for each location. The ratios typically varied from location-to-location and shift-to-shift. It was assumed that, at each sampling location, the gravimetric-to-RAM ratio was constant over the entire sampling period. The adjusted dust concentration for a specific time period during the shift then was obtained by multiplying the gravimetric/RAM ratio by the RAM concentration for the time period in question. These time periods were determined from the detailed time study records kept during the study.

Adjusted dust levels were calculated for the left rear corner, right rear corner, remote mining machine operator, and return sampling locations for the four machine positions shown in figure 1. Although gravimetric samplers were maintained at each sampling location, the use of RAM output with gravimetric data provided considerable detail regarding variations in dust levels with machine position. It also must be realized that the adjusted dust levels were calculated with knowledge of the RAM dust values. Although these adjusted levels were based upon gravimetric results, they could not be considered true gravimetric readings.

Dust levels were measured for three shifts at mine A. The adjusted dust levels at the left rear corner of the continuous miner, the right rear corner of the continuous miner, remote operator location, and the return sampling location are given in table 1. This table shows that position of the continuous miner had different effects on dust levels measured at these four sampling locations. The greatest changes occurred at the left rear and right rear corners of the continuous miner.

The first analysis considered the influence of continuous miner position on measured dust levels. For this evaluation, it was decided to compare dust levels at two distinct machine positions. In the first position, with the continuous miner was cutting on the off-curtain side of the face. This involved the averaging of dust levels for lifts 1 and 3. The second machine position had the continuous miner cutting on the curtain side of the face. Dust levels at this machine position were determined by averaging dust data from lifts 2 and 4. The results of this analysis are given in figure 2 and show that changes in machine position caused only minor changes in dust concentrations at the four sampling locations. Figure 2 does show, however, that the highest dust concentrations occurred at the left and right rear corners of the continuous miner. This implies that the remote machine operator should be located away from these corners to reduce personal dust exposure.

Figures 3(A) and 3(B) show typical locations of the remote operator for off-curtain side and curtain side positions of the continuous miner. These figures illustrate that, with blowing curtain ventilation, locations of the remote operator did not vary considerably with positions of the continuous miner. With the remote operator properly located at the curtain mouth, a constant flow of fresh air is provided over this individual. During this study, however, it was observed that the remote operator sometimes moved inby and to the left of the mouth of the intake curtain. This likely resulted in the high dust levels measured at

Table 1. Adjusted Dust Levels (mg/m^3) at Each Position of the Continuous Miner (Mine A)

Sampling Location	Position of the Continuous Miner			
	Lift 1	Lift 2	Lift 3	Lift 4
Left Rear Corner of the Continuous Miner	1.67	2.19	2.59	2.48
Right Rear Corner of the Continuous Miner	1.52	1.85	2.23	2.75
Remote Continuous Miner Operator[1]	0.92	0.78	0.85	0.85
Return Airway	0.80	1.04	0.85	0.73

Note:

1. Intake dust levels averaged 0.26 mg/m^3 during this study.

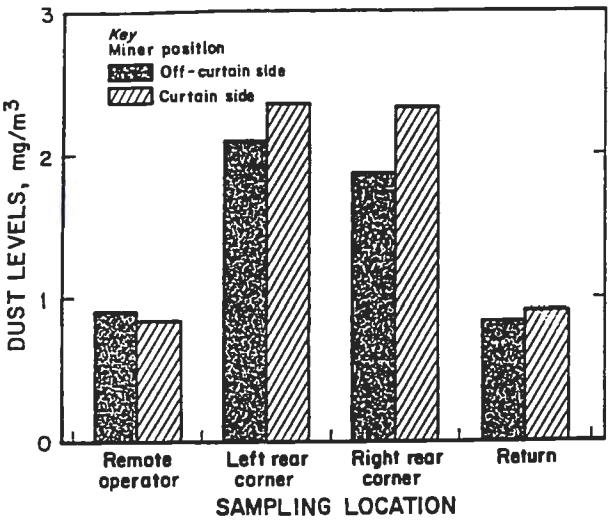

Figure 2. Effects of Continuous Miner Position on Measured Dust Levels (Mine A).

the remote operator location. It was not clear why the operator positioned himself away from the curtain, but this action may have been necessary to gain a better view of the cutting head.

Positioning the operator inby the intake curtain or to the left of the intake curtain should be avoided. These locations move the remote operator away from the fresh intake air and potentially closer to higher concentrations found at the right rear corner of the continuous miner. Positioning the operator to the left of the intake curtain also could place the remote operator downwind from the high dust levels found at the left and right rear corners.

Mine B

A similar study was conducted at an operation with the capability to use either a machine-mounted scrubber or a sprayfan system. This provided an opportunity to study the effects of continuous miner position on dust levels at the four sampling locations for both scrubber and sprayfan usage.

Mine B is located in the western coalfields. An exhaust line curtain hung along the right rib provided face ventilation at this operation. Curtain quantity averaged 7.1 m^3/sec (15000 cfm) with the scrubber operating and 6.1 m^3/sec (13000 cfm) with the sprayfan operating. Extended cuts of 12.1 meters (40 feet) were taken with a radio-remote continuous miner. Scrubber flow averaged 4.5 m^3/sec (9500 cfm). Entries were approximately 6.1 meters (20 feet) wide and 3.0 meters (10 feet) high. This operation used 5 lifts to extract 12.1-meter (40-foot) cuts. For this extraction sequence, lifts 1, 3, and 5 were curtain side cuts, while lifts 2 and 4 were off-curtain side cuts (figure 4). At this operation, initial sumps were taken on the curtain side of the entry.

The sampling arrangement for this study was very similar to that used at Mine A. Dust levels were measured at the left rear corner and right rear corners of the continuous miner, remote machine operator, and return airway. The left rear and right rear dust samplers were mounted on continuous miner frame approximately 8.5 meters (28 feet) from the cutting bits. As with Mine A, both gravimetric and instantaneous samplers were used at each location. This, again, permitted the calculation of adjusted dust levels for each of the five lift positions of the continuous miner. These adjusted values were calculated in the same manner given for Mine A.

Scrubber study: Four shifts were sampled at Mine B using the machine-mounted scrubber. The results of the sampling are given in table 2. The left rear corner and right rear corner sampling locations, again, exhibited the greatest variation in dust levels with machine position. Dust levels measured at the right rear corner sampling location generally exceeded those measured at the left rear corner sampling location. This was not surprising given the exhaust curtain ventilation scheme used at this operation. Such a scheme established a ventilation flow from the left side of the continuous miner to the right side of this

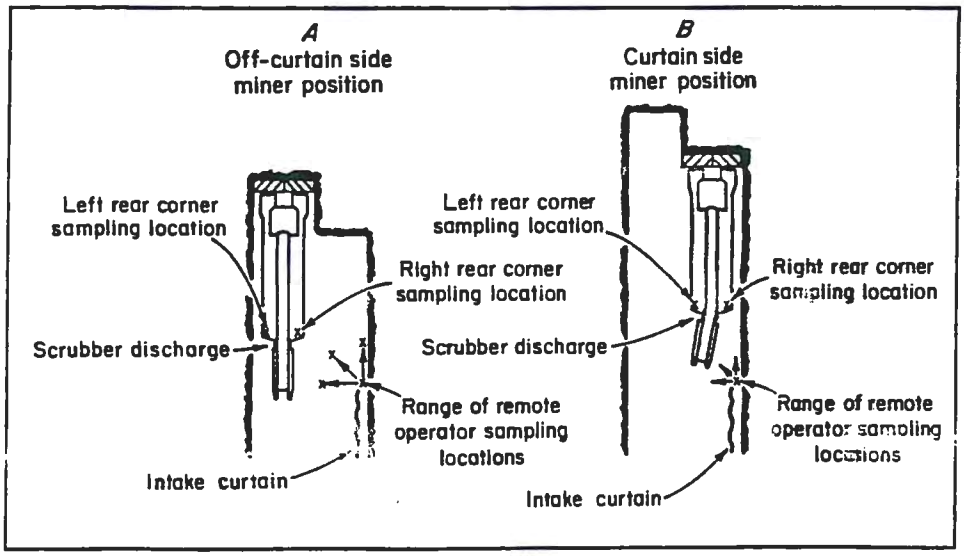

Figure 3. Typical Locations of Remote Operator (Mine A).

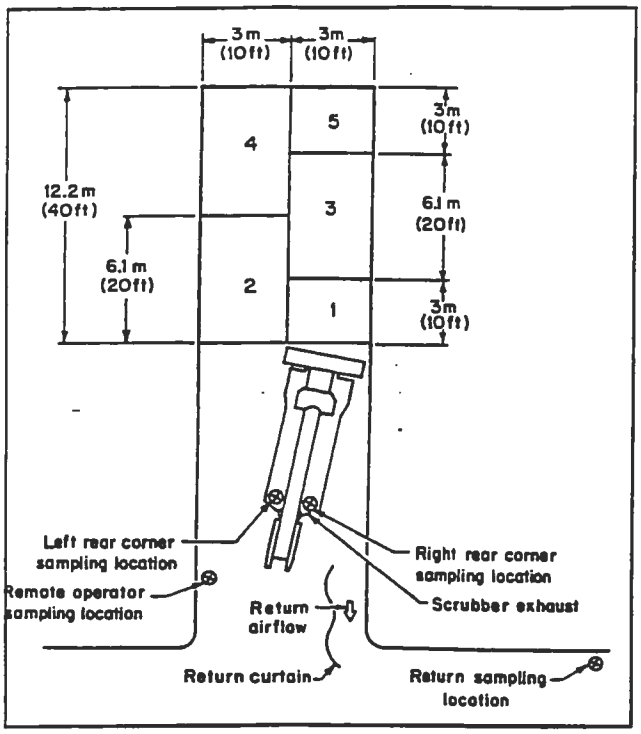

Figure 4. Five-step Arrangement Used at Mine B.

machine. Dust levels measured in the return also changed with position of the continuous miner. Remote operator dust levels, however, exhibited little variation with machine position.

The dust levels at the left and right rear corners exhibited the greatest variation with machine position. Dust concentrations at the left rear corner of the mining machine varied from roughly 1.6 mg/m^3 to nearly 3.2 mg/m^3. The variation at the right rear corner was even greater as concentrations ranged from roughly 2.6 mg/m^3 to nearly 6.0 mg/m^3. To further investigate this effect, dust levels were grouped broadly according to position of the continuous miner at the face.

As with the Mine A analysis, this evaluation compared average dust levels measured with the continuous miner cutting on the off-curtain side of the face versus those averages measured with the mining machine cutting on the curtain side of the face. Lifts 2 and 4 were off-curtain side positions while lifts 1,3, and 5 were curtain side positions. The results of this analysis are shown in figure 5. This figure shows that dust levels measured at the left rear corner of the continuous miner and at the remote operator did not change appreciably with position of the machine at the face. On the other hand, dust levels measured at the right rear corner of the continuous miner and in the return were higher with this machine cutting on the off-curtain side of the face. This implies that dust rollback increased on the right side at this machine position.

Due to the relatively high dust levels measured at the rear corner locations, it is recommended that the remote operator be

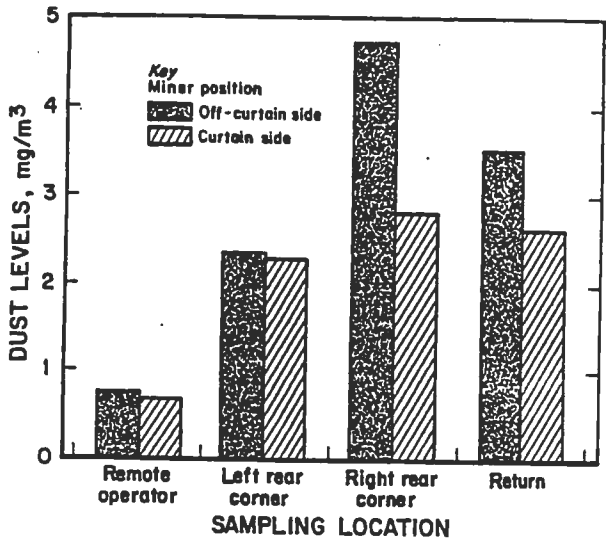

Figure 5. Effects of Continuous Miner Position on Measured Dust Levels (Mine B-scrubber)

located away from these areas to reduce his exposure. Typical locations of the remote mining machine operator often varied with the position of the continuous miner at the face. During

Table 2. Adjusted Dust Levels (mg/m^3) at Each Position of the Continuous Miner (Mine B-scrubber).

Sampling Location	Position of the Continuous Miner				
	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
Left Rear Corner of the Continuous Miner	1.61	2.75	2.69	1.57	3.19
Right Rear Corner of the Continuous Miner	2.88	4.34	2.63	5.99	5.65
Remote Continuous Miner Operator[1]	0.81	0.85	0.61	0.58	1.08
Return Airway	2.82	3.26	2.78	3.55	2.06

Note:

1. Intake dust levels averaged 0.13 mg/m^3 during this study.

off-curtain side cuts, for instance, the remote operator was located on either side of the entry outby the mouth of the return curtain (figure 6A). Choice of operator location depended upon visibility of the cutting head and clearance for the mobile equipment moving in that entry. With the continuous miner cutting on the curtain side of the face, the operator typically was positioned on the opposite side of the entry (figure 6B).

Although the remote operator moved from side to side in the entry, these movements occurred randomly. Thus, accurately isolating the effects of operator location on personal exposure was very difficult. As indicated in table 2, however, the exposures at the remote operator location were high. This suggests that this individual could have been affected by the location during either of the first two scrubber studies. Interestingly, dust levels at the left rear and right rear sampling locations increased greatly with the continuous miner cutting lifts 4 and 5. This suggests a possible degradation in sprayfan performance during these last two lifts. However, this appeared to have only minimal effect on outby dust levels.

Dust levels measured with the continuous miner cutting on the off-curtain side of the face were compared to those measured with the machine cutting on the curtain side of the face. Again, lifts 2 and 4 were off-curtain side positions while lifts 1, 3, and 5 were curtain side positions. As shown in figure 7, dust levels measured at the remote operator and right rear corner decreased

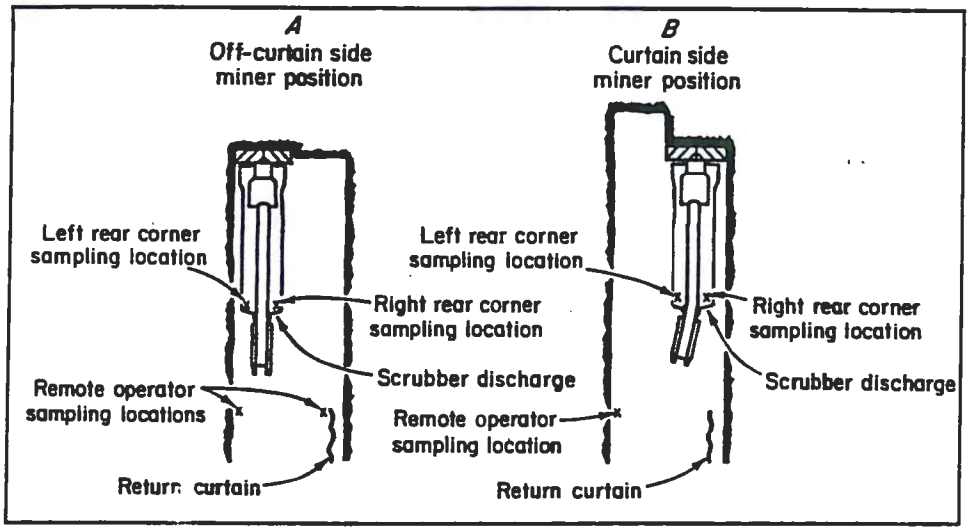

Figure 6. Typical Locations of Remote Operator at Mine B (scrubber).

higher dust levels present at the rear corners of the continuous miner.

Regardless of the operator's location, this individual must be aware of the high dust levels present at the rear corners of the continuous miner. This is especially true with the mining machine cutting on the off-curtain side of the face. In this position, dust concentrations are much higher at the right rear corner. Thus, the remote operator should be located such that his exposure time in these higher dust levels is minimized. This is most readily accomplished by placing this individual outby the mouth of the return curtain. This ensures that the remote operator stays in the fresh air flowing up to the machine.

Sprayfan study: Several shifts were measured at Mine B to investigate dust levels using the sprayfan system. Again, sampling was conducted at the left rear corner and right rear corners of the continuous miner, at the remote operator, and in the return. The results of this study are given in table 3 and show that dust concentrations measured at the right rear sampling location were considerably higher than those measured at the left rear corner sampling location. This is expected since the sprayfan system sweeps or pushes dust-laden air from the left side of the continuous miner to the right (return curtain) side of this machine. Also, dust levels measured at the right rear corner were much higher than those levels measured at this while dust levels measured at the left rear corner location increased. This figure also shows that, regardless of machine position at the face, high dust concentrations in excess of 15 mg/m^3 were measured at the right rear corner sampling location. To reduce personal exposure, the remote operator should be aware of the high dust levels, especially at the right rear corner. Typical locations of the remote operator with respect to the continuous miner were similar for either scrubber and sprayfan operation. With the machine positioned on the off-curtain side of the face, the remote operator was located outby the mouth of the exhaust curtain on either side of the entry (figure 8A). Choice of operator location, again, likely depended upon visibility of the cutting head and clearance for the mobile equipment. For curtain side positions of the continuous miner, the remote operator typically was located on the off-curtain side of the entry (figure 8B). Based upon the high rear corner dust levels measured during the sprayfan study, it is recommended that the remote operator stand in a location to minimize his exposure to these high dust levels. As with the scrubber study at this operation, it is best to stand outby the mouth of the return curtain.

Table 3 shows that the remote operator dust exposures were higher for lifts 1,2, and 5. Although specific causes for these high exposures could not be pinpointed, their magnitudes again emphasize the importance of proper positioning for the remote

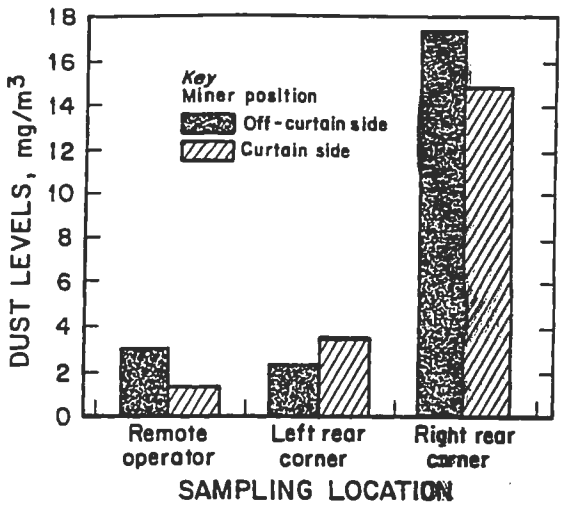

Figure 7. Effects of Continuous Miner Position on Measured Dust Levels (sprayfan)

operator when using the sprayfan system. More important, dust levels measured with the sprayfan system operating were much higher than those measured with the scrubber operating. This implies that proper positioning of the remote operator is much more critical with a sprayfan system in operation than with a scrubber system in operation.

CONCLUSIONS

This study investigated the effects of machine position on dust exposures measured at the remote operator location. Dust concentrations were measured at the left rear corner and right rear corner of the continuous miner. Dust levels measured at these two locations are viewed as measures of dust rollback from the cutting head. The remaining sampling locations included the remote operator and return airway. Two operations were examined as part of this study. Mine A operation used a blowing curtain face ventilation scheme with a machine-mounted scrubber. Mine B used exhaust curtain face ventilation with a machine-mounted scrubber. However, this operation also had the capability of running with a sprayfan system. Information gathered in this study was used to establish guidelines for placement of the remote operator to reduce dust exposure at that location.

It was discovered, for instance, that a blowing curtain ventilation scheme provided little protection against excessive dust exposure if the remote operator moved away from curtain mouth. At Mine A, the remote operator sometimes moved away from the curtain mouth, possibly to gain a better view of the cutting head. This likely led to the higher dust levels measured at the remote operator location. To reduce personal exposures, it is recommended that the remote operator stay within the mouth of the blowing curtain.

With an exhaust or return curtain ventilation scheme, operator positioning also was very important. The operator typically positioned himself on either the off-curtain side or curtain side of the entry depending upon needs for cutting head visibility and equipment clearance. Based upon the results of the Mine B study, it is recommended that the remote machine operator be located so that his exposures to the high dust levels present around the continuous miner are minimized. This is best accomplished by staying outby the mouth of the return curtain.

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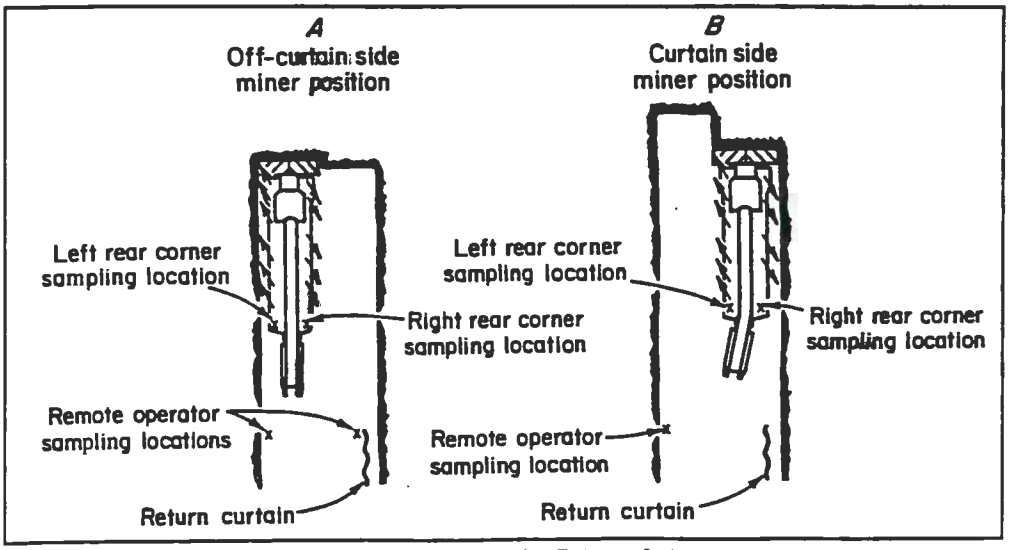

Figure 8. Typical Locations of Remote Operator at Mine B (sprayfan).

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Table 3. Adjusted Dust Levels (mg/m^3) at Each Position of the Continuous Miner (Mine B-sprayfan)

Sampling Location	Position of the Continuous Miner				
	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
Left Rear Corner of the Continuous Miner	1.40	1.33	1.85	5.11	8.73
Right Rear Corner of the Continuous Miner	12.14	14.00	16.11	24.63	21.03
Remote Continuous Miner Operator[1,2]	2.19	3.64	0.43	0.62	1.16
Return Airway[3]	no value	no value	no value	no value	no value

Notes:

1. Adjusted values not calculated due to malfunction of RAM sampling instrument. Gravimetric results presented instead.
2. Intake dust levels averaged 0.14 mg/m^3 during this study.
3. Adjusted values not calculated due to malfunction of RAM sampling instrument.