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Blowing Versus Exhausting Face Ventilation for Respirable-Dust Control on Continuous-Mining Sections

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BLOWING VERSUS EXHAUSTING FACE VENTILATION FOR RESPIRABLE DUST CONTROL ON CONTINUOUS MINING SECTIONS

by

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ABSTRACT

This paper discusses advantages and disadvantages of blowing and exhausting face ventilation systems. Results of respirable dust surveys conducted on sections employing blowing and exhausting face ventilation indicate that significantly lower respirable dust concentrations in the face area result when employing exhausting face ventilation.

INTRODUCTION

One of the primary purposes of any coal mine ventilation system is to dilute and remove methane and dust generated by the mining process. This is accomplished by a ventilation system composed of two subsystems: the primary ventilation system and the face ventilation system. In accordance with present Federal regulations, Title 30, Code of Federal Regulations, Part 75.301, the primary ventilation system must provide a minimum of 9,000 cubic feet of air per minute at the last open crosscut. The face ventilation system utilizes the air at the last open crosscut to sweep the working face with a minimum of 3,000 cfm to dilute and remove methane and dust generated by the mining process. In addition to the minimum quantity of air required, the minimum mean entry air velocity must be 60 feet per minute, unless a lower velocity has been determined adequate to control methane and respirable dust by the Coal Mine Health and Safety District Manager.

Prior to the 1969 Federal Coal Mine Health and Safety Act, which established a respirable dust standard (currently 2.0 mg/m^3), the main emphasis of coal mine ventilation was to maintain the methane concentration below 1 volume percent. However, the minimum air volume or velocities required by law for methane control are not necessarily adequate to maintain respirable dust concentrations below 2.0 mg/m^3. Consequently, face ventilation systems must be designed to provide the necessary air quantity and velocity to dilute and remove methane and respirable dust generated by the mining process.

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FACE VENTILATION SYSTEMS

Face ventilation systems may be classified into two general types: blowing and exhausting. Each type may employ line brattice and/or an auxiliary fan with tubing. Figure 1[2] shows typical face airflow patterns generated as the end of a blowing line brattice is varied from 5 to 20 feet from the face. Similar airflow patterns are generated when tubing is used.

As can be seen in figure 1, even with the end of the line brattice 20 feet from the face, adequate methane dilution should be achieved providng a sufficient quantity of air is supplied. However, to achieve this the distance from the brattice to the tight rib should be less than one-third the entry width. When the distance between the brattice and tight rib approaches or exceeds one-third the entry width, the airflow pattern of the blowing system is disrupted, resulting in decreased airflow across the face.[2]

A blowing face ventilation system (brattice or tubing) may be installed on either side of the face entry. Figure 1 shows that the most positive airflow across the face is achieved when the end of the brattice is maintained within 10 feet of the face. However, because of recirculation at the continuous miner operator's position, his respirable dust exposure is increased. To achieve adequate dust control at the operator's position with this type face ventilation system, the end of the tubing or brattice must be maintained outby the operator. When installed on the operator's side, this allows intake air to be discharged over the continuous miner operator. However, the discharge velocity of the blowing face ventilation system installed in this manner must be sufficient to provide adequate airflow across the face, otherwise, reducing the continuous miner operator's respirable dust exposure utilizing this procedure results in reduced methane control at the face. However, if the end of the line brattice or tubing is to be kept at a distance greater than 10 feet from the face, the Code of Federal Regulations, Title 30, Part 75.302-1 requires that a waiver be obtained from the Coal Mine Health and Safety District Manager.

If the brattice/tubing is installed along the rib opposite the continuous miner operator, dust-laden air from the face returns over the continuous miner operator increasing his respirable dust exposure. It must be emphasized that regardless of which side the brattice/tubing is installed, the dust-laden return air from a blowing face ventilation system returns over the shuttle car and/or loading machine operator, increasing his respirable dust exposure.

Figure 2[3] illustrates the decrease in air velocity that occurs with an increase in distance from the opening of a blowing and exhausting ventilation system of equal capacity. This illustrates that although adequate ventilation for methane control may be achieved with a blowing system with the end of the

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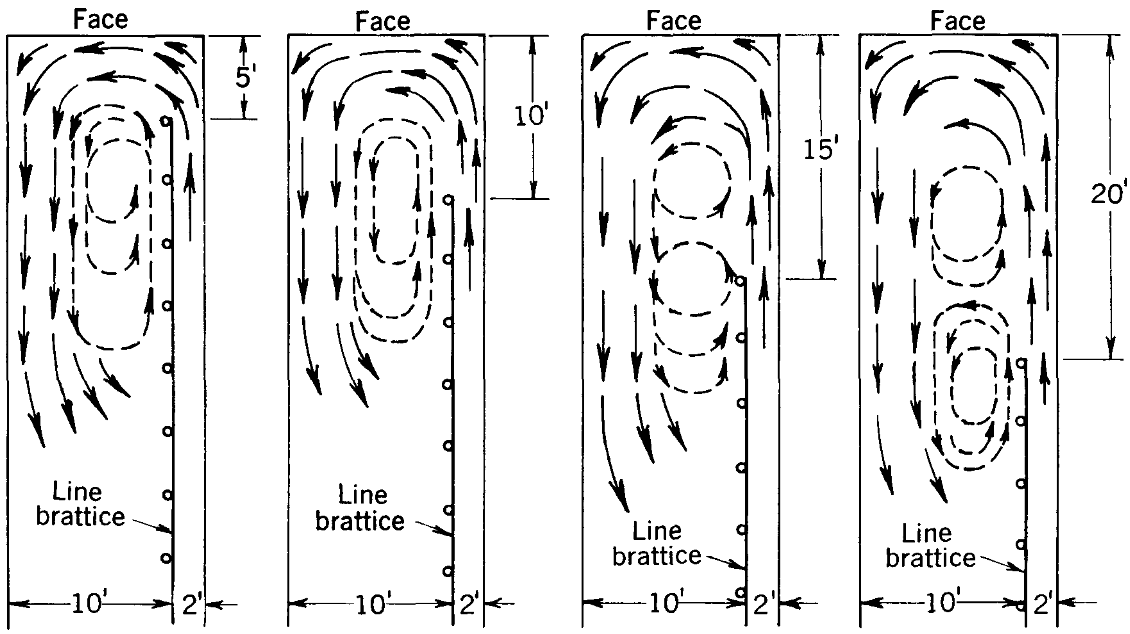
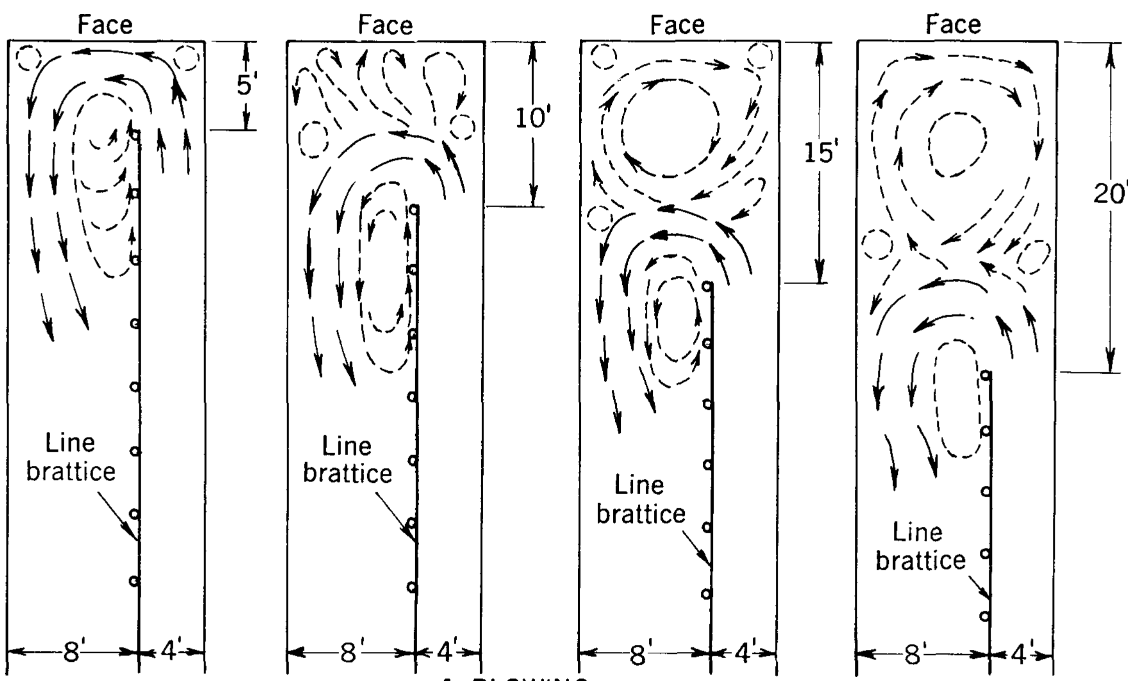
[2] Luxner, J. V. Face Ventilation in Underground Bituminous Coal Mines. Airflow and Methane Distribution Patterns in Immediate Face Area--Line Brattice. BuMines RI 7223, 1969, pp. 6-7, 11.

[3] Industrial Ventilation, A Manual of Recommended Practice. 13th ed., Am. Conf. of Gov. Ind. Hyg., 1974, pp. 1-5.



A BLOWING



A BLOWING

LEGEND

Airflow patterns independent of air volume

◌ Turbulence ⟶ Primary airflow - - - → Secondary airflow

FIGURE 1. - Airflow patterns generated with blowing line brattice.

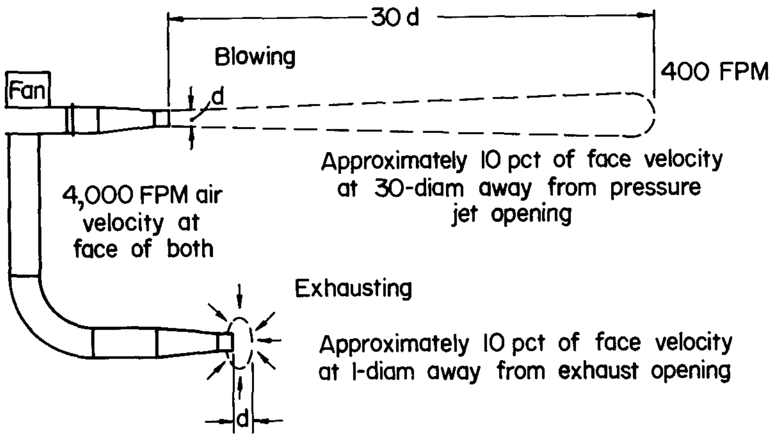


FIGURE 2. - Air velocity versus distance from end of tubing.

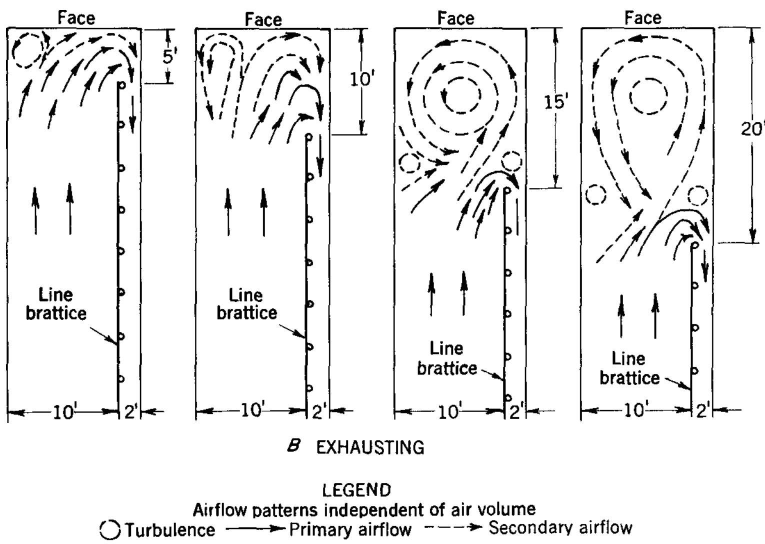


FIGURE 3. - Airflow patterns generated with exhausting line brattice.

tubing at a distance greater than 10 feet from the face, this is not necessarily true when employing an exhausting system.

Experiments conducted by MESA have shown that with two similar line brattice installations, one blowing and one exhausting, the blowing system is from 13 to 40 percent more efficient in delivering air to the face.[4] This is due primarily to the reduction in the airflow area that occurs between the tight rib and the brattice. With a blowing brattice system, the positive pressure behind the brattice forces the brattice away from the rib, increasing the airflow area, whereas with an exhaust brattice system, the brattice is forced toward the tight rib decreasing the airflow area. Because the pressure required to move air through airways of similar shape varies inversely as the airflow area to the five-halves power, small area reductions may result in large decreases in system efficiency. Therefore, it is critical that exhaust line brattice systems be installed carefully to minimize leakage.

Figure 3[4] shows that with the exhaust line brattice system the most positive airflow across the face occurs when the end of the brattice is maintained within 10 feet of the face. However, it is evident that some secondary airflow may occur in the corner of the face opposite the line brattice. Therefore, to achieve adequate methane control, it may be necessary to utilize a diffuser fan, mounted on the continuous mining machine, to discharge air to that area of the face. However, when a diffuser fan is employed in this manner some precautions should be taken:

[4]Dalzell, R. W. Face Ventilation in Underground Bituminous Coal Mines. Performance Characteristics of Common Jute Line Brattice. BuMines RI 6725, 1966, pp. 6-7.

1. The end of the exhaust system must be maintained inby the diffuser inlet under all operating conditions, and

2. The diffuser fan must not be operated when the exhaust face ventilation system is not in operation.

Exhausting face ventilation systems are excellent for controlling dust because intake air is passed over the workers while the dust-laden air is removed through the tubing or behind the line brattice. However, "an airflow of between 70 and 100 fpm across the entry"[5] should be maintained to insure effective respirable dust control.

COMPARISON OF RESPIRABLE DUST CONCENTRATIONS ON CONTINUOUS MINING SECTIONS WITH BLOWING AND EXHAUSTING FACE VENTILATION SYSTEMS

The Mining Enforcement and Safety Administration's Pittsburgh Technical Support Center's Dust Branch has conducted extensive respirable dust surveys on numerous sections employing blowing and exhausting face ventilation systems.

One study[6] was conducted on a section employing a Jeffrey Model 120-H Heliminer equipped with an integrally mounted dust collector. The face ventilation system employing blowing tubing behind a blowing line brattice is shown on figure 4. The ends of the brattice and tubing were maintained approximately 25 feet and 40 feet from the face, respectively. Approximately 5,000 cfm was discharged from the end of the line brattice. Respirable dust concentrations were measured at the continuous miner operator's position and the immediate return (a position in the last open crosscut between the main return and adjacent entry) with and without the dust collector operating. The sampling locations are depicted in figure 5.

A similar underground study[7] was conducted on a section employing a Jeffrey Model 120-M Heliminer employing the same model dust collector with an exhausting face ventilation system. The auxiliary face ventilation system shown on figure 6 consisted of a Joy 15-hp fan, exhausting approximately 7,000 to 8,000 cfm through 16-inch-diameter fiberglass tubing and a diffuser fan mounted directly in front of the continuous miner operator that delivered approximately 2,000 cfm to the corner of the face opposite the exhaust tubing. The end of the tubing was maintained within 10 feet of the face. Respirable dust concentrations were measured at the continuous miner and loading machine

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[5]Kingery, D. S., and others. Studies on the Control of Respirable Coal Mine Dust by Ventilation. BuMines TPR 19, 1969, p. 2.

[6]Tomb, T. F., R. L. Mundell, and C. D. Taylor. Underground Evaluation of a Machine-Mounted Dust Collector Used in Conjunction With a Blowing Face Ventilation System. MESA internal report.

[7]Tomb, T. F., R. L. Mundell, and C. D. Taylor. Underground Evaluation of a Machine-Mounted Dust Collector Used in Conjunction With an Exhaust Face Ventilation System. MESA internal report.

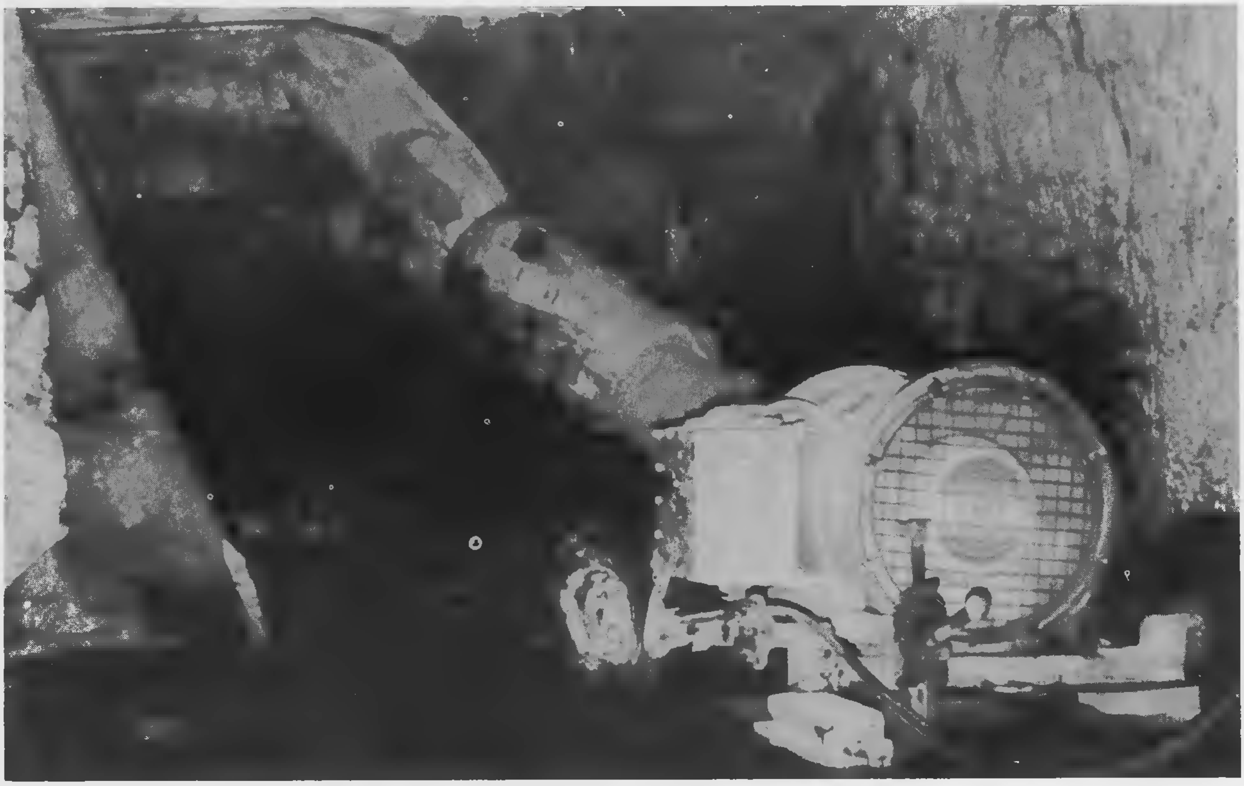


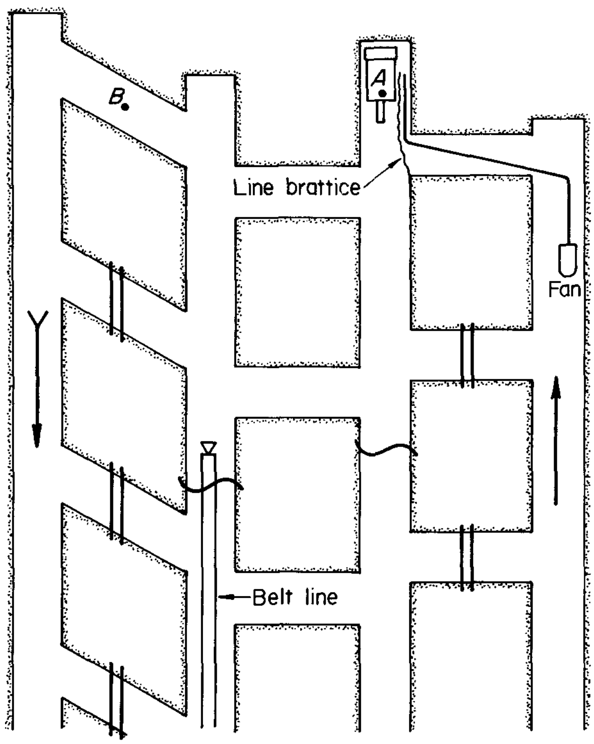
FIGURE 4. - Face ventilation system employing blowing tubing behind a blowing line brattice.

operator's positions with and without the dust collector operating. The sampling locations are depicted in figure 6.

Table 1 shows the mean face ventilation and respirable dust concentrations measured at the continuous miner operator's position, in the immediate return, and at the loading machine operator's position for the respective surveys.

TABLE 1. - Average respirable dust concentrations (mg/m^3, MRE equivalent) measured on sections employing continuous mining machines with integrally mounted dust collectors

Face ventilation	Blowing		Exhausting	
Dust collector	Off	On	Off	On
Continuous miner	9.2	3.3	1.2	1.1
Loading machine	-	-	0.6	0.8
Immediate return	7.6	2.5	-	-
Mean face ventilation (cfm)	5,400	5,400	8,000	7,100
Tonnage	409	375	301	282
Seam height (ft)	7		7	



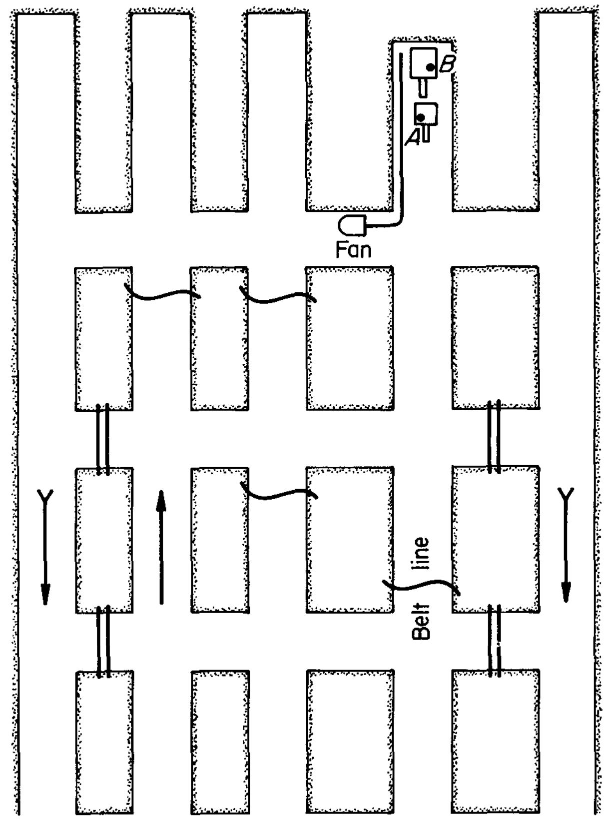
LEGEND

Permanent stopping
Curtain
Intake air
Return air

Sampling locations

A• Continuous mining machine
B• Immediate return

FIGURE 5. - Sampling locations on a section employing blowing face ventilation.



LEGEND

Permanent stopping
Curtain
Intake air
Return air

Sampling locations

A• Loading machine
B• Continuous mining machine

FIGURE 6. - Sampling locations on a section employing exhausting face ventilation.

The data in table 1 show that significantly lower respirable dust concentrations were measured on the section employing exhausting face ventilation with or without the dust collector operating. The low respirable dust concentrations, less than 2.0 mg/m^3, at the continuous miner and loading machine operators' positions were not affected by operation of the dust collector. This was attributed to the high capture efficiency of the exhausting face ventilation system.

Although the dust collector significantly reduced the respirable dust concentration at the continuous miner operator's position and in the immediate return on the section employing blowing face ventilation, the efficiency of the collector was not sufficient to prevent excessive respirable dust concentrations from returning over the continuous miner and shuttle car operators.

COMPARISON OF RESPIRABLE DUST CONCENTRATIONS MEASURED ON A BORING MACHINE SECTION WITH BLOWING AND EXHAUSTING FACE VENTILATION

Other respirable dust surveys[8] comparing blowing and exhausting face ventilation for respirable dust control were conducted on a section employing a boring-type continuous mining machine. The blowing face ventilation system employed a Joy 20-hp fan and 14-inch-diameter nonrigid tubing. The discharge from the tubing ranged from 3,000 to 4,500 cfm. The end of the tubing was kept immediately behind the continuous mining machine operator (approximately 25 feet from the face).

When an exhaust face ventilation system was employed on the same section, a Buffalo Forge 25-hp fan and elliptically shaped fiberglass tubing (16-inch equivalent diameter) were used. The airflow through the exhaust tubing ranged from 7,000 to 9,000 cfm. Initially, excessive leakage occurred at the tubing

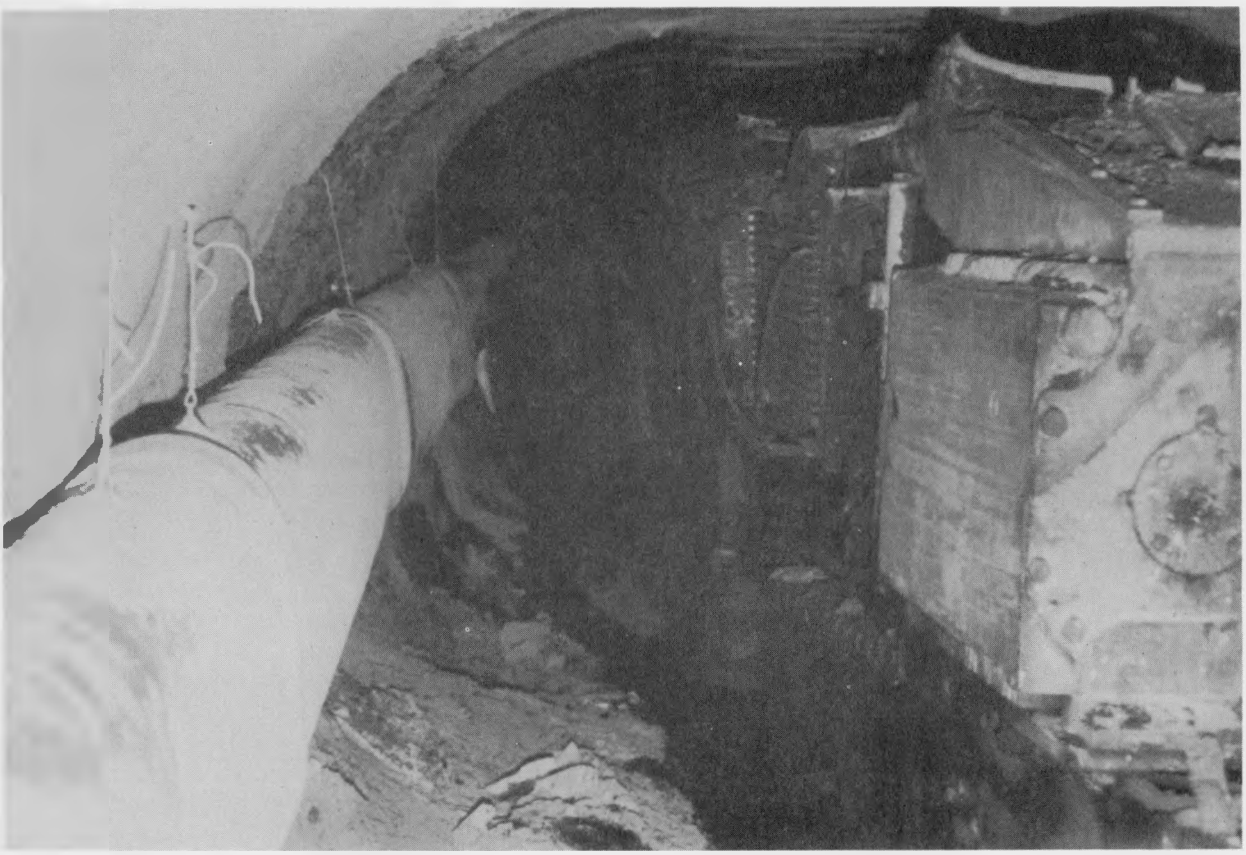


FIGURE 7. - Elliptically shaped fiberglass tubing employed on a boring machine section.

[8]Rosendahl, Thomas E., Pittsburgh Mining and Safety Research Center, U.S. Bureau of Mines Contract H0357001, "Development of an Effective Dust Control System With Secondary Ventilation on a Boring Machine"; contract awarded January 27, 1975, still ongoing as of July 1977.

joints due to difficulty in keeping the sections of tubing alined properly. Leakage was minimized using large rubber bands to seal the joints. The intake to the exhaust tubing could only be maintained within 15 feet of the face due to the size of the cutting head. This operation is shown on figures 7 and 8.

The average respirable dust exposures of the section employees are compared on table 2. With the exception of one roof bolter, the respirable dust exposure of each occupation exceeded the 2.0 mg/m^3 respirable dust standard when the blowing face ventilation system was used. The respirable dust exposure of each occupation was reduced to below the respirable dust standard when the exhausting face ventilation system was employed. The data also show that when the face ventilation system was changed from blowing to exhausting, the greatest percent reduction in respirable dust concentration occurred at the shuttle car and continuous mining machine operators' positions.

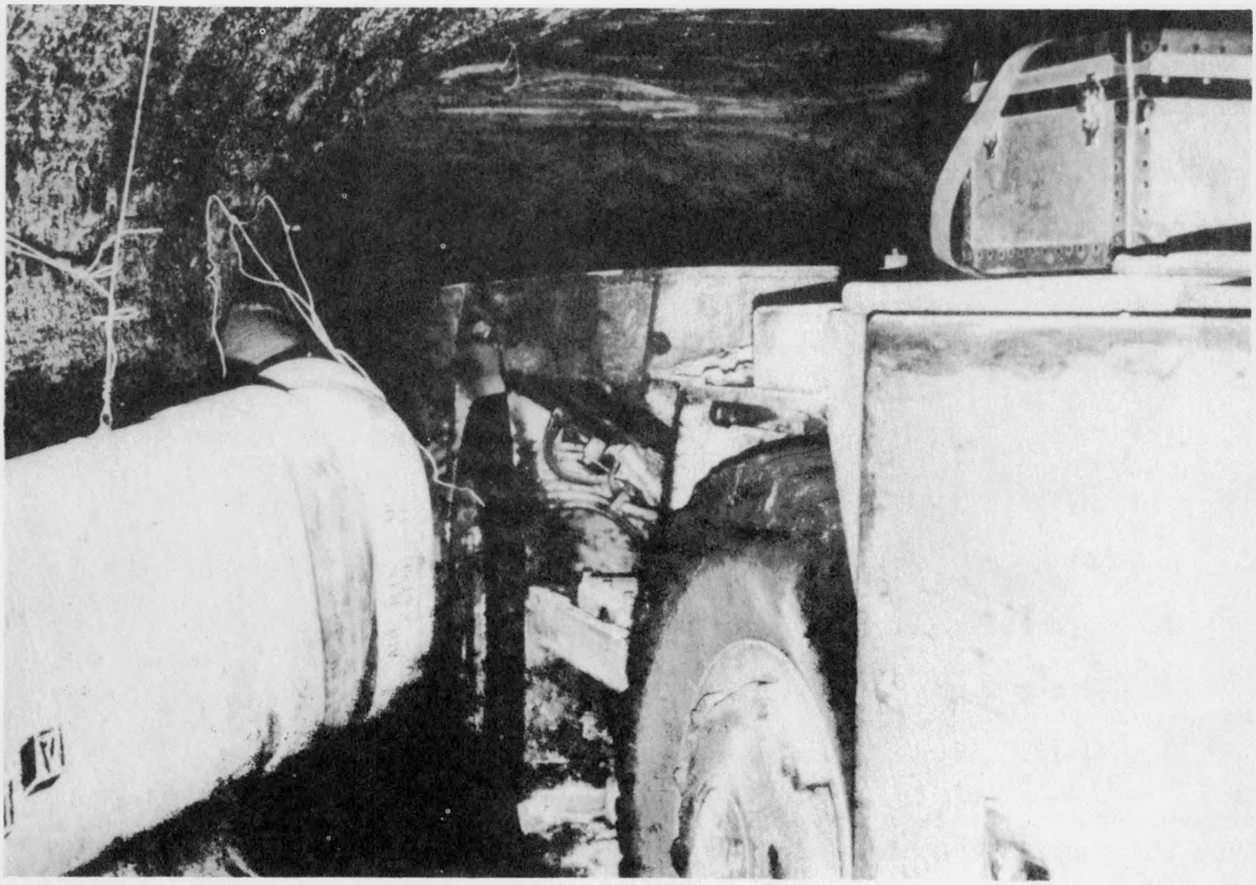


FIGURE 8. - Elliptically shaped fiberglass tubing employed on a boring machine section.

TABLE 2. - Average respirable dust concentrations (mg/m^3, MRE equivalent) measured on a boring machine section with blowing and exhausting face ventilation

Occupation	Face ventilation		Percent reduction
	Blowing	Exhausting	
Machine operator No. 1.........	5.1	1.2	76
Machine operator No. 2.........	5.0	1.7	66
Shuttle operator No. 1.........	3.8	1.3	66
Shuttle operator No. 2.........	6.2	1.4	77
Foreman........................	2.4	1.0	58
Repairman......................	2.1	1.0	52
Bob Cat operator...............	2.2	1.3	41
Roof bolter No. 1..............	1.8	1.1	39
Roof bolter No. 2..............	2.1	1.3	38
Tonnage........................	407	283	-
Ventilation (cfm)..............	3,000-4,500	7,000-9,000	-
Seam height (ft)...............	7	7	-

SUMMARY

Before enactment of the 1969 Coal Mine Health and Safety Act, coal mine face ventilation systems were designed primarily to dilute and remove methane from the face area. However, the respirable dust standard established by the Act necessitated implementation of face ventilation systems adequate to maintain the respirable dust concentration below the standard.

The two most common types of face ventilation systems (blowing and exhausting) currently employed on continuous mining sections to dilute, control, and remove methane and dust from the face utilize either line brattice and/or an auxiliary fan with tubing.

A blowing face ventilation system has the following advantages:

1. More efficient delivery of air to the face,

2. Better sweep of air across the face, and

3. Easier and less time required for installation.

However, the main disadvantage with the blowing system is that dust-laden air from the face is returned over the continuous miner and shuttle car operators, increasing their respirable dust exposure.

An exhausting face ventilation system courses intake air over the continuous miner and shuttle car operators, minimizing their respirable dust exposure. However, an exhausting face ventilation system has the following disadvantages:

1. Requires careful installation to minimize leakage,

2. May cause secondary airflow in the corner of the face opposite the end of the line brattice/tubing necessitating the use of a diffuser fan for methane control, and

3. Physical limitations may cause difficulty in using a diffuser fan for adequate methane control.

Extensive underground respirable dust surveys, conducted by MESA on sections employing blowing and exhausting face ventilation, indicate that significantly lower respirable dust concentrations resulted when employing exhausting face ventilation. Respirable dust surveys conducted on a boring machine section employing exhausting face ventilation showed that the greatest reduction in respirable dust concentration occurred at the boring machine and shuttle car operators' positions. However, the respirable dust exposure of all occupations on the section also showed a significant reduction.

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