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Replacing Brattice Cloth at Coal Faces With Air Curtains and Diffuser Fans, A Preliminary Study

UNITED STATES DEPARTMENT OF THE INTERIOR

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Replacing Brattice Cloth at Coal Faces With Air Curtains and Diffuser Fans, A Preliminary Study

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REPLACING BRATTICE CLOTH AT COAL FACES WITH AIR CURTAINS AND DIFFUSER FANS, A PRELIMINARY STUDY

by

Richard J. Bielicki,[1] Edward D. Thimons,[2] and Fred N. Kissell[3]

ABSTRACT

The possibility of replacing the brattice cloth closest to the coal mine working face with an air curtain mounted on top of a continuous-mining machine or with a diffuser fan was explored by the Bureau of Mines.

Preliminary tests conducted at a full-scale model working face with the brattice end set at 18 feet showed that the air curtain improved face ventilation only slightly and was not nearly as effective as placing the brattice at 10 feet. A 2,000-ft^3/min diffuser was more effective than the air curtain.

It is concluded that the air curtain probably could not function as a line brattice extension, although the diffuser fan may have some potential.

INTRODUCTION

Air curtains have been utilized as invisible barriers to unwanted air currents since their development in Germany in 1951. Their use in locations where there is a continuous flow of people, such as in department store doorways, is on the increase. They also are being used in industry and other places where shielding the air in one room from the air in another is important. This study deals with the utilization of the air curtain at the working face of a model coal mine.

The Code of Federal Regulations, Title 30, Part 75 requires that ventilation brattice or tubing be maintained at no more than 10 feet from a coal mine working face. Part 75 also sets minimum standards for air quality, quantity, and velocity to insure that air exchange at the face proceeds efficiently to prevent formation of an explosive methane-air mixture.

The 10-foot requirement is frequently not easy to meet, particularly if line brattice is used. Consequently, the Bureau of Mines is exploring

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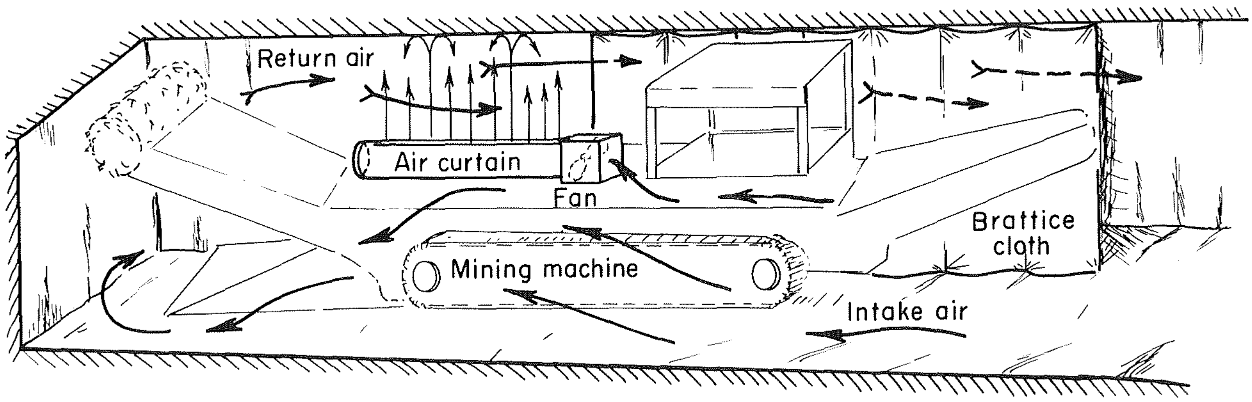

FIGURE 1. - Air curtain used as a line brattice extension.

alternate methods of face ventilation that offer some possibility of eliminating the need for brattice cloth in the immediate face area.

One possibility is to use an air curtain as a line brattice extension. With this arrangement, the line brattice only extends from the crosscut to a point near the rear of the continuous-mining machine, about 18 to 20 feet from the face. From here a 12-foot air curtain, mounted on top of the machine, extends toward the face. The sheet of air from the air curtain points straight up toward the roof and separates the intake and return air in the same fashion as a line brattice. Such a hypothetical air curtain is shown in figure 1.

Still another alternative to line brattice in the face area may be to equip a mining machine with a conventional diffuser fan. The diffuser is a machine-mounted fan, typically placed on the rear of the continuous miner, that projects a jet of air forward towards the face. The role of the diffuser fan in improving face ventilation has been described elsewhere (2-4).[4] The advantage of the diffuser fan compared with the air curtain is that it is familiar equipment within the mining industry.

This report describes a brief set of preliminary experiments to assess the feasibility of an air curtain used as a line brattice extension. This was done by comparing the effectiveness of an air curtain with that of a diffuser fan. The thought was that if the diffuser fan worked as well as or better than the air curtain, then research efforts to develop a line brattice extension would be more fruitful if the diffuser fan alternative were pursued.

ACKNOWLEDGMENTS

We wish to thank the personnel of the Pittsburgh Technical Support Center, Mining Enforcement and Safety Administration, especially Robert Dalzell, Chief, Ventilation, for their cooperation and support in the compilation of these data.

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

EXPERIMENTAL WORK

The experiments were conducted in a full-scale plywood model of a coal mine heading constructed by the Pittsburgh Technical Support Center of the Mining Enforcement and Safety Administration. The heading is equipped with a model of a Jeffrey 120M[5] fullface continuous miner. The heading is 7 feet high by 12 feet wide by 80 feet long. Gas is released at the working face through three evenly spaced horizontal pipes that extend the entire width of the face and have holes spaced along them to provide an even flow across the face. Sampling points are located at convenient spots throughout the model. The main use of the model is to measure methane distribution and airflow patterns under different ventilation conditions.

For this series of experiments, the machine cutterhead was in the down position rotating at 60 rpm. Methane was released only through the lowest of the three pipes, which is where most of the methane would be released during mining. Exhaust line brattice was used. The distance from the end of the brattice to the face was 18 feet. The quantity of air drawn behind the brattice by an auxiliary fan, located outside the model, ranged from 4,300 to 7,900 ft^3/min.

The methane concentration was measured at designated points within the face area. Bacharach continuous methane monitors were used, supplemented by MSA M-402 handheld methanometers. When handheld instruments were used, at least half a dozen readings were taken at each location and then averaged. Continuous readings were taken for a minimum of 10 minutes.

The air curtain plenum was a tube of sheet metal, 1-foot diameter by 13 feet long. One end was closed and a 1,700-ft^3/min fan was attached to the other. A 12-foot slot was cut in the side for the air curtain jet. The cylinder was placed directly on top of the mining machine as if it were an extension of the line brattice (fig. 1-2).

In the first set of experiments, the air jet was directed by a set of adjustable louvers, and the angle of the jet could be varied. However, the jet itself was so disperse it was effective only when the main ventilation flow into the brattice was not too high (fig. 2). In the second set of experiments, the louvers were replaced with a single narrow slot 3/8 inch wide by 12 feet long (fig.2). Baffle plates or turning vanes (not shown) were added to insure that the jet emerged at a 90° angle to the major axis of the plenum. The jet through this slot was much less disperse than that through the louvers. A typical air velocity at the slot exit was 4,200 ft/min; 1 foot up it was 1,200 ft/min, and 2 feet higher at the roof, it was 800 ft/min.

Engineering details and air curtain design theory are both readily available from air curtain manufacturers, and will not be presented in detail here.

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[5]Reference to specific equipment does not imply endorsement by the Bureau of Mines.

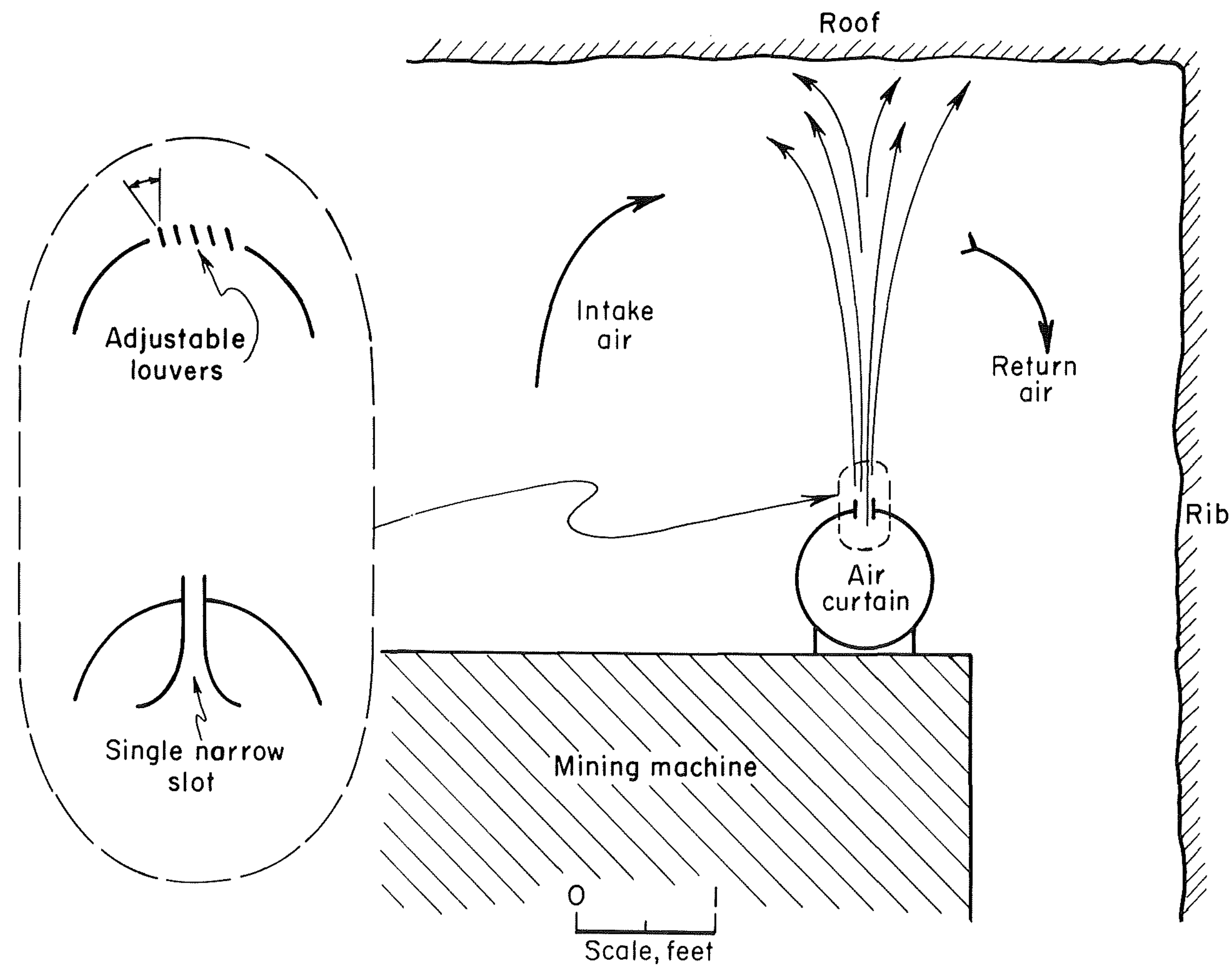

FIGURE 2. - Details of air curtain on mining machine.

RESULTS

In the first set of experiments, 10 ft^3/min of methane was released at the face and the main fan circulated 4,300 ft^3/min of air. Measurements were first made without the air curtain (fig. 3). Table 1 gives the average methane concentration at five locations in the face area (shown as A, C, D, F, and G). The high-value concentration was 1.7 percent methane, and the average of the five points was 0.53 percent. The air curtain was then installed and turned on (fig. 4). One series of measurements was made with the jet pointing straight up. In two other series, the jet angled 10° and 30° from the vertical towards the intake side. In each case, the high-value concentration was reduced by a factor of two, but this was at the expense of the other locations, since the average methane concentration was virtually unaffected. There was also no advantage to directing the jet at a slight angle.

TABLE 1. - First set of air curtain tests

(Percent CH_4)

	Location (fig. 3)					High value	Aver-age	Average if 100 pct efficiency[1]
	A	C	D	F	G			
AIRFLOW = 4,300 FT³/MIN; METHANE RELEASE RATE = 10 FT³/MIN								
No air curtain.......	0	1.7	0.08	0.29	0.60	1.7	0.53	0.23
Air curtain on--jet straight up.........	.14	.80	.44	.55	.54	.80	.49	.23
Air curtain on--jet angle 10°...........	.32	.78	.46	.56	.48	.78	.52	.23
Air curtain on--jet angle 30°...........	.32	.86	.54	.71	.62	.86	.61	.23
AIRFLOW = 7,900 FT³/MIN; METHANE RELEASE RATE = 13.5 FT³/MIN								
No air curtain.......	1.8	0.50	1.1	0.37	0	1.8	0.75	0.17
Air curtain on--jet straight up.........	.22	.82	.82	.88	.07	.88	.56	.17
Diffuser fan on......	1.0	.68	.16	.21	.05	.68	.42	.17
Brattice at 10 ft....	.77	.72	0	0	0	.77	.30	.17

[1]Methane flow divided by airflow.

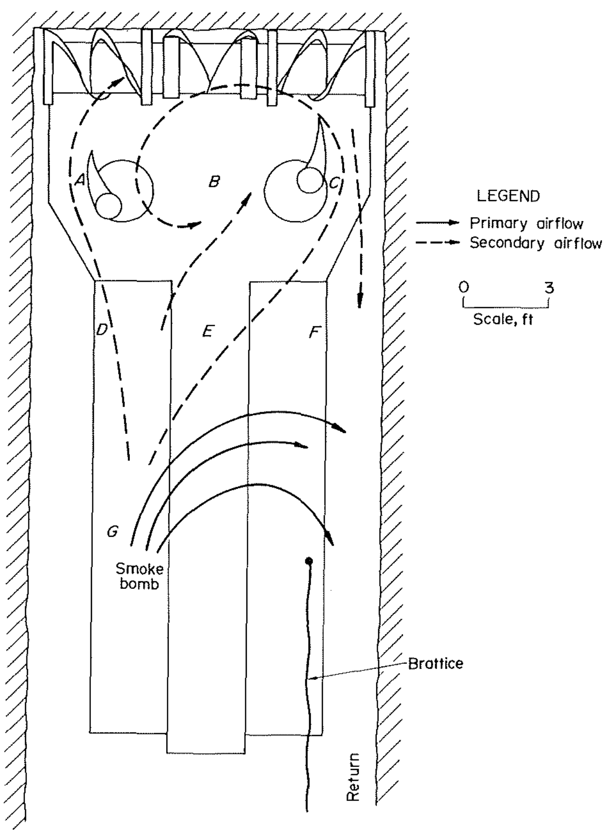

FIGURE 3. - Entry without air curtain.

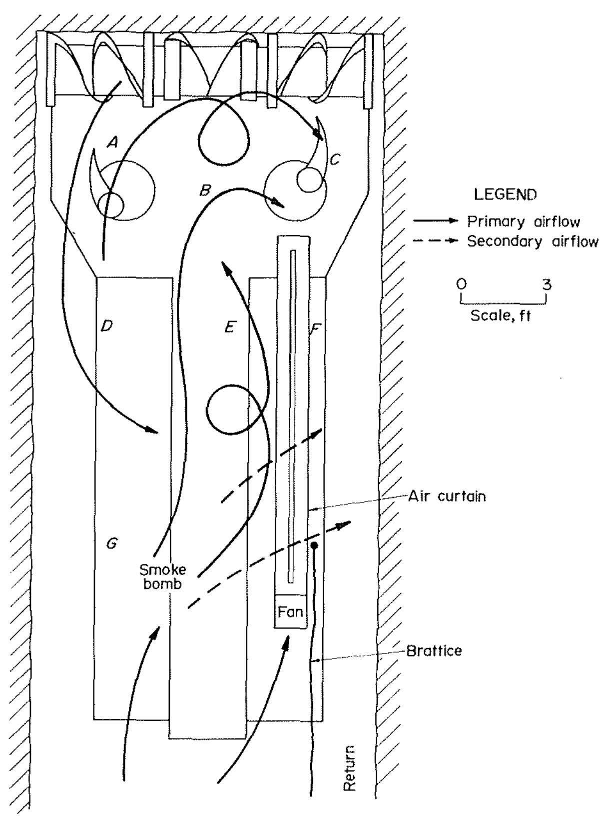

FIGURE 4. - Entry with air curtain on machine.

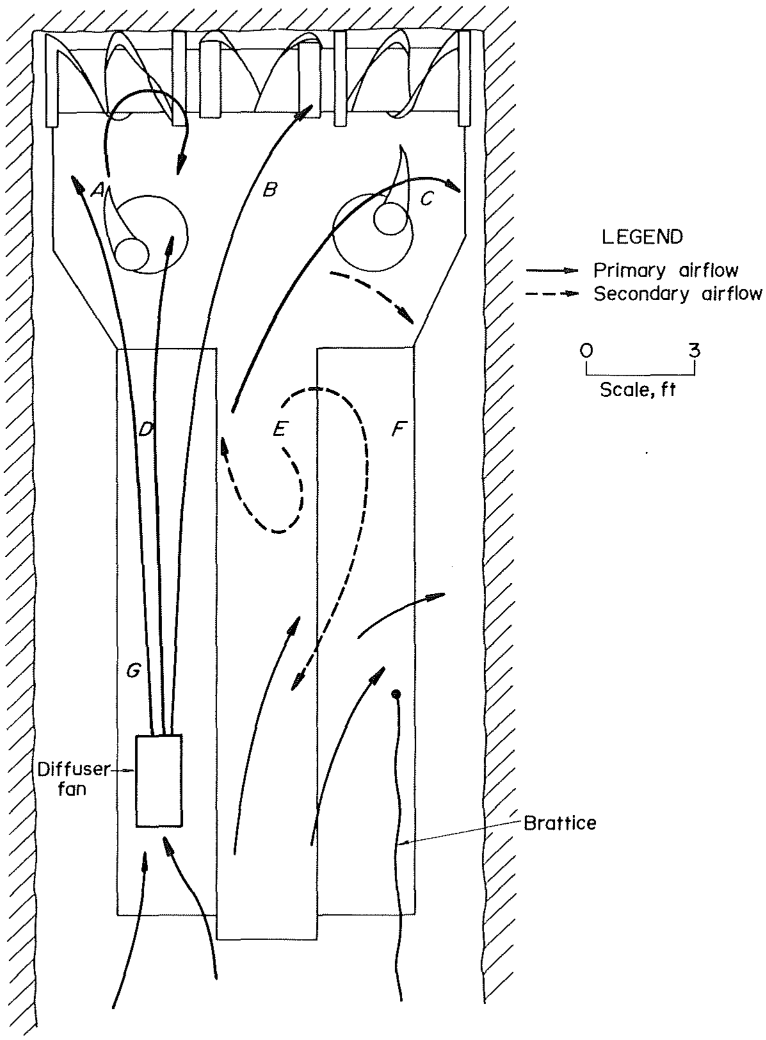

FIGURE 5. - Entry with diffuser fan on machine.

Following this, the airflow was boosted to 7,900 ft^3/min and the face methane emission rate to 13.5 ft^3/min (table 1). Without an air curtain, the high value was 1.8 percent and the average was 0.75 percent.

With the air curtain in place, the high value was reduced by a factor of two, and the average was also reduced somewhat.

Next, the air curtain was removed and the diffuser fan was installed (fig. 5). The diffuser fan reduced methane levels even more than the air curtain, lowering both the high value and the average concentration. These values may also be compared with some methane concentrations obtained under similar conditions (1) but with the brattice at 10 feet. Table 1 also gives the methane concentration that would be obtained at a face ventilation efficiency of 100 percent; that is, perfect mixing. It is apparent the diffuser fan is more effective than the air curtain, and neither was as effective in reducing the average methane level as maintaining the brattice at 10 feet. In no instance was close to 100 percent efficiency realized. The concentration average of 0.30 pct corresponds to $\frac{0.17}{0.30}$ = 57 pct efficiency.

Nevertheless, the air curtain seemed to have room for improvement because at the 7,900-ft^3/min airflow some of the ventilation air was penetrating the air curtain and going directly into the return. The slot was, therefore, redesigned to provide a jet which had a higher velocity and was less disperse. The modified slot used for the second set of experiments is shown in figure 2.

In the second set of experiments, the main airflow was at 5,100 ft^3/min (table 2). The air curtain reduced the high methane value, but increased the average slightly. Again the diffuser fan worked better, reducing both the high value and the average methane concentrations substantially.

TABLE 2. - Second set of air curtain tests[1]

(Percent CH_4)

	Location					High value	Aver-age	Average if 100 pct efficiency
	A	B	C	E	G			
No air curtain.......	0.78	0.43	2.3	0.48	0.025	2.3	0.80	0.29
Air curtain on--jet straight up.........	.74	1.4	1.3	.98	.35	1.4	.95	.29
Diffuser fan on......	.43	.20	.74	.15	.13	.74	.33	.29

[1]Airflow = 5,100 ft^3/min; methane release rate = 15 ft^3/min.

Smoke tests were conducted following the methane tests; a smoke bomb was released near location G, and movement of the smoke cloud was observed. Without the air curtain, most of the primary fresh air went directly into the return and the face was ventilated only with secondary airflows. With the air curtain in place, most of the fresh air appeared to be going to the face; however, the methane monitor readings indicate otherwise. With the diffuser fan operating (fig. 5), a strong jet of air was projected all the way to the face on the left side.

CONCLUSIONS

A machine-mounted air curtain tested as a line brattice extension under a limited set of conditions gave mixed results. The high-value methane concentration in the working face area was reduced substantially, but the average concentration over five monitors was essentially unchanged. When a diffuser fan was substituted for the air curtain, the high-value and the average methane concentrations were greatly reduced, although the fan was not as effective in reducing the average methane level as placing the brattice at 10 feet.

It would seem from these few tests that future research efforts to develop a line brattice extension should be concentrated on diffuser fan studies.

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