Chapter 84

TRANSLUCENT FACE PARTITION FOR LONGWALL DUST CONTROL

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Abstract. Controlling worker dust exposure on longwall mining systems is difficult because the working face area serves as an immediate return during the mining cycle and the amount of airborne dust generated is directly related to production. Since improvements in longwall mining technology have significantly boosted production levels, additional technology is needed to control the airborne respirable dust generated at present and future production levels. One concept to reduce longwall worker's dust exposure is to maintain two splits of air at the face -- a clean intake split in the workers walkway, and a return (dusty) split over the face conveyor.

The U. S. Bureau of Mines has recently investigated a concept to overcome the visibility handicap of face partitions by utilizing a permeable polyester mesh. The mesh material was anticipated to provide adequate air-splitting capabilities as long as the pressure differential between the face and worker walkway was minimal. Initial testing of this concept at the Bureau's Lake Lynn Laboratory showed that notable reductions could be achieved with a 1/8 in (3.18 mm) and 1/16 in (1.59 mm) mesh opening size. Dust reductions at 100 ft (30.5 m) and 200 ft (61.0 m) downstream of source were 58 and 36 pct, respectively, for the 1/8 in mesh and 79 and 55 pct, respectively for the 1/16 in mesh. Longwall application of the 1/8 in mesh showed similar results to the Lake Lynn Laboratory tests. A flame retardant mesh was used underground with portable lighting mounted on the shearing machine for face side lighting.

INTRODUCTION

Longwall mining technology has notably improved over the last decade, with advances expected to continue. Technological advancements include higher powered shearers, larger-capacity face conveyors, improved support capabilities, and overall equipment reliability. These changes have helped longwall production triple since 1980 with roughly the same number of longwall systems in operation. Currently, longwall mining accounts for about one-third of the total U.S. underground coal production (Thimons, Jankowski, and Finfinger, 1991). Continual elevation of longwall productivity increases the difficulty of maintaining compliance with the 2.0 mg/m^3 Federal respirable dust standard.

Most of the airborne respirable dust on a longwall is generated by the shearer as it traverses the face cutting coal (Jankowski, Organiscak, and Jayaraman, 1983; 1990). The face area and the worker's walkway serve as a return for the shearer. Therefore, employees working adjacent or inby the shearer can be exposed to high concentrations of airborne respirable dust. One concept presumed to reduce the amount of worker dust exposure is to sustain a clean split of air in the workers' walkway.

Several methods have been examined previously to create a cleaner split of air for the workers in the support walkway, but were either in-effective or severely limited in practical underground application (Babbitt and Ruggieri, 1990). One technique used a series of walkway curtains hung perpendicular to the airflow. The curtains increased the air velocity over the face conveyor, but caused severe eddying of the contaminated face airflow into the walkway between curtains. Another technique extended the face conveyor spillplate to create a barrier between the face area and worker walkway.

Laboratory tests found that the barrier had to be extended to full height to touch the underside of the roof supports to achieve improvement in air-splitting effectiveness. However, practical limitations of a solid barrier would make this technique very difficult, if not impossible to implement underground. Finally, a compressed air spray system on the roof supports was studied to confine the shearer dust cloud to the face area. Laboratory studies have shown that this concept helped to contain face airflow only at lower air velocities and would require a high-capacity compressed air supply, diminishing its practicality for underground use (Laurito and Singh, 1987).

The Bureau recently investigated the effectiveness of creating two parallel splits of airflow along the longwall face with a permeable polyester mesh partition. The translucent mesh technique was initially tested at the Bureau's Lake Lynn Laboratory to examine its feasibility, followed by an underground longwall study. This paper describes the research conducted and the results.

LAKE LYNN LABORATORY EXPERIMENTS

Lake Lynn Laboratory tests were conducted to determine the feasibility of maintaining two parallel splits of air with several different types of permeable mesh and to select an optimum mesh-type for underground application. After examining several dozen materials, three polyester mesh type cloth fabrics were chosen as possibilities for a passive barrier. Polyester mesh fabrics were chosen because of their strength, durability, and flexibility. These mesh types were selected to cover a wide range of porosities, and their properties are shown in Table 1.

MESH TYPE	A	B	C
OPENING SIZE, in (mm)	1/4 (6.35)	1/8 (3.18)	1/16 (1.59)
OPEN AREA, Pct	83.7	52.5	30.0
FIBER CONTENT	POLYESTER	POLYESTER	POLYESTER
WEIGHT, oz/yd^2 (g/m^2)	4.70 (159)	6.30 (214)	10.75 (365)
MESH COUNT, holes/in^2 (holes/cm^2)	5 X 3.5 (2.0 x 1.4)	4.5 X 9 (1.8 x 3.5)	8 X 10 (3.1 x 3.9)
BALL BURST, psi (Kpa)	200 (1,380)	300 (2,070)	550 (3,790)
THICKNESS, in (mm)	0.020 (0.051)	0.040 (0.102)	0.050 (0.127)

Table 1. Mesh Material Characteristics.

Initial air-splitting testing focused on determining the effect of open area on dust leakage through the mesh over a normal range of air velocities observed underground. Typical longwall face dimensions and airflows were simulated in the Lake Lynn Experimental Mine. A 600 ft (183 m) long section of an 18 ft (5.5 m) wide entry was narrowed to 8 ft (2.4 m) with a brattice cloth wall as shown in figure 1. The other part of the entry was sealed with a check curtain which was also used to regulate the air velocity in the narrow test entry. A 500 ft (152.4 m) section of test mesh material was hung in the middle of the 8 ft wide entry to create two parallel airways. Airborne dust was generated on the entry's rib side using a Vibra Screw SCR-20 feeder to allocate fine coal dust into a compressed air dust (68 pct less than 10 um) distribution system.

Dust levels were measured on both sides of the simulated longwall entry to determine the effect of the mesh on air-splitting. Dust sampling stations were located at 100 ft (30.5 m) intervals downstream of the feeder in both sides of the simulated longwall entry. Tests were conducted with the three types of mesh and with no mesh (baseline). Each sampling station had three personal gravimetric samplers and one RAM (Real-Time Aerosol Monitor) instrument to measure airborne respirable dust (figure 1). In addition, a dust sampling station was located 25 ft (7.6 m) upwind of the feeder to verify that clean air was supplied to the simulated mine entry. Air velocity in the test entry was measured at this intake air sampling station upstream of the feeder, and the air velocity was assumed to be roughly equal along the simulated entry.

Testing was conducted at air velocities of 200, 400, 600, and 800 ft/min (1.02, 2.03, 3.05, and 4.06 m/s) with dust feed rates adjusted proportionally with the ventilation to produce similar dust concentrations for all tests. Three baseline tests were conducted at each of these airflows without the mesh present to measure natural dust dispersion properties in the simulated longwall entry. Three tests were also conducted at each airflow level and for each mesh material. Since hanging and removing the mesh required a considerable amount of time, random sampling was not conducted. However, mesh and baseline tests were moderately mixed up with many of the velocity variations made with a particular mesh material in place. A test consisted of running the dust feeder for 65 minutes and recording dust levels at each sampling location. All the information presented for these experiments was determined from the gravimetric personal samplers. The RAM instrument was used to verify that uniform dust generation was obtained during all tests.

Baseline tests without the mesh show that dust diffusion rapidly evolves across the entry from the source. Figure 2

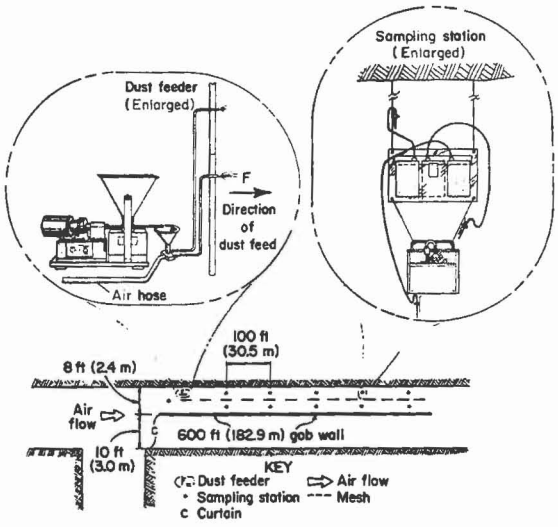

Figure 1. Lake Lynn Laboratory layout of airsplitting experiment (Plan View).

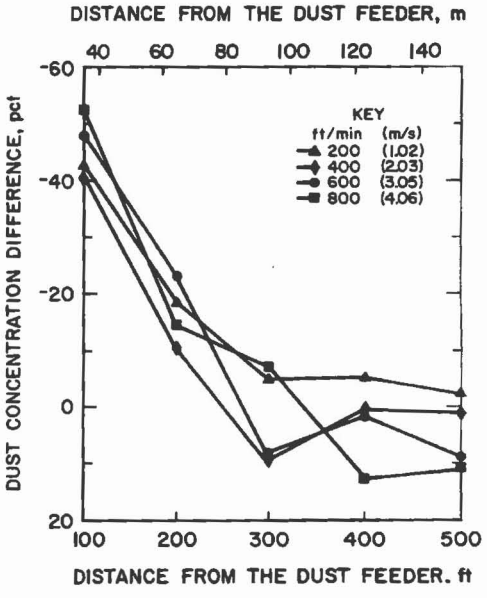

Figure 2. Average dust concentration differences across from the feeder side of the entry without the mesh partition (Baseline Tests).

shows the average dust concentration differences across the two sides of the entry during the baseline tests at the various air velocities. Dust concentration differences in the test entry without the mesh decreased to roughly 50 pct and 0 pct at 100 ft and 250 ft (76.2 m) downstream of the dust source, respectively. Dust concentration differences across the entry showed some variation along the last half of the face, especially for the higher air velocities. For the higher air velocities, the dust concentrations along the last half of the entry were higher on the opposite side of the feeder. This may be an indication that the rib side of the entry (feeder side of entry) developed turbulence at the higher airflows, which could possibly have caused more of the airflow to follow the smooth gob side wall

of the entry. However, the airborne dust did rapidly diffuse cross the entry at all air velocities tested.

All three mesh types showed dust reductions compared with over the baseline conditions. Dust reductions for the three mesh types over the baseline conditions at 200, 400, 600, and 800 ft/min can be seen in figures 3, 4, 5, and 6, respectively. Mesh air-splitting effectiveness over the baseline tests was found to be generally related to the mesh opening size or porosity. The smaller the opening size or lower porosity, the better the air splitting effectiveness. The dust reduction of the 1/4 in (6.35 mm) mesh size was noticeably lower than that of the 1/8 in and 1/16 in mesh sizes at all air velocities. However, at the higher air velocities (600 and 800 ft/min, only marginal dust reduction differences were observed between the 1/8 in and 1/16 in mesh sizes, especially along the last half of the entry. The effectiveness of the 1/4 in and 1/8 in mesh sizes seemed to remain relatively the same with respect to airflow, with only slight improvements noticed at the higher air velocities. Effectiveness of the 1/16 in mesh was noticeably reduced at the higher airflows. This indicates to the authors that a higher pressure differential was probably created with the 1/16 in mesh between the rough rib side and the smooth gob wall side of the entry at the higher air velocities. Considerable decreases in 1/16 in mesh effectiveness were especially observed especially in the second half of the entry where dust concentration variations were noticed during the baseline tests at high air velocities. Although some discrepancies were observed in the laboratory experiments, the translucent mesh air splitting concept was shown to be effective.

UNDERGROUND SYSTEM DEVELOPMENT

A cooperative longwall operator was expressed interest in experimenting with this air-splitting concept to control airborne respirable dust inby the shearing machine. A visit to the operation was made to gather equipment specifications and to obtain operator input into designing a system application of this concept for its longwall. The criteria considered for system design included:

* effectiveness
* visibility
* durability
* safety

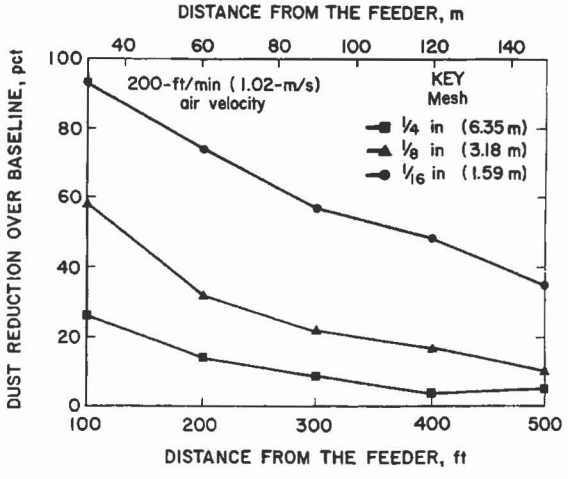

Figure 3. Average mesh dust efficiencies measured in the laboratory at 200 ft/min air velocity.

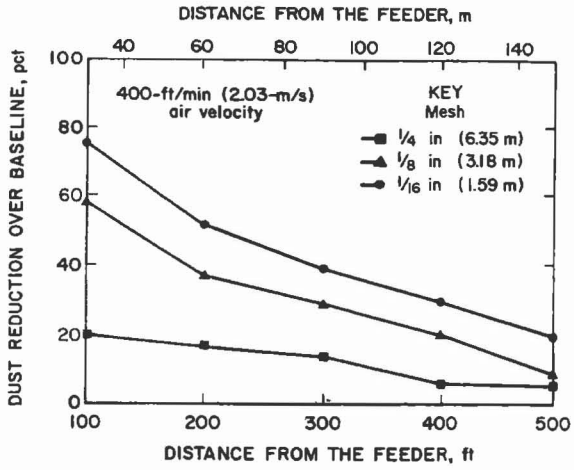

Figure 4. Average mesh dust efficiencies measured in the laboratory at 400 ft/min air velocity.

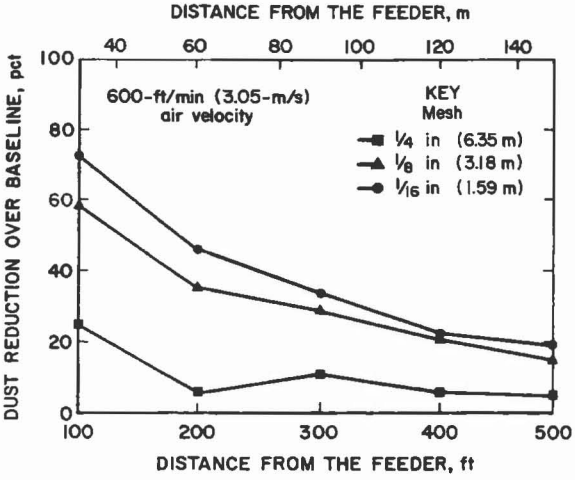

Figure 5. Average mesh dust efficiencies measured in the laboratory at 600 ft/min air velocity.

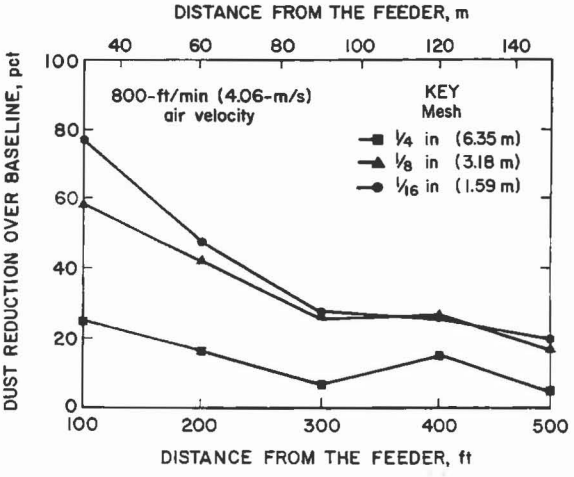

Figure 6. Average mesh dust efficiencies measured in the laboratory at 800 ft/min air velocity.

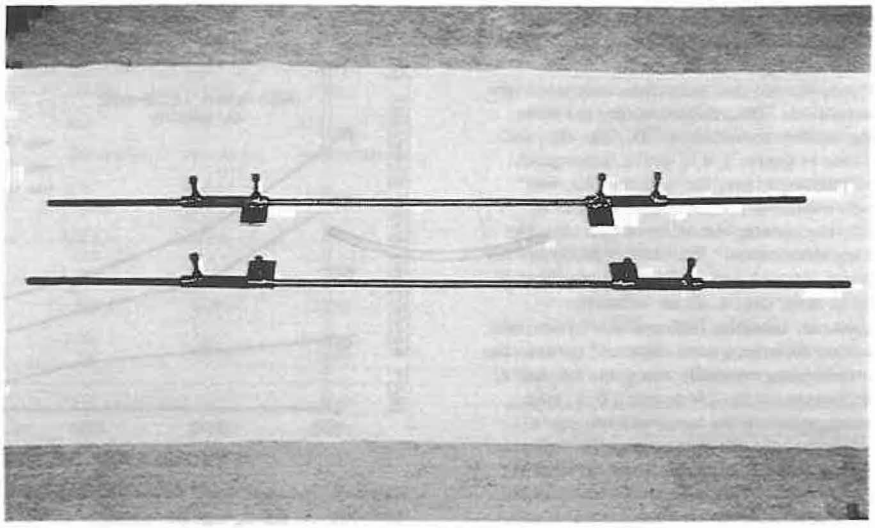

Figure 7. Mesh-hanging system hardware utilized in the underground evaluation.

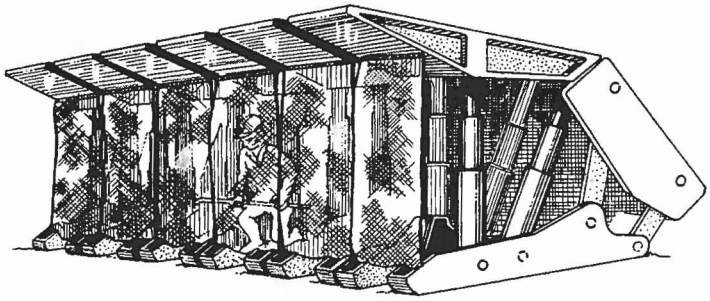

Figure 8. Translucent mesh partition mounted on the shields to isolate the worker walkway from the working face.

The 1/8 in mesh was selected for this system because the experimental results showed that this size material provided almost as good air-splitting effectiveness as the 1/16 in mesh, with 75 pct more open area for improved worker visibility. It was also decided to hang the mesh continuously from rods secured to the underside of each shield canopy using existing light fixture bolts (figures 7, 8). Between each shield, amber latex tubing was attached to the end of each bar to provide the flexibility of continuously hanging the mesh. Several feet of mesh were bunched together between shields and slid along the tubing during support movement. Also, in order to be installed underground, the mesh had to be classified as a low-risk fire hazard by the ASTM E-162 Test, "Standard Method Test for Surface Flammability of Materials Using a Radiant Heat Energy Source." The 1/8 in mesh treated with a flame retardant solution was tested in an independent laboratory and found to have a very low flame spread index of 2.2 ± 0.6[1], which explicitly falls into the low-risk Class A material (Class A reflects a 0 to 25 flame spread index; the highest risk category is Class C with a flame spread index between 75 and 100). Finally, the seam mined was a high-volatile group B bituminous coal with a historically low rate of methane emission, notably reducing any potential methane buildup areas with the translucent mesh.

[1] All confidence intervals used in this paper are at the 95 percent level.

Preliminary operational testing of the system was conducted along a limited area of the face (14 shields or 70 ft (21.3 m)) before the underground dust control experiment was conducted. This operational testing was conducted so that any system weaknesses could be identified and improved. The mesh application system was found to be durable and performed well under support movement. However, the shearer operators had some difficulty seeing the shearer through the test section of mesh. Therefore, it was decided that battery operated lights would be temporarily mounted to the shearer during the experiments to backlight the shearer and face area for improved operator visibility.

UNDERGROUND EVALUATION OF MESH CONCEPT

Dust control effectiveness testing of the mesh application system was conducted along two-thirds of the longwall face during multiple production shifts. Four-hundred and sixty feet (140.2 m) of mesh was continuously mounted from shields 4 through 95. This longwall operation had 148 two-legged shields (740 ft, (225.5 m)) and the 12 ft (3.7 m) to 14 ft (4.3 m) high seam was mined with a double drum ranging arm shearer. The shearer cut the lower two-thirds of the seam during the head-to-tail cut pass and trimmed the roof and floor during the tail-to-head cleanup pass with support movement inby the shearer.

Mobile dust sampling was conducted with respect to the shearer. Dust sampling was conducted 50 ft (15.2 m) outby, 100 ft inby, and 200 ft inby the shearing machine. A RAM instrument and four personal samplers were used at each mobile sampling location. Two personal samplers were run during the head-to-tail pass, and two personal samplers were run during the tail-to-head pass between shields 4 and 95. Two stationary personal samplers were also collected at the last open crosscut and at shield 10. Air velocity measurements were made along the face over the face conveyor and in the workers' walkway. Two shifts of sampling was conducted with the mesh in place for a total of six head-to-tail and six tail-to-head passes. Three shifts of sampling was conducted without the mesh for a total of nine head-to-tail and nine tail-to-head passes. Visibility through the mesh remained a problem for the shearer operators, so only two shifts of sampling was conducted with the mesh. Observations during these two shifts of mesh trials indicate that low-intensity light of the temporary battery lights was inadequate, requiring a higher-intensity light system on the face side of the mesh.

Underground results have shown that the mesh can be an effective air splitting method at a longwall operation. Figures 9 and 10 show the average gravimetric dust concentrations measured adjacent to the shearer during the head-to-tail cut and tail-to-head cleanup passes, respectively. During the head-to-tail cut pass notable reductions were achieved with the mesh (figure 9). Reductions of 52 pct and 43 pct were achieved 100 ft and 200 ft inby the shearer, respectively. The effect of production on these dust reductions were considered minimal, since the average shearer tram speeds for this comparison were similar (with mesh 21.9 $\pm$ 3.4 ft/min (0.11 $\pm$ 0.01 m/s); without mesh 22.0 $\pm$ 1.5 ft/min (0.11 $\pm$ 0.01 m/s). Similar dust reductions were achieved with this mesh type at comparable air velocities at Lake Lynn Laboratory (see figure 4), verifying the laboratory results.

Negligible changes in dust concentrations were observed during the tail-to-head cleanup pass (figure 10). Production rate also remained essentially the same during this comparison (with mesh 29.9 $\pm$ 4.1 ft/min (0.15 $\pm$ 0.01 m/s); without mesh 31.0 $\pm$ 2.6 ft/m (0.15 $\pm$ 0.01 m/s). However, the mesh configuration during this pass was irregular with respect to airflow since supports were advanced between the shearer and inby sampling locations. The mesh was perpendicular to airflow when the supports were being advanced and was a likely cause of the decline in the mesh effectiveness (figure 11). Also, the dust concentrations inby the shearer during this cleanup pass were almost twice as high as those of the head-to-tail cut pass. The shearer cut the upper few feet of the roof coal with the lead drum directly against the airflow, causing a large dust plume at the lead drum. Some of the dust plume was observed to flow through the mesh toward the worker walkway.

Airflow during this survey remained relatively comparable at the face and in the worker walkway with and without the mesh. Figure 12 shows the average face and walkway air velocity profiles during the survey. The air velocity profiles show that both face and walkway air losses into the gob occurred up to shield 20 with and without the mesh. From shield 20 to 40, the face airflow increased at the face and decreased in walkway with and without the mesh, indicating that walkway airflow moved back into the face area and was not noticeably affected by the mesh. From shield 40 to 80, air velocities increased at the face and in the walkway without the mesh. Face and walkway air velocities with the mesh remained relatively more stable at these locations. This indicates that the mesh may have provided some resistance to gob air returning to the face. Since the air velocity differences with and without the mesh were not significant, these marginal changes could also be attributed to small changes in face height and gob consolidation. However, the air velocities measured do

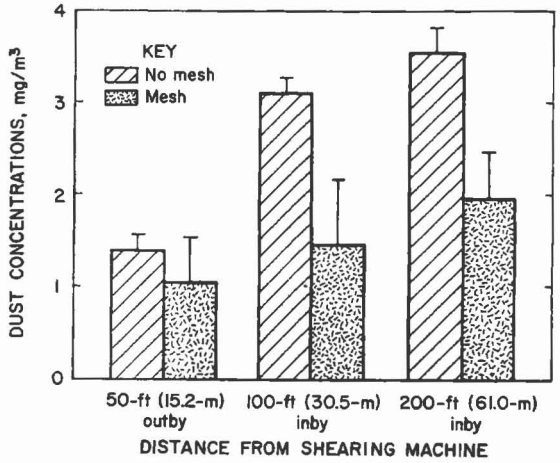

Figure 9. Underground dust concentrations measured at three mobile sampling locations around the shearing machine during the head-to-tail pass (error bars show the 95 pct confidence interval).

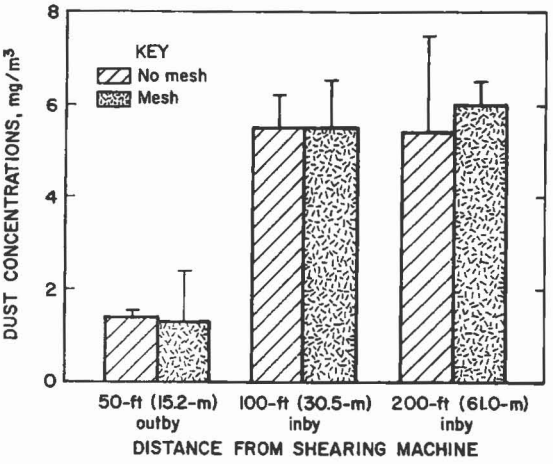

Figure 10. Underground dust concentrations measured at three mobile sampling locations around the shearing machine during the tail-to-head clean-up pass (error bars show the 95 pct confidence interval).

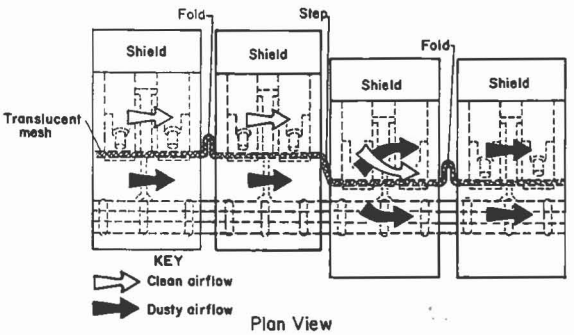

Figure 11. Irregular mesh configuration during support movement on the tail-to-head pass.

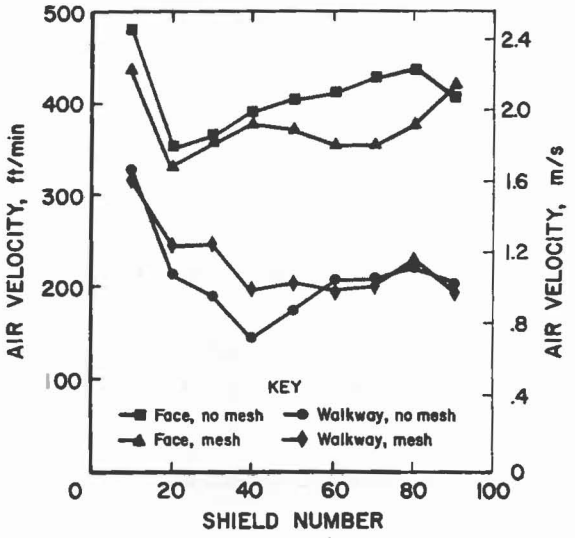

Figure 12. Face and worker walkway air velocities measured with and without the mesh.

indicate that the mesh did not significantly alter the longwall ventilation patterns, and the effect of ventilation on the mesh's dust control effectiveness measured during this study was minimal.

CONCLUSIONS

The concept of holding airborne shearer generated dust to the face area by splitting the airflow along the face with a translucent mesh material was established to be feasible both in the laboratory and underground. Notable dust reductions were measured up to 200 ft inby the dust source or shearing machine. The underground study showed that the translucent mesh did not significantly alter the longwall airflow patterns along the portion of the face where it was applied. However, relative velocity trends down the face indicate that the mesh may have marginally increased the resistance of airflow from flowing out of the gob back toward the face. Since the mesh restricts the intermixing of the face and walkway airflows, dust and/or gas produced at the face or walkway area will tend to be held there along the face by the mesh. Application of this concept at gassy longwalls could possibly lead to higher-than-normal gas levels at the face or in the walkway, depending on the origin of gas (such as face, floor, or gob). Thus, more caution must be used when applying this concept in gassy mines. Flame-retardant polyester mesh materials can be manufactured and are available for underground use. The initial mesh-hanging system proved to be relatively functional and durable. Although the support movement formed mesh continuity irregularities and inadequate operator visibility through the mesh was experienced during the underground survey, the authors conclude that these problems can be overcome with improved application systems.

More application research is needed to better integrate this concept into the longwall mining system. One suggested improvement to this mesh hanging system would be to hang the mesh from cables pivoted from every fourth or fifth shield to reduce the mesh irregularities from support movement. Another mesh application system would be to mount the mesh to cable supported by heavy-duty pogo-stick-type devices secured to the cable trough (figure 13). These pogo-stick devices would need a ball-and-caster-type apparatus on top to allow shield movement and could be spaced out along the face at designated shields. Lack of visibility of the face through the mesh can probably be resolved by providing higher-intensity lights powered by the shearer and/or additional shield-mounted lights on the face side of the mesh. Only through system application development can this air-splitting concept be made more compatible with the operating environment.

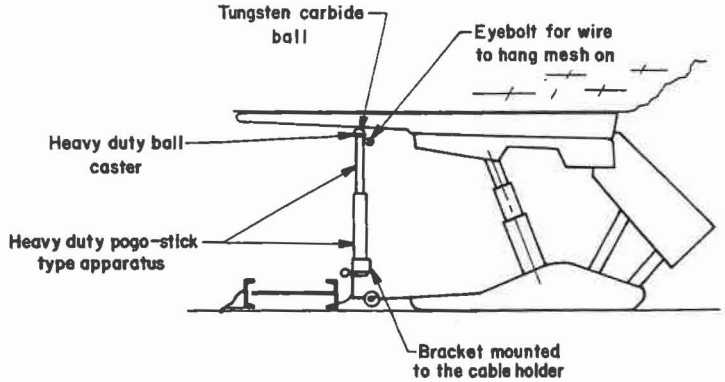

Figure 13. Alternative mesh application system for a longwall face.

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