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Evaluation of a Combined Face Ventilation System Used With a Remotely Operated Mining Machine

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EVALUATION OF A COMBINED FACE VENTILATION SYSTEM USED WITH A REMOTELY OPERATED MINING MACHINE

By E. Divers,¹ N. Jayaraman,¹ and J. Custer²

ABSTRACT

This Bureau of Mines report presents results of an underground evaluation to determine the respirable dust and gas control effectiveness of a combined (push-pull) face ventilation system for coal mines. The system utilizes both blowing and exhaust curtain, continuous miners equipped with radio remote control, and flight conveyors. Bureau of Mines tests showed a 97% reduction in respirable dust concentrations from the usual cab position on the continuous miner to the remote control operator's position. This allowed the remote control operator to be well within, and the usual cab position to exceed, Federal respirable dust standards. Tests utilizing a safe tracer gas, sulfur hexafluoride (SF_6), to determine the face ventilation effectiveness of the combined blowing and exhaust system showed that the system also has excellent methane dispersion capability.

Where wide entries permit, this combined face ventilation system and use of remote control can be a very effective method for dust and gas control.

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INTRODUCTION

Various research studies by the Bureau of Mines have consistently shown that effective ventilation is still the primary and most cost effective technique for removing dust and gas from coal mine face operations. There are three basic face ventilation systems: Blowing, exhaust, and combined.

Blowing systems can be very effective in sweeping gas from the face. They can also increase production by allowing deeper cuts. Unfortunately, blowing systems usually create severe dust problems by allowing the dust created by the continuous miner to roll back beyond the miner operator. The standard procedure for alleviating this problem is to place a mechanical dust collector (scrubber) on the mining machine. Scrubbers are expensive and create additional maintenance problems, but increased production can justify their use.

Exhaust face ventilation can also offer good dust control when the line curtain is maintained reasonably close to the face. Maintaining this curtain is troublesome, and severe safety problems result for personnel extending curtain beyond permanently supported roof. These problems can also limit the depth cut, thus lowering production.

Where conditions permit, combined face ventilation systems, using both blowing and exhaust curtain, potentially offer the best features of each, allowing good dust and gas control and deeper cutting.

Required conditions are wide entries, 20 ft or more, which allow room for both curtains, and reasonably good roof to allow deep cuts.

On most continuous miner sections, the dust exposure of the continuous miner operator is primarily attributable to the cutting action of the machine itself. Most of the dust cloud originates at the face, and the exposure of the operator depends largely on how far this dust spreads near the cab where the operator sits. Radio and other types of remote control units that are now available, and which weigh only 5 lb, allow the continuous miner operator to move farther back from the face area than the conventional position in the cab, thus reducing exposure to dust.

Solar Fuel Co., a division of Gulf+Western Industries, Inc., is using a combined face ventilation system with a remotely controlled unit, that appears to offer high production with excellent dust and gas control. An underground test program was arranged by the Bureau of Mines to evaluate the effectiveness of the combined face ventilation system for both respirable dust and gas control, with special attention to the effects of remote control in the continuous miner operator's exposure to dust. Since the mine selected (Solar #5A mine) did not have a significant gas problem, Bureau personnel used a safe tracer gas (SF_6) technique developed by the Bureau³ to determine face ventilation effectiveness.

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The authors would like to thank Dr. Fred N. Kissell of the Pittsburgh Research Center for initially suggesting the possible advantages of the double brattice systems and further technical contributions during the progress of the studies. The authors also appreciate the excellent

cooperation given by all personnel at Solar Fuel Co.

³Vinson, R. P., F. N. Kissell, J. C. LaScola, and E. D. Thimons. Face Ventilation Measurement With Sulfur Hexafluoride (SF_6). BuMines RI 8473, 1980, 16 pp.

MINE TEST SITE DESCRIPTION

Solar Fuel operates two drift mines in the upper Freeport "E" seam, just north of Somerset, Pa. Seam height is approximately 42 in. All mines utilize flight conveyors and radio remote control with Jeffrey 101 continuous miners. Typical development is three 20-ft-wide entries on 50-ft centers. Face crews normally consist of five workers: a remote control miner operator, roof bolter operator and helper, bridge carrier operator, and brattice worker-carrier. Typical shift production is 350 tons.

For the preliminary survey the blowing curtain was on the left and just behind the continuous miner. Spray water flow rate was 15 gpm and 70 psig at the nozzle. The exhaust curtain was on the right and extended inby 10 ft past the blowing curtain. Primary airflow at the end of the exhaust curtain was 4,500 cfm.

Both curtains were hung from roof bolt plates with wood wedges, and no special effort was made to eliminate curtain sag between roof bolts. Indeed, leakage from the blowing to the exhaust side of the entry allowed the remote control operator to remain in fresh intake air. With deep penetration into the entry, about half of the air leaked to the exhaust side. Although the volume of leakage was approximately 4,500 cfm, no measurable air movement was detected between the blowing and exhaust curtain. Since the continuous miner was cutting into a 14-in rockband, large quantities of visible dust were generated. This dust cloud seldom rolled back beyond the inby end of the exhaust curtain, and it was very easy for the remote control operator to stay out of the visible dust and still remain within 20 ft or so of the miner.

PRELIMINARY SURVEY

A preliminary underground survey was conducted to determine the best dust and gas sampling procedures. During this survey, two GCA⁴ RAM-I dust monitors were used to rapidly evaluate short-term dust concentrations. Simultaneous 10-sec interval readings were taken for 7 min at two locations: one at the remote control operator's position, 10 ft outby the continuous miner, and the other immediately across the entry behind the exhaust curtain. Safety conditions would not allow readings at the usual cab position on the

continuous miner. During this survey, the operator tended to keep about 10 ft from the miner and just outby the left fender. Respirable dust concentrations at this location were approximately 5% of those behind the exhaust curtain. During this survey the miner was making a 10-ft-deep slab cut on the left side in a 50-ft-deep by 20-ft-wide entry. These initial observations and dust readings were encouraging, and a more thorough dust sampling program was initiated.

RESPIRABLE DUST CONTROL EVALUATION

For this respirable dust control evaluation, 8-hr gravimetric (personal) samplers, identical to those commonly used underground, were used. A cluster of three samplers was placed in the immediate return to evaluate total dust generated at the face. An identical cluster of three was placed at the usual cab

position on the continuous miner, and two were connected to the radio control unit. Samplers were taken for three consecutive daylight shifts. Production including rock was 350, 295, and 285 tons, respectively. During this period, 12 place changes were made. The remote control operator for these tests was positioned between 10 and 20 ft from the continuous miner. Subsequent analysis of the gravimetric samples showed a 97% reduction (table 1) in respirable dust

⁴Reference to specific products does not imply endorsement by the Bureau of Mines.

concentrations at the remote position compared with the cab position on the machine. Note that the 3.21-mg/m³ concentration at the usual cab location is not in compliance with Federal regulations (2 mg/m³).

TABLE 1. - 8-hr gravimetric sampling results: Respirable dust concentration, mg/m²

(Mean values appear in parentheses)

10/26/81	10/27/81	10/28/81	3-Shift average
CAB POSITION ON MACHINE			
3.27	2.70	1.84	
4.12	3.59	2.20	
5.62	3.71	1.80	
(4.34)	(3.33)	(1.95)	(3.21)
REMOTE			
0.15	0.10	0.08	
.13	.08	.09	
(.14)	(.09)	(.08)	(0.11)
RETURN			
7.06	3.08	3.41	
7.15	3.71	3.28	
	3.41	3.66	
(7.11)	(3.40)	(3.45)	(4.35)

NOTE.--Comparing the remote operator's position to the cab position on the machine, the 3.21:0.11 ratio of the means is equivalent to 29.1, for a dust reduction of 97%.

These results are consistent with a study conducted by Bituminous Coal Research, Inc.,⁵ which indicates that dust samplers ahead of the remote control operator were exposed to substantially higher dust levels than either the sampler worn by the operator or samplers mounted behind the operator. For example, a sampler located just 3 ft ahead of the operator's position on the continuous

⁵Kost, J. A., and R. D. Saltsman. Evaluation of the Respirable Dust Area Sampling Concept as Related to the Continuous Miner Operator. Bituminous Coal Research, Inc., BCR Rept. L-792, January 1977, pp. 25-30.

miner may indicate a concentration up to twice that at the operator's position. It can therefore be seen that a remote control system, that keeps the remote control operator farther from the face can reduce the operator's dust exposure considerably.

GAS CONTROL EFFECTIVENESS

Determining the gas dispersion ability of coal mine face ventilation systems can present problems, especially in mines like Solar Fuel's #5A mine, which is non-gassy. Fortunately, a simple and effective technique⁶ recently developed by the Bureau of Mines was available. With this technique a small quantity (25 cm³) of SF₆ tracer gas was released immediately behind the continuous miner cutter head. Simultaneous 10-cm³ grab samples were taken at specific time intervals behind the exhaust curtain at location S, (fig. 1) and at the remote control operator's position. After gas chromatograph analysis of the samples, the percentage of SF₆ removed with respect to time was calculated and plotted. This can be compared with similar tests from other face ventilation systems known also to be effective.

Prior to the tests, ventilating air volumes, curtain setbacks, and face configurations were recorded, and a tee was placed in line with one end to the SF₆ syringe and the other to a hand-operated tire pump with the handle extended. Then the SF₆ was released through 1/4-in-ID polyvinyl chloride tubing connected from a position just behind the cutting head to a position just outby the right fender. Following a prearranged signal to those taking the grab samples, the total volume of 25 cm³ of SF₆ was injected, and the pump handle was depressed several times to insure complete dispersion. For

⁶Divers, E. F., J. C. LaScola, and G. J. Hundman. New Twin Scrubber Installation for Continuous Mining Machines. BuMines TPR 112, 1981, 10 pp.

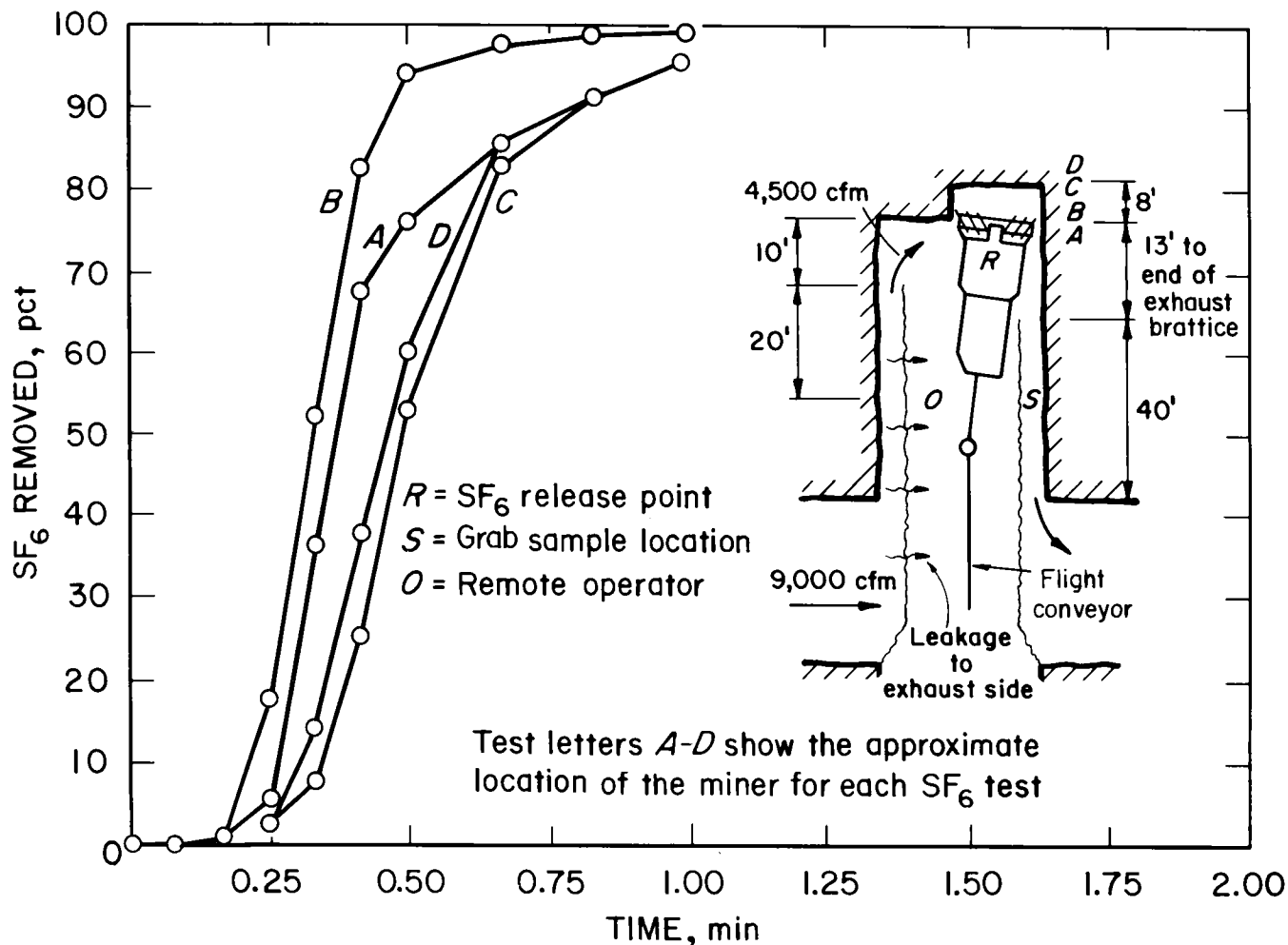


FIGURE 1. - SF₆ removed during box cut at various depths indicated by tests A, B, C, and D.

these tests, six grab samples were taken at each location (fig. 1) at 5-sec intervals, followed by six additional samples at longer time intervals. These air samples were analyzed for SF₆ content and used to plot graphs showing SF₆ removed versus time (fig. 1 and fig. 2).

The first-cut series of SF₆ tests were conducted with the continuous miner making an 8-ft-deep box cut on the right (exhaust) side. Four tests were conducted and no effort was made to influence the remote control operator's standard cutting procedures. Water spray flow rates were 15 gpm and 70 psig at the nozzle. In gassy mines, it is assumed that the operator would box-cut on the blowing side to better disperse face methane emissions. Even with the box cut opposite the blowing side, the test

showed good potential methane dispersion. SF₆ samples showed a rapid rise and decay at the return location behind the exhaust curtain approximately 10 ft outby the continuous miner. This immediate sharp rise and decay is typical of good face ventilation.

The face ventilation measurement conducted in a previous underground study⁷ showed that with conventional sprays, 1-ft box cut, a 9.5-ft curtain distance, and 3,600 cfm of airflow behind the curtain, 70% of the SF₆ was removed in approximately 1 min. In this study, 90% of SF₆ was removed in 1 min or less under all conditions of testing from A to F, indicating a very high degree of effectiveness for the double-curtain system.

⁷Work cited in footnote 3.

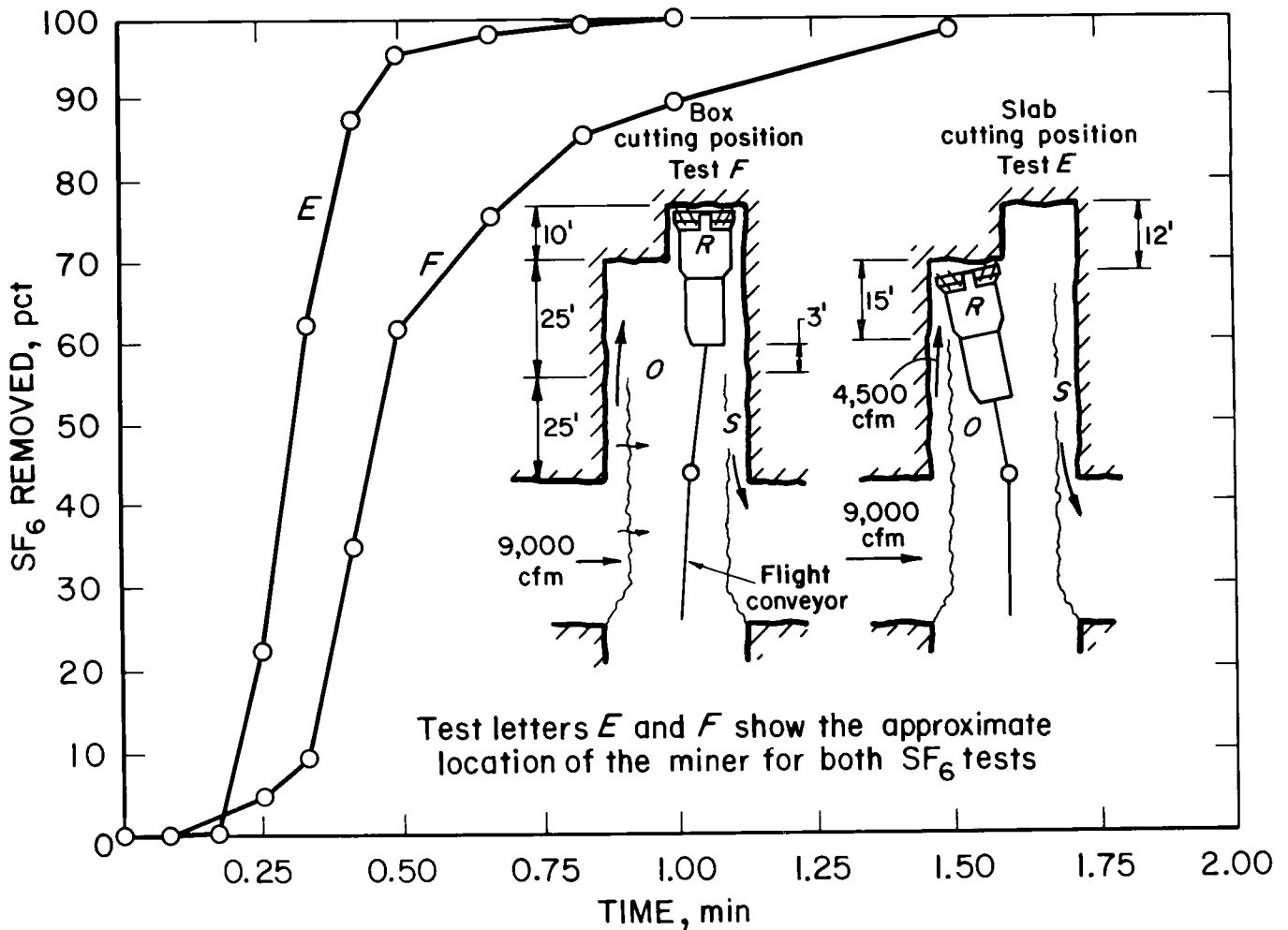


FIGURE 2. - SF₆ removed during box cut (test F) and slab cut (test E). See figure 1 for explanation of O, R, and S.

The exact release point for the SF₆ was not recorded for the previous study, but favored the offside of the boom, just behind the sprays. For Solar Fuel's underground test, release was just behind the

sprays, atop the boom and about 2 ft from the edge of the boom on the exhaust curtain side. The effects of this difference, if any, are not known.

COMMENTS

Past experience has shown that the effects of many underground coal mine dust control techniques can be more clearly seen when rockbands are being cut. A distinct plume can normally be observed entering the exhaust curtain, or the duct inlet when scrubbers are used. During these tests at Solar Fuel, wide rockbands (up to 18 in) were cut. This resulted in a plainly visible plume from the auger that was immediately drawn into the

exhaust curtain, when the exhaust curtain was maintained reasonably close to the face. When the exhaust curtain was not close to the face, a visible dust cloud created by the auger would drift slowly back over the continuous miner, beyond the cab position on the machine. With remote control, the operator could readily back away from this dust cloud. As a result, the remote control operator was normally in clean intake air. This

backaway position seldom exceeded 20 ft from the continuous miner. During these tests the miner made 12 place changes. The remote control operator stayed in clean air in all observed cutting positions.

Experience of dust control personnel at the Bureau of Mines shows that coal mine dust reductions of this magnitude (97%) are rare and can be especially important to mines with a reduced standard due to silica.

CONCLUSIONS

The combined face ventilation and remote control system used by Solar Fuel offers excellent dust and gas control. Bureau of Mines tests showed a 97% reduction in 8-hr respirable dust concentrations when comparing the usual cab position on the continuous miner with the remote (radio-controlled) position. These tests also showed that an operator in the cab position on the continuous miner would be exposed to dust

concentrations that exceed Federal regulations (2 mg/m^3), whereas he/she would be well within Federal limitation at the remote position. Other tests with a safe tracer gas, SF_6 , to determine face ventilation effectiveness for methane dispersion showed that the combined face ventilation system was more effective than 9.5-ft exhaust brattice at 3,600 cfm of primary airflow under the conditions tested.