LONGWALL DUST SOURCES AND CONTROLS: A CASE STUDY

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ABSTRACT

The Bureau of Mines (BOM) and Jim Walter Resources (JWR) entered into an agreement to evaluate BOM dust control research at Jim Walter's #7 Mine. The initial step in this agreement called for the BOM to conduct dust source surveys on the #1 and #2 longwall sections at #7 Mine to identify the relative contribution of the various dust sources and determine the effectiveness of the control parameters in use. The source surveys would indicate which areas should be addressed and would be used to focus future research.

Instantaneous and gravimetric dust samplers were used with mobile and fixed-point sampling strategies to isolate different dust sources and determine the relative contribution from each source. In addition, water flow measurements, air flow measurements, run-of-mine coal samples, cutting procedures, and time study information were collected to supplement analysis of the dust data. A description of these sampling procedures is presented and offers insight into methodologies which can be used to isolate dust sources.

The dust source evaluation indicated that dust generation on these longwall faces was well controlled and that no individual source contributed a disproportionate amount of dust. Typically, dust generation from the shearer is the most significant source of dust on the longwall faces and can overshadow the dust contributions from other sources. However, on each of the longwalls at #7 mine, the stageloader and shield movement contributions were nearly equal to dust generation from the shearer. The equality of these sources results from the low dust levels observed for the shearer and not because the stageloader and shield movement sources were unusually high. Intake dust levels from the main intake and belt entry were found to be low also.

The low levels of dust generation were attributed to the level at which the primary control parameters, airflow and water flow, were applied on these faces. A discussion of the control parameters and resulting dust levels is presented. In addition, proximate analysis of the run-of-mine samples shows that the moist fuel ratio of the coal at #7 Mine indicates that the coal is inherently less dusty relative to other coals.

INTRODUCTION

In a joint meeting between the BOM, JWR and United Mine Workers of America (UMWA), JWR and UMWA personnel expressed an interest in having the BOM determine if JWR's dust control techniques were consistent with state-of-the-art controls and identify alternate control techniques that may be most appropriate for increasing the dust control capabilities at JWR mines. The BOM indicated that it has developed several new control technologies that need to be implemented and evaluated at mine sites. It appeared that by working together all parties could advance their objectives and it was decided that the BOM should focus research efforts on the two longwall sections operating in #7 mine.

The mining procedures and dust controls employed on each of these longwalls was quite similar. Historically, compliance with the dust standard was easier to maintain on #2 longwall. Dust source evaluations on each of these longwalls should illustrate any significant differences in dust generation and would then guide future research efforts to address the most significant problems. Multiple sampling strategies were utilized in an effort to obtain information on the relative contributions of respirable dust from the various sources typically found on longwalls[1]. None of the sampling completed by the BOM was full-shift sampling and the resulting dust levels are not relevant for compliance purposes.

Two BOM sampling crews traveled to #7 mine and utilized the same sampling procedures and equipment on each of the longwalls so that comparisons between faces could be made. A discussion of the sampling equipment and procedures will be presented. Data results collected for each of the longwalls will be discussed separately.

SAMPLING EQUIPMENT AND PROCEDURES

Two types of dust measurements were obtained for these surveys: gravimetric and light-scattering. Gravimetric samples are an accepted measure of respirable dust through collection of a physical sample on a filter. However, gravimetric samples only provide a time-weighted average for the entire sampling period and unwanted sampling intervals (i.e., extended down times) cannot be separated from the sample once collected. The gravimetric dust samples were collected with MSA Flow-Lite pumps identical to those used by the mining industry to collect compliance samples.

A Real-time Aerosol Monitor (RAM) light-scattering sampler was used to collect instantaneous dust readings, which were recorded by a data logger for later analysis. The real-time record of the RAM allows for analysis over a user-selected time frame and provides the capability to remove unwanted sampling periods from the analysis. The RAM samplers also provide a visual profile of the dust levels, which can be used to examine periods of interest or identify particularly high dust levels. Unfortunately, RAM measurements are sensitive to differences in material composition and water mist, so that only a relative measure of the dust concentration can be obtained. Also, no physical dust sample is collected and retained by the RAM. The RAM concentrations can, however, be adjusted to a gravimetric base by multiplying the RAM concentrations by the ratio of gravimetric to overall RAM average, as determined from the full sampling period.

Fixed Point Sampling

Gravimetric and RAM instantaneous dust samplers were located at fixed sampling locations in the main intake, belt entry, at shield 15, and approximately 10 shields from the tailgate end of each face. The main intake samplers were located in the last open crosscut and used to isolate the dust contributions from outby sources. The belt entry samplers were located outby the last open crosscut and the stageloader and measured the dust levels coming from the belt entry. The shield 15 sampling location was used to monitor the concentration of the air coming onto the face, which would include contamination from the stageloader and face transfer point. The tailgate sampler was used as an indication of the total dust generation that reached the tailgate and can represent dust sources outby and along the face.

At each of these locations, three gravimetric samplers and one RAM sampler were located adjacent to one another and operated over the same sampling period. The individual concentrations from the three samplers were combined to calculate an average gravimetric dust concentration for each location. At these fixed sampling locations, samplers were typically started at the beginning of the shift and operated continuously until sampling was completed.

Shearer Mobile Sampling

Mobile dust sampling was conducted around the shearer in order to determine the amount of dust generated by the shearer. Three sampling team members were needed to conduct this sampling and were positioned at the following locations: approximately 7.62 meters (25 feet) upwind of the shearer, at the headgate end of the shearer, and approximately 15.24 m (50 ft) downwind of the shearer. Each of the team members maintained their relative positions with the shearer as it moved across the face. The upwind position measured the intake dust levels reaching the shearer. The difference between the downwind sampler and the upwind sample represented the dust generated by the shearer. The samples collected at the shearer provide an indication of the dust levels at the shearer operator controls on the machine.

At these mobile sampling locations, four gravimetric filters were worn by each team member. Two of the filters were used to measure dust levels during the head-to-tail pass[2], while the other two filters were used for the tail-to-head pass. The sampling times for each location and direction were recorded and used to determine the dust concentration for each type of pass. One RAM sampler was also carried by each team member and operated on a continuous basis. The operating times for the gravimetric samplers were used to calculate the RAM concentrations for these same time periods and the gravimetric to RAM ratio used to adjust the RAM data.

Likewise, the RAM data from the fixed sampling locations was used to calculate the average dust concentration at the fixed locations for the mobile sampling time periods. The gravimetric to RAM ratio at each fixed location was then used to calculate a gravimetric-based RAM concentration for each pass. These gravimetric-based concentrations were then used to calculate the relative contribution generated by each source.

Shearer Profile Sampling

The respirable dust profile around the shearer was determined by placing a RAM sampler at a fixed location along the face (i.e., shield 50) and monitoring the dust levels as the shearer passes this location[3]. One team member traveled with the shearer and monitored its relative location to the RAM sampler. For the tail-to-head passes, one member of the sampling team would travel with the shearer and signal as it moved in 1.52 m (5 ft) increments from a location with the headgate drum 7.62 m (25 ft) downstream of the sampler (shield 55) to a position with the tailgate drum 15.24 m (50 ft) upstream of the sampler (shield 40). A second team member was positioned at the RAM and recorded the dust level when signaled. For the head-to-tail passes, the sampling order was reversed in that dust readings were obtained as the shearer moved from a position 15.24 m (50 ft) upstream of the sampler (shield 40) to a position 7.62 m (25 ft) downstream of the sampler (shield 55). Profile data was collected at shields 50 and 100. This profile data from the two locations was summarized for each direction and indicates if, where, and how much shearer generated dust migrates into the walkway.

Shield Dust Sampling

Mobile sampling was conducted to isolate the respirable dust liberated during shield movement on the head-to-tail passes. One team member was positioned approximately 7.62 m (25 ft) outby all shield movement while a second team member remained approximately 7.62 m inby all shield movement. Each team member carried a RAM sampler and noted the beginning and ending time of the mobile sampling. The average concentrations for these sampling periods were calculated and the difference between the outby and inby concentrations was attributed to shield dust.

Control Parameter Monitoring

Environmental parameters such as airflow, water flow and water pressure were also measured. Vane anemometers were used to collect spot and traverse readings in the entries and along the face. Water flow meters were installed in the water line supplying the shearer and in the water line supplying the stageloader sprays. Each shearer was equipped with a pressure gage at the water inlet on the machine and was used to monitor line pressure to the shearer. Hand-held pressure gages were used to measure the nozzle operating pressure at the shearer drum sprays.

Run-of-mine Coal Samples

Run-of-mine coal samples were collected on each longwall in order to determine the added moisture content of the coal at several locations along the coal haulage path and to conduct a proximate analysis to examine the physical composition of each product. Samples were collected at four locations to attempt to isolate the amount of moisture added by the shearer, panline sprays, transfer point sprays and stageloader/crusher sprays. Samples were collected at approximately shield 75, shield 5, at the inlet to the stageloader and at the transfer point onto the section conveyor belt. Approximately 13.6 kilograms (30 pounds) of run-of-mine product was collected at these locations and placed in sealed containers for transport. Each of these samples were weighed and then air dried to determine the surface moisture content. The samples were then prepared for the proximate analysis.

Mining Procedures

A unidirectional cutting sequence was utilized on both longwalls. The shearer would cut in the tail-to-head direction and clean on the head-to-tail pass. In general, shield advance was completed on the head-to-tail pass. Problems with the immediate roof on longwall #1 resulted in every other shield being advanced behind the shearer as it made the tail-to-head cut. The remaining shields were then advanced on the cleaning pass.

The spray systems used on the shearers, along the face, at the transfer point and in the stageloader were very similar for the two faces. A splitter arm was installed on the headgate side of each shearer, in addition to external sprays on the shearer body. Individual sprays were mounted on the panline at 20 shield intervals and directed toward the coal in the face conveyor. Water sprays were mounted at the face conveyor to stageloader transfer point. A series of sprays were mounted inside the stageloader and also at the discharge point onto the section belt.

The #2 longwall had recently started a new panel, while #1 longwall was nearing completion of a panel. The #2 panel had yet to reach the first of the methane bleeder holes that are drilled in each longwall panel at #7 mine. Consequently, the #2 longwall was supplied nearly twice the amount of airflow as #1 to overcome a relatively loose gob and substantial methane liberation.

DATA ANALYSIS

Because of operational problems encountered during the three-day survey (liberation of methane, roof rock and face spalls, equipment breakdowns), the desired amount of data was not obtained for each type of sampling performed. As a result, the data results should not be considered absolute measures but should be viewed as a means to identify relative differences and trends. Additional data would be needed to develop statistical significance.

Longwall # 1

Table 1 shows the results of fixed point gravimetric sampling for the three sampling shifts. The three samples collected at each location during each shift were used to calculate an average concentration for that shift. In general, the dust concentrations at each location were relatively consistent from one shift to the next.

The air coming to the face in the main intake was found to contain low quantities of respirable dust, indicating minimal contamination from outby sources. Dust concentrations varied from 0.02 to 0.09 mg/m^3. Low dust levels, between 0.08 to 0.15 mg/m^3, were also observed in the belt entry. These concentrations are low for a belt entry particularly when considering the high relative velocity between the ventilating air and coal movement in the opposite direction on the belt.

The dust levels at shield 15 show an increase of approximately 0.5 mg/m^3 above the dust levels in the belt entry. The stageloader/crusher was properly enclosed and equipped with a number of internal water sprays but had to process a considerable quantity of oversized coal and rock. Sampling crew members observed large pieces of rock and coal sloughing off of the face in front of the shearer as it cut from tailgate to headgate. As these large pieces entered the crusher on an intermittent basis, considerable dust was generated thus allowing a heavy dust cloud to be emitted into the ventilating air.

The dust concentrations measured at the tailgate were between a low of 0.93 mg/m^3 to a high of 1.52 mg/m^3. These concentrations are relatively low for sampling downwind of a longwall shearer, even when considering that significant down-time was encountered on each of the sampling days. Production typically consisted of two cutting and cleaning passes during the sampling period.

The shearer mobile sampling results for the gravimetric samples are included in Table 2. These results show that, in general, the dust concentrations were higher during the tail-to-head cut than for head-to-tail cleanup. The exception was at the shearer upwind location where the concentration was higher during the head-to-tail pass. This was attributed to shield advance being close to the upwind location. The dust cloud liberated during shield movement did not have an opportunity to mix with the face air before being sampled.

The difference in dust levels between the downwind and upwind sampling locations around the shearer is dust make attributed to the shearer itself. To identify the severity of this dust source relative to other sources, the fixed sampling data from the intake, belt and shield 15 were utilized to determine the contributions from outby sources. The sampling times for the mobile gravimetric sampling was considered as the time base for all comparisons. Consequently, the RAM data from the fixed locations was used to calculate the relative concentrations for the mobile periods. The relative RAM concentrations were then adjusted to a gravimetric base for comparison purposes.

Table 3 shows the estimated contributions of the different sources. The dust contributions from the stageloader/face transfer locations were determined by subtracting the intake/belt dust concentration from shield 15 levels. Similarly, the contribution from shield movement and face conveyor was determined by subtracting the shield 15 dust levels from the upwind shearer dust levels. Figure 1 illustrates the net contributions from each source for each direction.

During the tail-to-head cutting passes, the maximum dust contribution was from the stageloader/headgate transfer locations. This source contributed 0.80 mg/m^3 (37.7%) of the total dust. As mentioned previously, large pieces of rock and coal had to go through the crusher and clouds of dust would be discharged as large pieces were crushed. The dust suppression system for the crusher may have been momentarily overwhelmed allowing these dust clouds to be liberated and carried to the face by the ventilating airstream.

The shield movement/face conveyor source was the second highest source, generating 0.64 mg/m^3 (30.2%) of dust. The shearer was the next major source with 0.58 mg/m^3 (27.4%). The belt conveyor contributed the least at 0.10 mg/m^3 (4.7%).

Visually, it seemed as if the shearer was generating significant quantities of respirable dust when face rolls occurred during the tail-to-head cuts. As the shearer moved toward the headgate, the face would roll producing a large black cloud of dust that would temporarily obscure view of the headgate drum. Apparently, this highly visual dust cloud contained a large fraction of non-respirable dust since the shearer dust make was not very high.

During the head-to-tail cleanup pass, the stageloader/headgate transfer was once again the largest dust source at 0.75 mg/m^3 (52.1%). The net dust increase at the shearer upwind sampling location was found to be 0.58 mg/m^3 (41.0 %) and is attributed to dust liberated during shield movement. The shearer upwind sampling location was immediately downstream of shield movement so that this sampling location would be exposed to a concentrated cloud of dust from the shield movement. Apparently, the dust liberated during shield movement was diluted by the ventilating air, because dust levels measured 15.24 m (50 ft) downwind of the shearer were less than those sampled at the upwind location. The relative difference in dust levels between the upwind and downwind locations also indicates that the shearer can not be producing significant quantities of respirable dust.

Mobile sampling was conducted to determine the dust generated from shield movement. RAM data was used to calculate dust contribution between upwind and downwind shield locations. During the head to tail pass every other shield was being moved forward. Results indicate that 0.28 mg/m^3 was the concentration upwind while 0.50 mg/m^3 was the concentration downwind. This contribution of 0.22 mg/m^3 is somewhat less than the mobile sampling value of 0.64 mg/m^3 obtained with shearer mobile sampling. However, it should be noted that limited data is available and these values provide an indication of the range for shield dust generation.

A profile of dust concentrations was constructed out of measurements taken while the shearer was passing a fixed sampling point. Several passes were sampled and this data combined to calculate average dust levels as measured 7.62 m (25 ft) upwind to 15.24 m (50 ft) downwind of the shearer. Figure 2 shows these average dust levels for the cleaning pass. This graph indicates that upwind dust levels on the cleanup pass are higher than the levels observed downwind of the shearer. This agrees with the shearer mobile sampling results. Figure 2 also shows that the dust levels are relatively consistent around the shearer with small spikes occurring at the tailgate drum and 6.10 m (20 ft) downwind of the tailgate drum. Generally, it shows that the shearer does not produce excessive dust and/or the ventilating air does not allow the dust to migrate into the walkway in the vicinity of the shearer.

Figure 3 shows the profile for the shearer cutting from tail-to-head. During the cutting passes, the concentrations remained between 0.6 mg/m^3 and 0.7 mg/m^3 until the headgate drum passed the fixed sampler. At that time, the concentration increased suggesting that dust from the headgate drum moves toward the walkway. The dust remains relatively consistent until a spike in dust levels is found 10.67 m (35 ft) downwind of the tailgate drum. This indicates that the air velocities at the face rapidly dilutes the dust cloud to low dust concentrations and maintains the cloud in a fairly uniform state as it moves down the face.

Figure 4 shows air velocities at different locations on the face. This face was not equipped with a gob curtain at the headgate and velocities indicate that intake air is traveling into the gob rather than turning down the face. It appears that the air returns to the face around shield 30. Additional fluctuations in air velocity above and below the mean of 3.67 meters per second (723 feet per minute) occur at several locations down the face and may result from the gob caving in a nonuniform manner.

The air quantities are shown in Figure 5 and with the absence of large variations in mining height, follow the same general trend as air velocity. The average air quantity as calculated with a rough estimate of the area on the face was 26.67 cubic meters per second (56,500 cubic feet per minute).

Water flow and pressure readings were obtained for the shearer. The shearer was utilizing between 416.35 (110) and 435.28 liters per minute (115 gallons per minute) as determined from spot measurements from an in-line water meter. A pressure gage was installed at the water inlet on the shearer and spot readings indicated a dynamic pressure of 689.5 kilopascals (100 pounds per square inch). The nozzle operating pressure of the shearer drum sprays was determined by removing a spray nozzle and inserting a pressure gage. The operating pressure was found to be 586.1 kPa (85 psi).

Water flow to the stageloader sprays was also determined with an in-line meter and found to be approximately 56.78 lpm (15 gpm).

<u>Longwall # 2</u>

The gravimetric dust concentrations from the fixed point sampling locations are provided in Table 1. The dust levels at each location were relatively consistent from one shift to the next. The average intake (0.24 mg/m^3) and belt dust (0.25 mg/m^3) levels appear low and dust liberation from the stageloader/crusher does not add excessive quantities to the intake air reaching the face. Likewise, the tailgate samples appear relatively low (0.96 mg/m^3) for a downwind sampling location. These fixed point dust levels were obtained with production averaging two cutting and two cleaning passes during each sampling shift.

The shearer mobile sampling results for the gravimetric samples are included in Table 2 for both the head-to-tail cleanup and tail-to-head cut directions. Again, the multiple samples for each location had relatively good reproducibility. These results were somewhat surprising in that the upwind and downwind locations had higher dust levels for the head-to-tail cleanup pass than for the tail-to-head cutting pass. The most obvious source of this higher dust on the cleanup pass is advancement of shield supports. Also, the shearer drums were lowered on the cleanup pass and used to trim floor rock.

The relative dust contributions from each of the dust sources was calculated in the same manner as described for Longwall #1 and results are presented in Table 4. Figure 6 illustrates the net contributions from each source for each type of pass. This data indicates that the major dust sources for the head-to-tail cleanup passes are the shield/face conveyor and shearer. The intake and belt dust sources only account for 0.15 mg/m^3 (6.6%), while the stageloader contributed 0.42 mg/m^3 (18.9%). Respirable dust liberation from the shield movement/face conveyor sources accounted for 0.86 mg/m^3 (38.6%), which was slightly higher than the shearer at 0.80 mg/m^3 (35.9%). Shield movement resulted in the discharge of a visible cloud of dust that, based on these results, contained a substantial fraction of respirable dust.

Figure 6 also shows that the intake, belt and stageloader generate nearly identical dust levels for the cutting pass as those found on the cleaning pass. The respirable dust level downwind of the shearer was approximately half as great as the cleanup pass. It has already been suggested that part of this reduced dust level can be attributed to shield movement. Table 4 results support this hypothesis in that the relative contribution from the shield movement/face conveyor source for the head-to-tail pass was 0.86 mg/m^3 as compared to 0.21 mg/m^3 for face conveyor only on the tail-to-head cut. Therefore, the shield movement is contributing approximately 0.65 mg/m^3 or 29.1% of the total for head-to-tail passes. It also appears that the shearer is not producing as much dust on the cutting pass as for the cleanup. Part of this may result from trimming floor rock on the cleanup pass. Also, the headgate drum cuts and loads the majority of material during the cutting pass but is shielded from the ventilating air by the coal face. However, for the cleaning pass, both shearer drums are cleaning and trimming the floor and are exposed to the ventilating air. Dust liberated by coal lifted over the ranging arm has a greater opportunity to be entrained in the airstream.

The data from the shearer profile sampling was used to produce the graphs shown in Figures 7 and 8 . The head-to-tail graph, Figure 7, indicates that some dust boil out occurs briefly around the headgate drum but levels quickly drop at the midpoint. Dust begins to rise at the tailgate drum again and remains relatively stable downwind of the shearer. For the tail-to-head passes, Figure 8, the dust remains relatively stable until the tailgate drum position is reached and then dust boil out occurs. These two graphs again suggest that the shielding of the headgate drum provided by the coal face during the tail-to-head cutting passes prevent dust generated by the headgate drum from being entrained in the ventilating air. Also, these graphs confirm low dust generation from the shearer in that the downwind dust levels are not substantially higher than the upwind levels (approximately 0.5 to 0.9 mg/m^3 higher).

Mobile sampling was conducted in an attempt to isolate the dust generated from shield movement. RAM data was used to calculate relative dust levels upwind and downwind of shield movement during the head-to-tail cleanup pass. Unfortunately, only one pass was sampled but the data from this pass agrees with the results obtained for the shearer mobile sampling. The upwind RAM measured a concentration of 0.29 mg/m^3, while the downwind RAM measured 1.03 mg/m^3 for a net dust generation of 0.74 mg/m^3. Although this is a relative RAM number, it does compare favorably to the gravimetrically adjusted concentration of 0.65 mg/m^3 determined from the shearer mobile sampling and indicates that shield movement is a relatively major source on longwall #2.

In addition to dust measurements, environmental parameters were also monitored. Airflow readings were taken in the intake to the longwall face and belt entries to determine the quantity of ventilating air that was reaching the section. Approximately 41.54 m^3/s (88,000 cfm) was measured in the intake and 30.68 m^3/s (65,000 cfm) measured in the belt entry for a total of 72.22 m^3/s (153,000 cfm).

Spot velocity readings and rough measurements of the area on the face were also made. Figure 4 illustrates the velocity fluctuations that occur across the length of the face. The velocities shown at each shield location is the average velocity of the spot readings taken during the three sampling shifts. All of the velocity readings across the face were averaged to obtain the average face velocity of 7.62 m/s (1500 fpm).

The area under the shields was estimated and used to calculate relative air quantities along the face. This data is shown in Figure 5. A gob curtain was installed on this longwall face and seemed to turn the intake air down the face in the area of shield 10.

Water flow meters were installed in individual water lines supplying the stageloader and shearer. The water flow used by stageloader sprays was observed in spot readings to be between 56.78 (15) and 75.70 lpm (20 gpm). The water meter in the shearer water line was rated for 0-340.65 lpm (0-90 gpm) and when the shearer water was turned on, the water flow was above the capacity of the meter. JWR personnel had stated that the water flow systems for the two shearers were similar and when installing a 0-681.3 lpm (0-180 gpm) meter in the water line for the #1 shearer, a water flow of 115 gpm was measured. Also, JWR had conducted a water flow study on the #2 longwall approximately eight months prior to the BOM survey and found 476.91 lpm (126 gpm) to be used by the shearer. As a result, it appears that over 378.5 lpm (100 gpm) is being applied by the shearer.

Water pressure to the shearer was measured with a pressure gage at the water inlet to the shearer. A dynamic water pressure of at least 1034.2 kPa (150 psi) was observed when all sprays were operating, including water sprays at the stageloader. A reading of the nozzle operating pressure was found to be 551.6 kPa (80 psi) with all shearer sprays operating. This reading was taken when the stageloader sprays were off, so that an inlet pressure to the shearer of 1310.0 kPa (190 psi) was observed during the nozzle test.

ADDITIONAL ANALYSES

Run-of-mine coal samples from longwall #1 were collected during a cutting pass. The face operations were temporarily halted so that all samples could be collected simultaneously and provide a moisture profile of a "continuous stream" of coal in the system at that time. Surface moisture was determined for these samples. It should be noted that only one set of samples was collected so that the results should not be viewed as absolute, but rather, provide an indication of the distribution of the water at various locations of the face.

The moisture content at mid-face is attributed to the shearer and was found to be 1.7%. The moisture at shield #5 was 2.4% and the increase can be attributed to the sprays mounted on the panline at shields #20, #40, and #60. A significant increase in moisture to 5.1% was observed for the coal entering the crusher and can be attributed to the sprays at the face conveyor to stageloader transfer. The coal from the belt had a moisture content of 5.2%.

For longwall #2, problems with the collection and analysis of the coal samples resulted in only obtaining valid moisture data from the face location and the belt. These results generally agree with the data from longwall #1. The face sample had a moisture content of 2.0%, while the belt sample contained 3.7% moisture.

These samples indicate that a substantial amount of water is applied after the coal leaves the face. From a dust control standpoint, it would be more advantageous to apply as much water to the coal as soon as the coal is cut to minimize liberation into the airstream. A significant amount of water is being discharged from the shearer but does not appear to maximize wetting of the coal. For example, a substantial quantity of water is being discharged from the bottom of the ranging arm in a jet spray pattern onto the face-side edge of the face conveyor. This appeared to be a substantial quantity of water but was not being directly applied to the coal on the face conveyor. Likewise, the Joy shearer on longwall #2 had cooling water discharging directly onto the haulage track of the machine from three separate spray blocks. Again, this water was not being applied directly to the coal. A more effective usage of this water could be obtained by redirecting the discharge to the shearer drums or onto the face conveyor.

On-going BOM research has indicated that a relationship may exist between the specific characteristics of a coal seam and the levels of airborne respirable dust generated from that seam[4]. One such relationship has been found between the moist fuel ratio (fixed carbon divided by volatile matter divided by inherent moisture) and dust liberation in laboratory experiments. Figure 9 illustrates this relationship for a multitude of coals.

The proximate analysis from the run-of-mine coal samples was used to calculate a moist fuel ratio of 3.0 for No. 7 mine. As shown in Figure 9, this ratio corresponds to relatively low levels of airborne respirable dust. It should be stressed that this relationship is for respirable dust and does not account for all airborne dust. At No. 7 mine, a substantial quantity of dust is airborne during face spalls and shield movement. Based upon sampling results of the RAM and gravimetric samplers, this highly visible dust cloud was not primarily respirable in nature.

A significant difference in air velocity was found between longwall #1 and #2. The impact of this difference was examined by comparing the respirable dust levels from the downwind mobile sampling for each of the faces. A summary of the average face velocity and downwind dust levels for each face is provided:

	AVERAGE FACE AIRFLOW				DOWNWIND DUST LEVELS	
LONGWALL	M/SEC.	FPM	M^3/SEC.	CFM	H -> T	T -> H
1	3.67	723	26.90	57,000	1.44	2.12
2	7.62	1500	50.03	106,000	2.23	1.05

This data indicates that the impact of face velocity is not clearly defined. During the cutting pass (T -> H), the dust levels from longwall

#2 are approximately 50% less than those from longwall #1. This relationship may be viewed as an indication of improved dust dilution resulting from the higher air quantity present on longwall #2. However, the dust/airflow trend is reversed for the head-to-tail pass and may be viewed as increased entrainment from the higher air velocity present on longwall #2. Definitive data was not collected to fully evaluate the benefits of added dilution versus unwanted entrainment resulting from high face velocities. Additional research is in this area is warranted.

SUMMARY

Based on the results of this sampling, it would appear that the downwind dust levels, which were used as an indication of respirable dust make on the face, are quite low. For the T -> H cutting passes, downwind dust levels were found to be 2.1 mg/m^3 and 1.1 mg/m^3 for longwall faces #1 and #2, respectively. Longwall faces sampled for other BOM dust surveys have produced downwind dust levels as high as 16 mg/m^3, with levels commonly observed between 4 and 10 mg/m^3.

In general, the dust contribution from the various sources are well controlled, particularly the dust generated by the shearer. During this survey, net dust-make calculated for the shearer was found to be less than 1 mg/m^3 for both longwall faces, regardless of the type of cutting or cleaning pass being made. The effective dust control was attributed to the high level of application for the control parameters used during the survey. Average airflow for longwall 1 was 26.90 m^3/s (57,000 cfm) and 50.03 m^3/s (106,000 cfm) for longwall 2. Water flow on both faces was over 378.5 lpm (100 gpm). Also, the moist fuel ratio, a factor used in ongoing BOM research to relate respirable dust generation potential to composition of the coal, indicates that the coal seam at No. 7 mine may be inherently less dusty than many other coals found throughout the United States.

The low dust levels observed at No. 7 mine during the BOM survey precluded the immediate need for implementation and testing of additional controls by the BOM. Current BOM dust control research initiatives would not be very applicable given the conditions found at No. 7 mine.

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3. U.S. Bureau of Mines. Instantaneous Sampling Improves Longwall Dust Control, Technology News No. 134, February 1982.

4. Page, S.J., J.A. Organiscak, and J. Quattro. Coal Proximate Analyses Correlation With Airborne Respirable Dust, Fuel Magazine, 1993.

TABLE 1. FIXED-POINT GRAVIMETRIC SAMPLING RESULTS

A. LONGWALL #1

	SHIFT I		SHIFT 2		SHIFT 3		
SAMPLING LOCATION	DUST CONCEN.	SHIFT AVERAGE	DUST CONCEN.	SHIFT AVERAGE	DUST CONCEN.	SHIFT AVERAGE	SURVEY AVERAGE
INTAKE	0.04 0.13 0.09	0.09	0.00 0.04 0.02	0.02	0.02 0.04 0.03	0.03	0.05
BELT	0.11 0.14 0.06	0.10	0.08 0.06 0.10	0.08	0.18 0.13 0.15	0.15	0.11
SHIELD 15	0.69 0.63 0.68	0.67	0.58 0.52 0.43	0.51	0.73 0.77 0.35	0.62	0.60
TAILGATE	1.48 1.45 1.62	1.52	0.92 0.90 0.96	0.93	1.26 1.19 1.33	1.26	1.23

B. LONGWALL #2

	SHIFT 1		SHIFT 2		SHIFT 3		
SAMPLING LOCATION	DUST CONCEN.	SHIFT AVERAGE	DUST CONCEN.	SHIFT AVERAGE	DUST CONCEN.	SHIFT AVERAGE	SURVEY AVERAGE
INTAKE	0.14 0.10 0.16	0.13	0.32 0.35 0.39	0.35	0.25 0.17 0.26	0.23	0.24
BELT	0.13 0.30 0.08	0.17	0.36 0.32 0.35	0.34	0.24 0.23 0.22	0.23	0.25
SHIELD 15	0.43 0.34 0.50	0.42	0.51 0.55 0.56	0.54	0.70 0.67 0.65	0.67	0.55
TAILGATE	0.87 0.93 0.85	0.88	0.80 0.85 0.93	0.86	1.14 1.19 1.07	1.13	0.96

TABLE 2. SUMMARY OF GRAVIMETRIC RESULTS FOR SHEARER MOBILE SAMPLING

		LONGWALL #1		LONGWALL #2	
SAMPLING LOCATION	PASS DIRECTION	DUST CONCENTRATION	AVERAGE PASS CONCENTRATION	DUST CONCENTRATION	AVERAGE PASS CONCENTRATION
UPWIND	H -> T	1.72		1.43	
	H -> T	1.69	1.71	1.43	1.43
	T -> H	1.67		0.79	
	T -> H	1.41	1.54	0.76	0.78
SHEARER	H -> T	1.18		VOID	
	H -> T	VOID	1.18	0.70	0.70
	T -> H	2.49		0.71	
	T -> H	2.82	2.66	0.67	0.69
DOWNWIND	H -> T	1.34		2.25	
	H -> T	1.55	1.45	2.21	2.23
	T -> H	2.07		1.29	
	T -> H	2.17	2.12	0.82	1.06

TABLE 3. RELATIVE CONTRIBUTION OF RESPIRABLE DUST FROM EACH SOURCE ON LONGWALL #1

A. TAIL-TO-HEAD CUT

SAMPLING LOCATION	GRAV CONCEN.	RAM CONCEN.	GRAV/RAM RATIO	CUT CONCEN.	ADJUSTED CUT CONCEN.	DUST SOURCE	NET CONCEN.	PCT OF DUST MAKE
INTAKE	0.09	N/A	N/A	N/A	N/A			
BELT	0.11	0.20	0.55	0.33	0.18	INTAKE/BELT	0.10	4.7
SHIELD 15	0.67	0.74	0.90	1.00	0.90	STAGELOADER/HG TRANSFER	0.80	37.7
UPWIND SHEARER	1.54	1.28	1.20	1.28	1.54	SHIELD/FACE CONVEYOR	0.64	30.2
DOWNWIND SHEARER	2.12	N/A	N/A	N/A	2.12	SHEARER	0.58	27.4

B. HEAD-TO-TAIL CLEANUP

SAMPLING LOCATION	GRAV CONCEN.	RAM CONCEN.	GRAV/RAM RATIO	CLEANUP CONCEN.	ADJUSTED CLEANUP CONCEN.	DUST SOURCE	NET CONCEN.	PCT OF DUST MAKE
INTAKE	0.09	N/A	N/A	N/A	N/A			
BELT	0.11	0.20	0.55	0.20	0.11	INTAKE/BELT	0.10	6.9
SHIELD 15	0.67	0.74	0.91	0.95	0.86	STAGELOADER/HG TRANSFER	0.75	52.1
UPWIND SHEARER	1.71	0.81	2.11	0.81	1.71	SHIELD/FACE CONVEYOR	0.58	41.0
DOWNWIND SHEARER	1.44	1.22	1.18	1.22	1.44	SHEARER	NEG.	NEG.

TABLE 4. RELATIVE CONTRIBUTION OF RESPIRABLE DUST FROM EACH SOURCE ON LONGWALL #2

A. HEAD-TO-TAIL CLEANUP

SAMPLING LOCATION	GRAV CONCEN.	RAM CONCEN.	GRAV/RAM RATIO	CLEANUP CONCEN.	ADJUSTED CLEANUP CONCEN.	DUST SOURCE	NET CONCEN.	PCT OF DUST MAKE
INTAKE	0.14	0.20	0.70	0.20	0.14			
BELT	0.17	0.27	0.63	0.26	0.16	INTAKE/BELT	0.15	6.6
SHIELD 15	0.42	0.40	1.05	0.54	0.57	STAGELOADER/HG TRANSFER	0.42	18.9
UPWIND SHEARER	1.43	0.57	2.51	0.57	1.43	SHIELD/FACE CONVEYOR	0.86	38.6
DOWNWIND SHEARER	2.23	1.61	1.39	1.61	2.23	SHEARER	0.80	35.9

B. TAIL-TO-HEAD CUT

SAMPLING LOCATION	GRAV CONCEN.	RAM CONCEN.	GRAV/RAM RATIO	CUT CONCEN.	ADJUSTED CUT CONCEN.	DUST SOURCE	NET CONCEN.	PCT OF DUST MAKE
INTAKE	0.14	0.20	0.70	0.21	0.15			
BELT	0.17	0.27	0.63	0.28	0.18	INTAKE/BELT	0.16	15.4
SHIELD 15	0.42	0.40	1.05	0.53	0.56	STAGELOADER/ HG TRANSFER	0.40	37.9
UPWIND	0.77	0.40	1.93	0.40	0.77	FACE CONVEYOR	0.21	20.0
DOWNWIND SHEARER	1.05	0.66	1.59	0.66	1.05	SHEARER	0.28	26.7

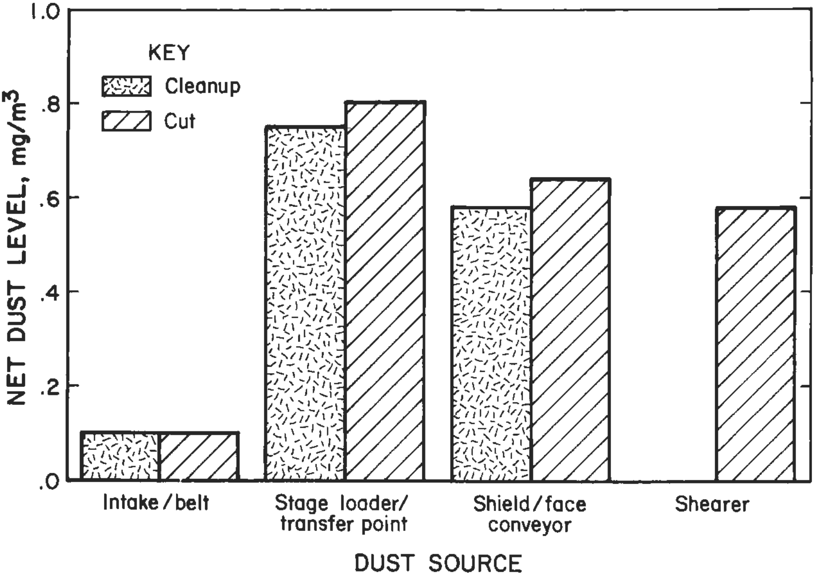

FIGURE 1. NET DUST LEVELS FROM EACH SOURCE ON LONGWALL #1

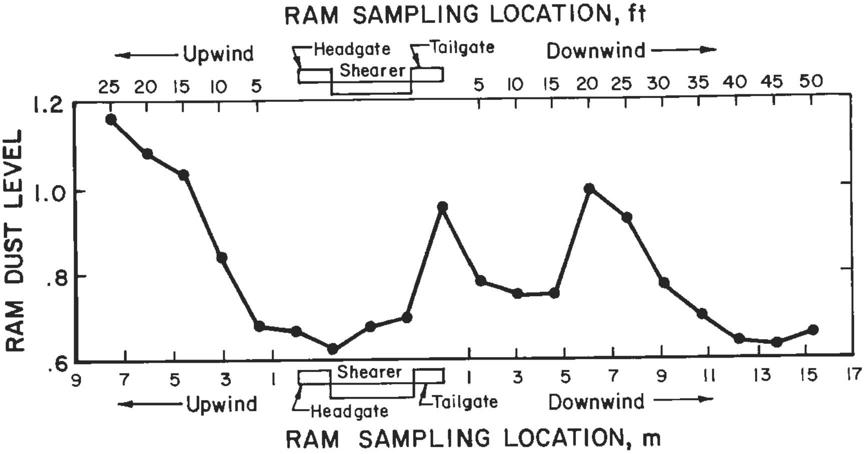

FIGURE 2. DUST PROFILE FOR CLEANING PASSES ON LONGWALL #1

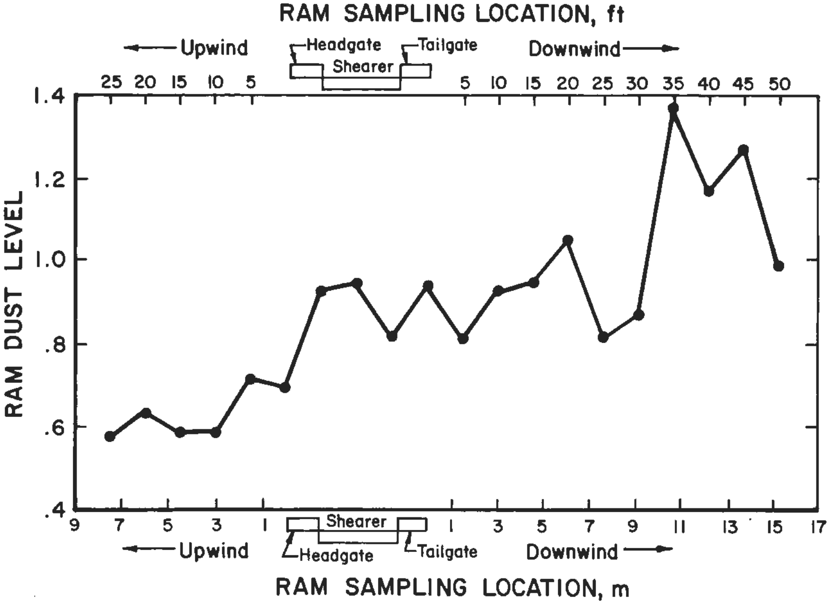

FIGURE 3. DUST PROFILE FOR CUTTING PASSES ON LONGWALL #1

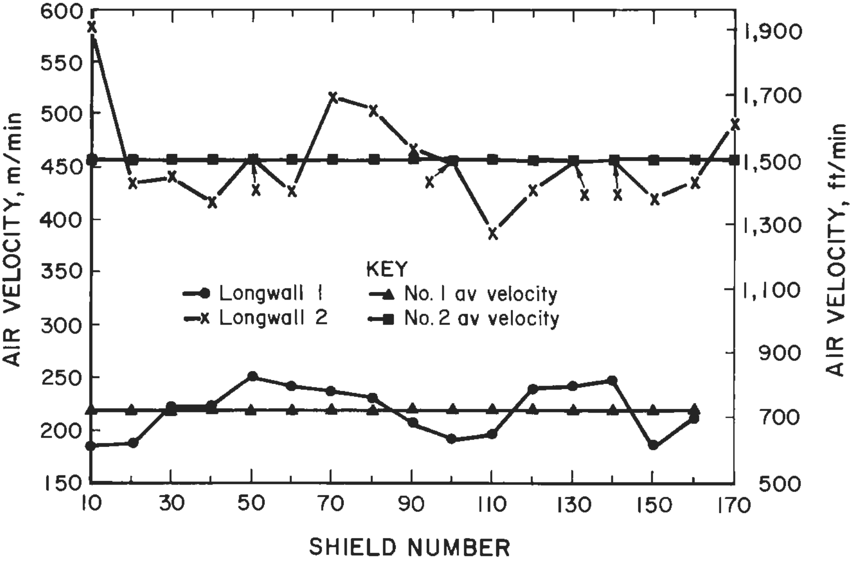

FIGURE 4. SUMMARY OF AIR VELOCITY MEASUREMENTS

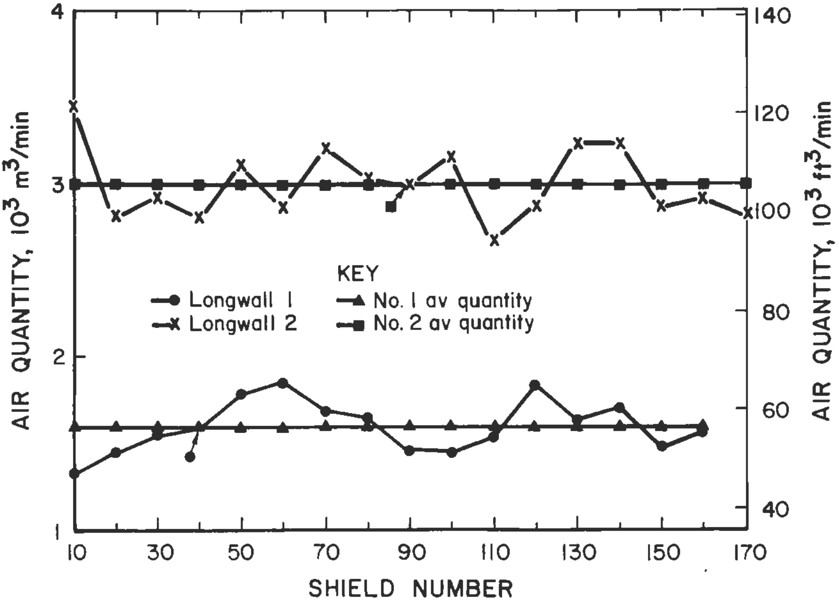

FIGURE 5. SUMMARY OF AIR QUANTITY CALCULATIONS

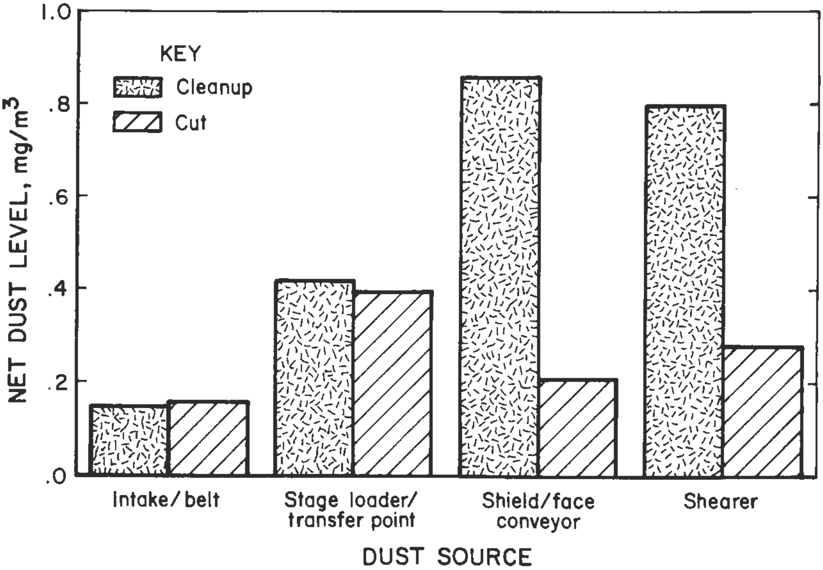

FIGURE 6. NET DUST LEVELS FROM EACH SOURCE ON LONGWALL #2

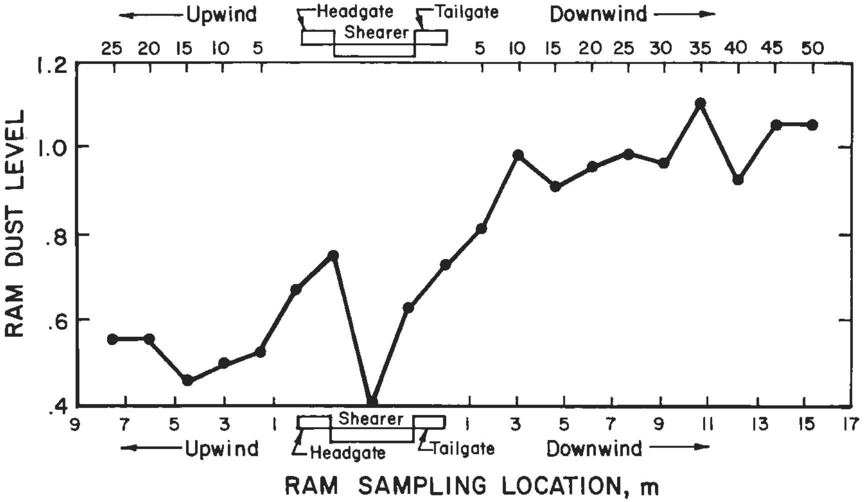

FIGURE 7. DUST PROFILE FOR CLEANING PASSES ON LONGWALL #2

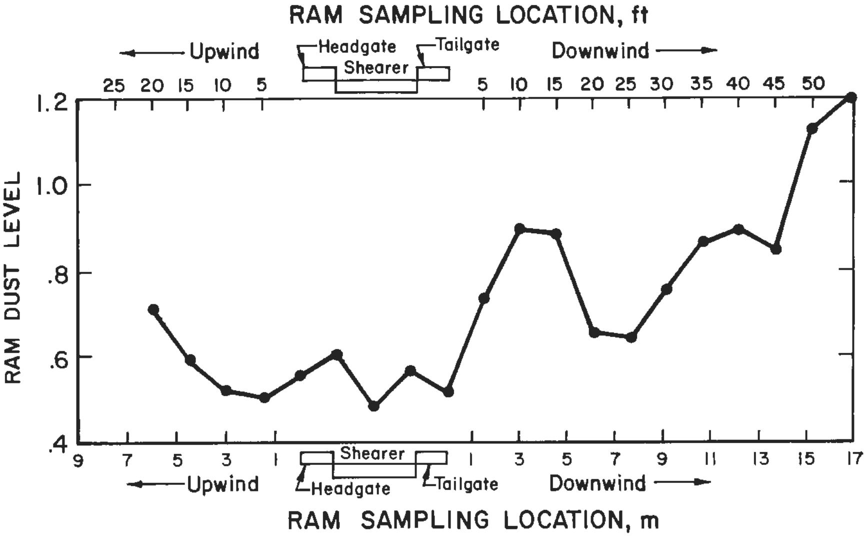

FIGURE 8. DUST PROFILE FOR CUTTING PASSES ON LONGWALL #2

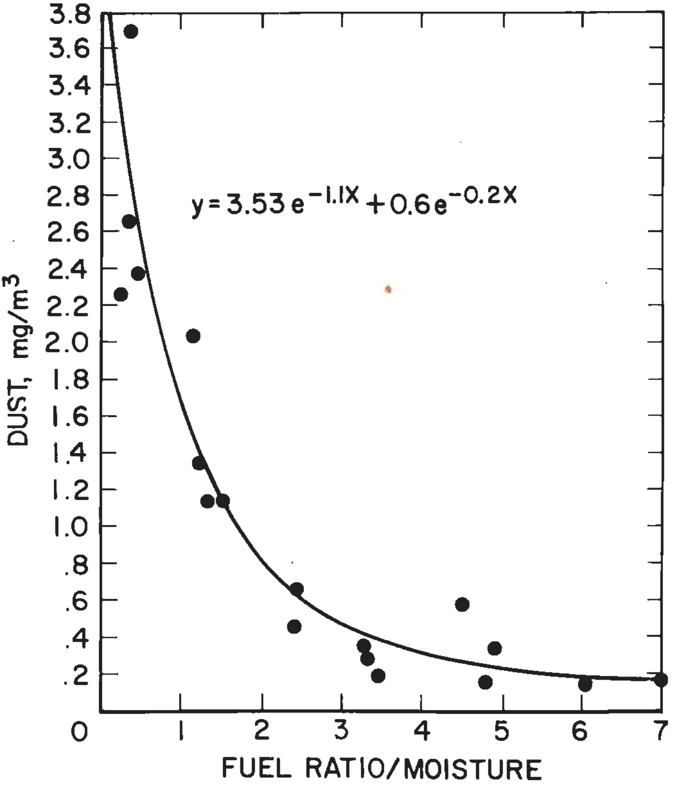

FIGURE 9. RELATIONSHIP BETWEEN AIRBORNE RESPIRABLE DUST AND MOIST FUEL RATIO

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