IC 9366

BUREAU OF MINES
INFORMATION CIRCULAR/1993

Update on Ventilation for Longwall Mine Dust Control

By Robert A. Jankowski, Natesa I. Jayaraman,
and J. Drew Potts

UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. Department of the Interior Mission Statement

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Information Circular 9366

Update on Ventilation for Longwall Mine Dust Control

By Robert A. Jankowski, Natesa I. Jayaraman, and J. Drew Potts

UNITED STATES DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

BUREAU OF MINES

Library of Congress Cataloging in Publication Data:

Jankowski, Robert A.

Update on ventilation for longwall mine dust control / by Robert A. Jankowski, Natesa I. Jayaraman, and J. Drew Potts.

p. cm. — (Bureau of Mines Information circular; 9366)

Includes bibliographical references (p. 11).

1. Longwall mining—Dust control. 2. Mine ventilation. 3. Mine dusts. I. Jayaraman, Natesa I. II. Potts, J. Drew. III. Title. IV. Series: Information circular (United States. Bureau of Mines); 9366.

TN295.U4 [TN312] 622 s—dc20 [622'.83] 93-22830 CIP

CONTENTS

ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cfm	cubic foot per minute	mg/m	milligram per meter
fpm	foot per minute	m/s	meter per second
ft	foot	m^3/s	meter cubed per second
h	hour	mt	metric ton
m	meter	st	short ton

UPDATE ON VENTILATION FOR LONGWALL MINE DUST CONTROL

By Robert A. Jankowski,[1] Natesa I. Jayaraman,[2] and J. Drew Potts[2]

ABSTRACT

The U.S. Bureau of Mines, in cooperation with the Mine Safety and Health Administration (MSHA) and the mining industry, has identified and demonstrated the effectiveness of several improved face ventilation techniques for longwall mining systems. These include the following: identifying improved techniques for measuring face ventilation parameters on longwall sections, installing curtains at the intake end of the longwall face to maximize usage of the primary airflow, identifying optimum face airflow rates for maximizing dilution effects, and coursing the primary face intake from tailgate to headgate to minimize outby airflow contamination. Application of these techniques throughout the mining industry should reduce the health hazard associated with excessive exposure to respirable coal mine dust.

[1]Group supervisor.
[2]Mining engineer.
Pittsburgh Research Center, U.S. Bureau of Mines, Pittsburgh, PA.

INTRODUCTION

As with all mining methods, ventilation is the primary means to control dust and methane in longwall operations. Improved ventilation techniques for room-and-pillar mining have been well documented by both industry and Government research. However, longwall face ventilation has often been overlooked. Only recently have face ventilation parameters for longwall mining systems been studied in detail.

The U.S. Bureau of Mines, in cooperation with several mining companies, has recently identified and documented the effectiveness of certain improved face ventilation techniques for longwall operations. These studies have shown that assessment of the primary intake alone is not sufficient; the direction and utilization of the primary airflow is critical for dust control. Substantial improvements can be obtained through application of these advanced techniques.

This work was done in support of the USBM's goal to improve the health of the Nation's miners.

HIGHER AIR QUANTITIES AND VOLUMES HELP CONTROL AIRBORNE DUST

In most longwall operations, the face airflow is usually measured at the crosscut in the headgate entry. Although this intake quantity often exceeds 30,000 cfm (14.2 m^3/s), this measurement is usually not representative of face airflow. Figure 1 shows the results obtained using an improved method for measuring face ventilation parameters. Ventilation measurements are taken at every 10th support; the resulting profile can be used to determine "average" face airflow, effective utilization of the primary intake, and air loss to the gob. As shown in figure 1, airflow along the face is seldom uniform. A measurement at any single location may not be representative of the average face airflow. With a ventilation profile, the mine operator can discover problem areas and more accurately determine the specific ventilation parameters on a given longwall face.

Face air velocities of at least 400 to 450 fpm (2.0 to 2.3 m/s) appear to be the minimum appropriate for dust control (*1*).[3] Once again, these values are for the average face velocity profile and should be maintained for the entire face length. With optimum air utilization, these values would equal minimum average intake air quantities of 20,000 cfm (9.4 m^3/s) for a 5-ft (1.5-m) coal seam and 30,000 cfm (14.2 m^3/s) for a 7-ft (2.1-m) seam. In the past, air velocities above 650 fpm (3.3 m/s) were thought to cause entrainment of dust from coal transport and dust liberation during support movement (fig. 2). Recent studies by MSHA (*2*) now show that as face air quantities increase even beyond 1,200 fpm, respirable dust levels due to dust generated along the face decrease. The USBM is currently attempting to identify a cooperative mine site at which to conduct further studies of the impact of air velocity increases on dust entrainment along the face.

Minimum average face air velocities of 400 to 450 fpm (2.0 to 2.3 m/s) help to control respirable dust in three ways. The higher air velocities provide greater air quantities for better dilution of intake dust (fig. 3) as well as dust generated during support movement. Higher velocities over the shearer help to confine the dust to the face area and lower contamination in the walkway (fig. 4). Finally, these higher velocities improve diffusion of dust from stagnant areas in the headgate and along the support line.

CURTAINS IN HEADGATE PROVIDE BETTER DIRECTION OF PRIMARY AIRFLOW

Often, loss of air into the gob in the headgate area prevents maximum utilization of the air available to ventilate the longwall face. The gob behind the first few supports remains open owing to the roof bolts in the headgate entry, and a large gap usually exists between the first support and the entry rib. As a result, a substantial portion of the ventilation air from the headgate entry leaks back into the gob (fig. 5*A*), lowering the airflow along the face. Moreover, this air laden with dust generated during gob falls may reenter the face area, compounding the dust problem.

A gob curtain (fig. 5*B*), installed between the first support and the rib in the headgate entry, can force the ventilation airstream to make a 90° turn, staying on the face side of the supports, rather than leaking into the gob. The curtain is suspended from the roof to the floor and advanced with the supports at each pass.

The USBM (*3*) has collected extensive face air velocity data (fig. 6) with and without the gob curtain in use. The average face air velocity with the curtain installed was approximately 35% greater than without the curtain. The

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

biggest improvement due to this curtain is seen at the first 25 to 30 supports, where the increased air volume lowers dust concentrations through dilution. The gob curtain is easy to use, install, and maintain, and it is fabricated from material that is readily available in all mines.

In many longwall operations, misapplication of the primary airflow may actually contribute to increased dust levels. One source of extreme concentrations of respirable dust for longwall shearer operators is the headgate shearer drum as it cuts through into the headgate entry. As the drum cuts into the entry, it is exposed to the primary ventilation airstream (fig. *7A*). The high-velocity air passes through and over the drum, picking up large quantities of dust; this dust is carried into the walkway and over the shearer operators. Although this operation is usually of short duration, the resulting dust levels are extremely high. Concentrations ranging from 20 to 30 mg/m^3 have been measured at several mines, using instantaneous dust monitors at the operator position. Thus, the cumulative effect on full-shift exposure levels can be significant, particularly on high-production faces where this operation may be performed six to eight times per shift.

To overcome this problem, some coal mine operators use a "cutout" curtain in the headgate to shield the lead drum from the ventilation airstream as it cuts out into the headgate (fig. *7B*). The curtain redirects the primary air so that it flows out and around the drum. The curtain is usually located 4 to 6 ft (1.2 to 1.8 m) back from the corner of the face, so that maximum shielding is provided without interference with the drum, and is suspended from the roof between the panel side rib and the stage-loader. The curtain need only be in place during the actual cutout operation and is advanced every other pass.

The USBM (*4*) has conducted underground evaluations to document the improvements achieved through installation of a cutout curtain. Dust levels at the operator positions were monitored using instantaneous dust monitors as the shearer cut out and cleaned up at the headgate (fig. 8). Concentrations monitored with and without the curtain indicated that the curtain can reduce the exposure of the tailgate shearer drum operator by 50 to 60% during this phase of the mining cycle. To achieve these improvements, the curtain must be installed tightly against the mine roof and must extend sufficiently into the headgate entry.

IMPACT OF BELT ENTRY AIR

An increasing number of mines are either using or petitioning to use belt entry air to ventilate active longwall face areas. Using the belt entry as an intake entry may allow delivery of more air to the face, providing better dust and methane dilution. The USBM, as part of its goal to improve the health of the Nation's miners, recently conducted underground dust surveys to further explore this topic (*5*). Results of these studies have shown that a 1,000-ft (300-m) increase in belt entry length or a 200- to 500-st (181- to 453-mt)-per-shift increase in production resulted in roughly a 0.1-mg/m^3 increase in dust. Dust levels inby the belthead appeared to be independent of belt entry airflow, over the range of airflow observed during the surveys.

Compliance data analyzed by MSHA (*6*) have shown that mines using belt entry air to ventilate work areas did not have significantly different respirable dust levels at the designated occupation than mines not using belt air. According to MSHA, in one district, mines using belt entry air had a significantly lower mean dust concentration than mines not using belt air. From a theoretical standpoint, applying the dilution formula shows that *if* belt entry air represents additional air brought to the face and *if* belt entry dust levels, including those at the stage-loader and crusher, can be maintained below the average dust level measured at the designated occupation, it is beneficial from a dust compliance perspective for the mine to use belt entry air to ventilate work areas.

Using the belt entry as an additional source of intake air results in an increased number of outby dust sources. The conveyor belt itself is a source of dust, and the stage-loader and crusher are always in intake air if the belt entry is used to ventilate the face. The USBM has conducted extensive research and has demonstrated effective technology to control dust from these sources (*7*).

VENTILATION FROM TAILGATE TO HEADGATE LOWERS INTAKE DUST LEVELS

On many longwall faces, intake contamination can pose a substantial dust control problem. In order for the primary intake to reach the face, this airflow must pass over the stage-loader and crusher in the headgate. Recent advances in longwall dust sampling by the USBM (*8*) have shown that on some faces these dust sources contribute more than half the dust to which face workers are exposed (fig. 9). Also, when the air is coursed from headgate to tailgate, the relative velocity of the air and the coal moving on the panline can entrain dust from the conveyor, particularly if the coal is dry.

On longwall faces where the stage-loader and crusher are a significant dust source, dust levels can be reduced by coursing the primary airflow from tailgate to headgate, in the same direction as coal transport (fig. 10). This positions the face workers upwind of these dust sources. Studies conducted on two longwalls that coursed their airflow from tailgate to headgate showed that these longwalls had much better than average compliance records. In both cases, sampling indicated that the reversed airflow was a major factor contributing to lower dust levels.

Figure 11 shows a typical instantaneous intake dust level profile measured with the shearer cutting and the airflow coursed from headgate to tailgate. In these operations, the dust generated by the crusher and transfer points, as well as by coal transport along the face, contributed to higher intake dust levels. Figure 11 also shows the typical intake dust level profile on the two longwall operations that ventilated from tailgate to headgate. Reversing the airflow lowered the instantaneous dust level by almost 1 mg/m^3. The reduction in the 8-h shift concentration would be less, depending on the fraction of the shift time in which the shearer is operating. An additional advantage of tailgate-to-headgate face ventilation is that it lessens the impact of unidirectional cutting. Previous USBM studies (*9*) have shown that cutting with the direction of airflow creates less dust than cutting against the airflow. In conventional headgate-to-tailgate ventilation, most of the coal must pass through the shearer underframe, and large pieces may cause blockage and production delays. In tailgate-to-headgate ventilation, the directions of face airflow, coal transport, and the major cut are all the same. Thus, most longwall operations can utilize a cutting sequence that improves dust control without a major negative impact on coal production.

One of the greatest difficulties involved in maintaining an intake on the tailgate end of the longwall panel is keeping the tailgate entries open. Roof pressure associated with extracted adjacent panels tends to create roof falls in the tailgate entries. This problem can be reduced by choosing the correct size for chain pillars. If overburden conditions permit, the pillars adjacent to the active gob should be sized to "yield" before the roof of the tailgate breaks. Tailgate entries should also be supported by two rows of cribsets, in addition to the regular roof bolt pattern. An auxiliary intake (fig. 10) must also be maintained at the headgate end of the face to provide a clean-air split for face workers in this area.

CONCLUSIONS

In many longwall mining operations, the direction and utilization of the primary airflow is often neglected. The USBM, in cooperation with various mining companies, has recently identified and documented the effectiveness of several improved face ventilation techniques that can substantially reduce the respirable dust exposures of longwall face workers.

Face air velocities of 400 to 450 fpm (2.0 to 2.3 m/s) appear to be the minimum that is appropriate for effective respirable dust control. These higher velocities help to control dust in three ways: Large air quantities provide for better dilution of intake and support dust, higher velocities over the shearer body help to confine the dust to the face and lower contamination in the walkway, and this range of velocities helps to diffuse dust from stagnant areas along the longwall face. Studies indicate that as face air velocities continue to increase, dust exposure levels along the face decrease.

Curtains in the headgate provide for better direction and utilization of the primary airflow. A gob curtain may be installed between the first support and the entry rib to force the ventilating airstream to make a 90° turn at the face end and prevent air loss to the gob. This curtain can substantially increase air velocity down the face, providing improved dust control. A curtain may also be installed in the headgate, between the panel rib and the stage-loader, to shield the shearer drum from the primary intake as it cuts out at the face end. This curtain can significantly reduce the amount of dust carried into the walkway during this phase of the mining cycle.

An increasing number of mines are either using or petitioning to use belt entry air to ventilate active longwall face areas, primarily for methane dilution. Surveys have shown no negative impacts on dust levels.

Finally, face ventilation from tailgate to headgate can significantly reduce intake contamination by placing the crusher and stage-loader downwind of face workers. In addition, tailgate-to-headgate ventilation lessens the impact of unidirectional cutting, thus allowing most longwall operations to utilize a cutting sequence that improves dust control without a major impact on production. Tailgate-to-headgate face ventilation is only applicable on longwalls that are able to maintain an open tailgate to serve as a primary intake.

Since ventilation is the primary means used to control dust in longwall operations, application of these techniques should help mine operators reduce dust levels, providing improved health protection for face workers and easier compliance with Federal standards.

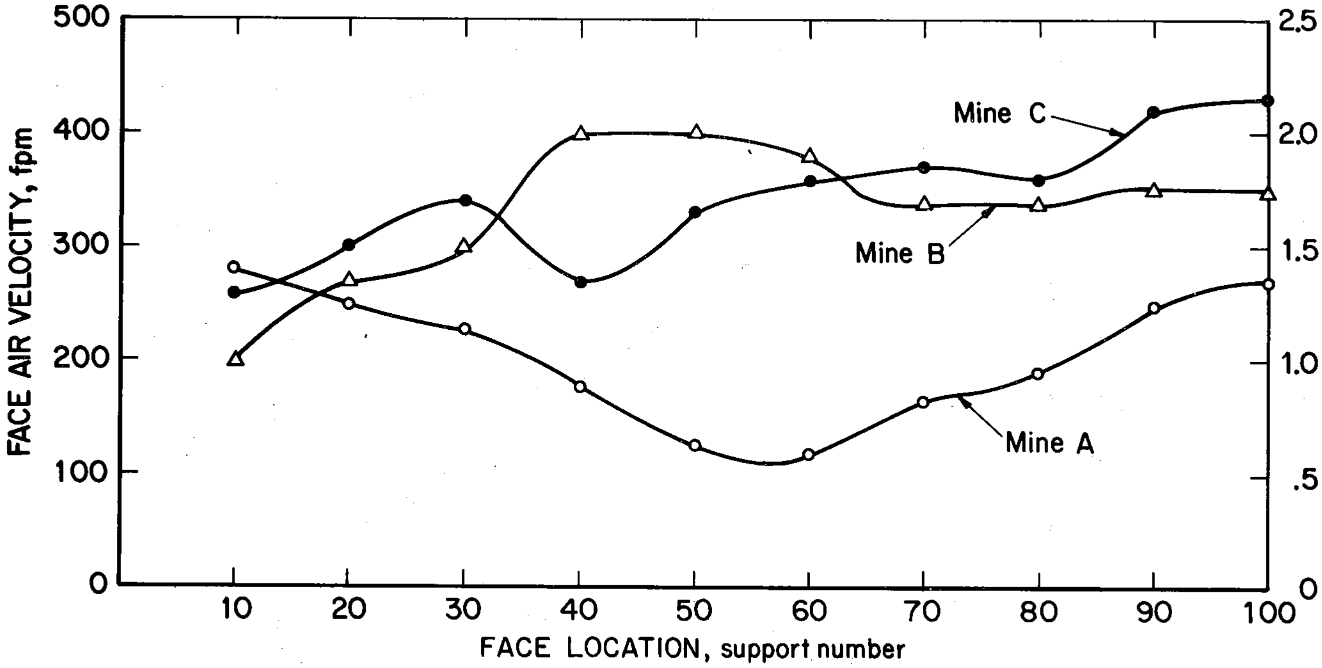

Figure 1.—Comparison of ventilation profiles from three longwall faces.

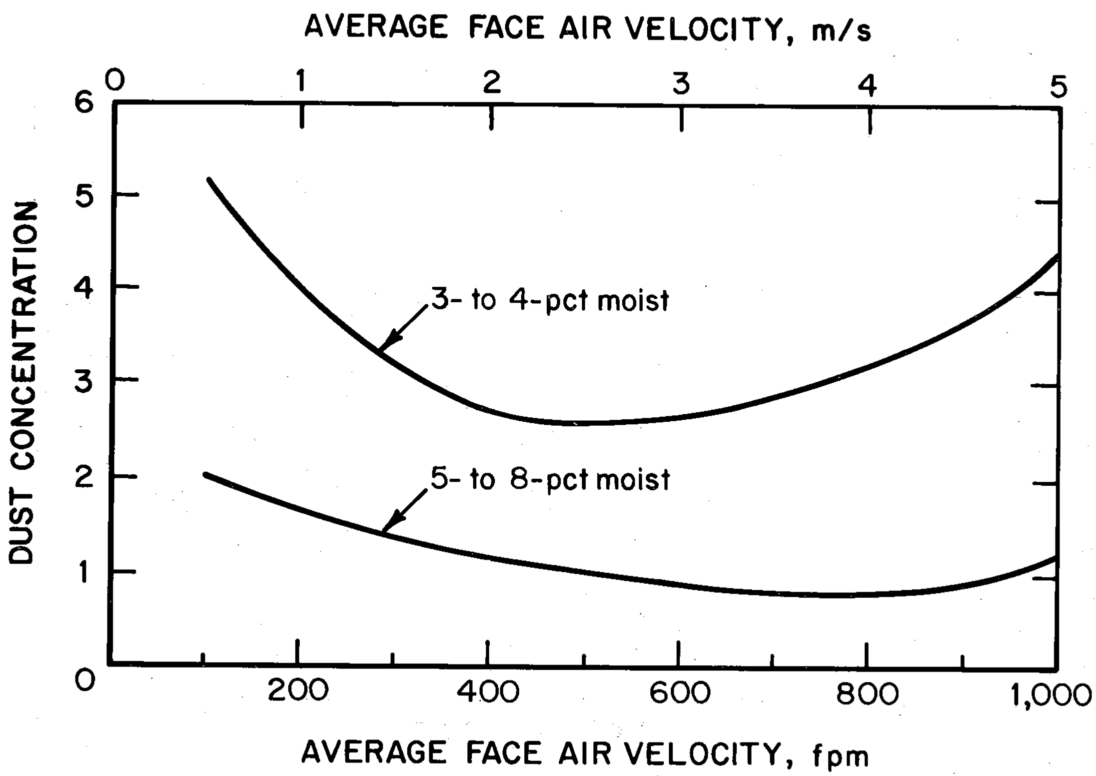

Figure 2.—Respirable dust concentration versus average face air velocity.

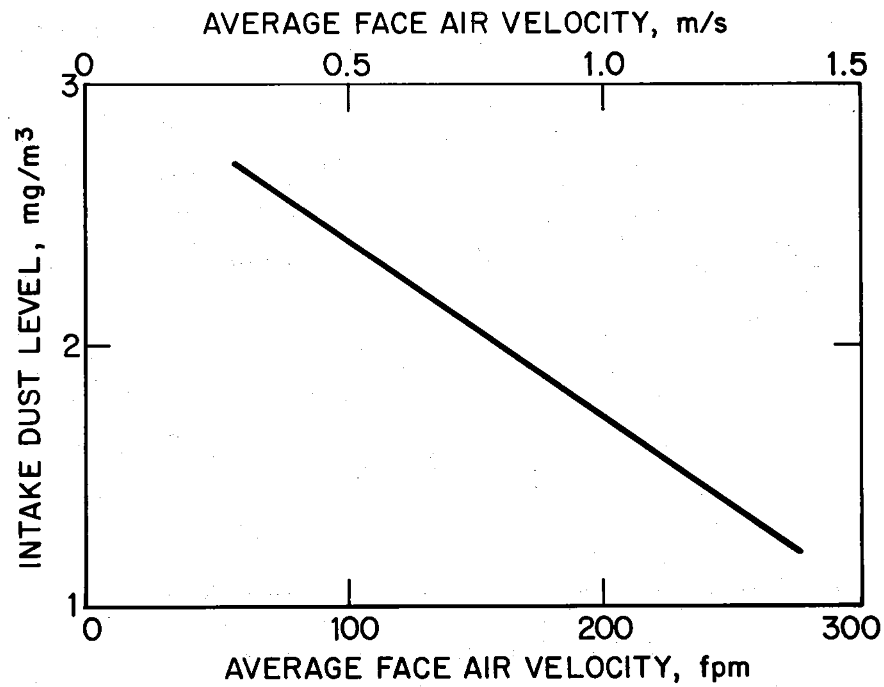

Figure 3.—Reduction in intake dust obtained by increasing face air velocity.

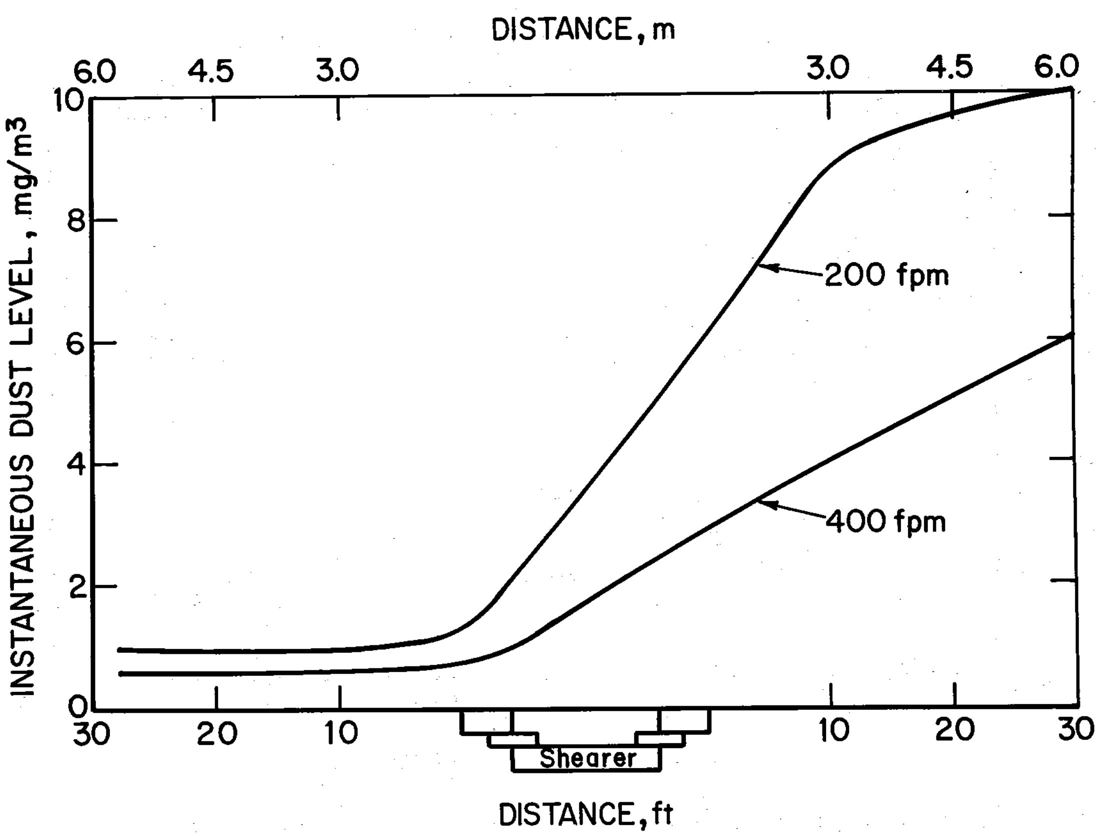

Figure 4.—Comparison of changes in dust level profile around shearer due to increased face air velocity.

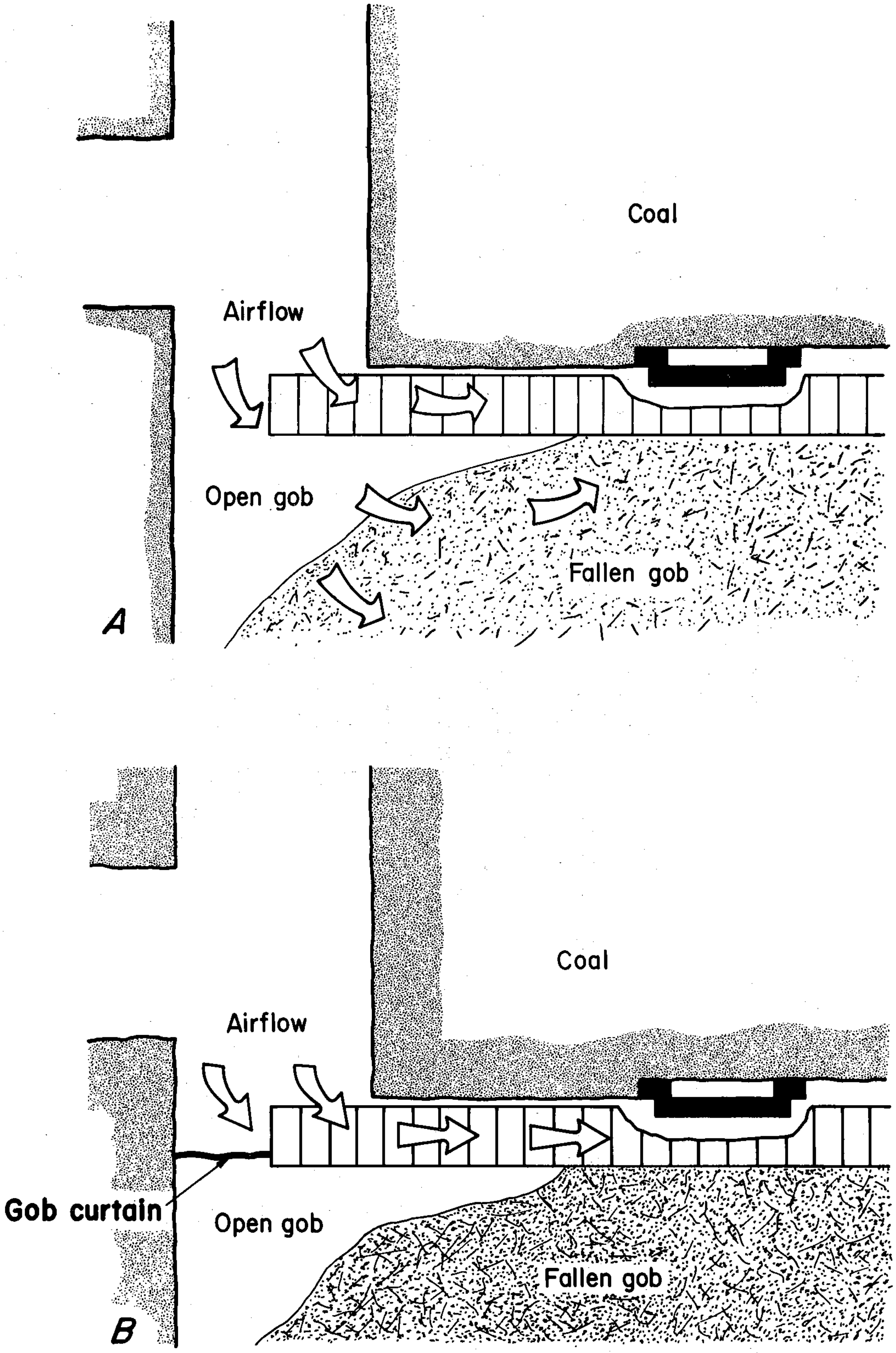

Figure 5.—Effect of gob curtain on face ventilation. *A*, Without curtain, ventilation airflow from headgate entry may often leak into gob; *B*, gob curtain closes gap between first support and entry rib, forcing more air down longwall face.

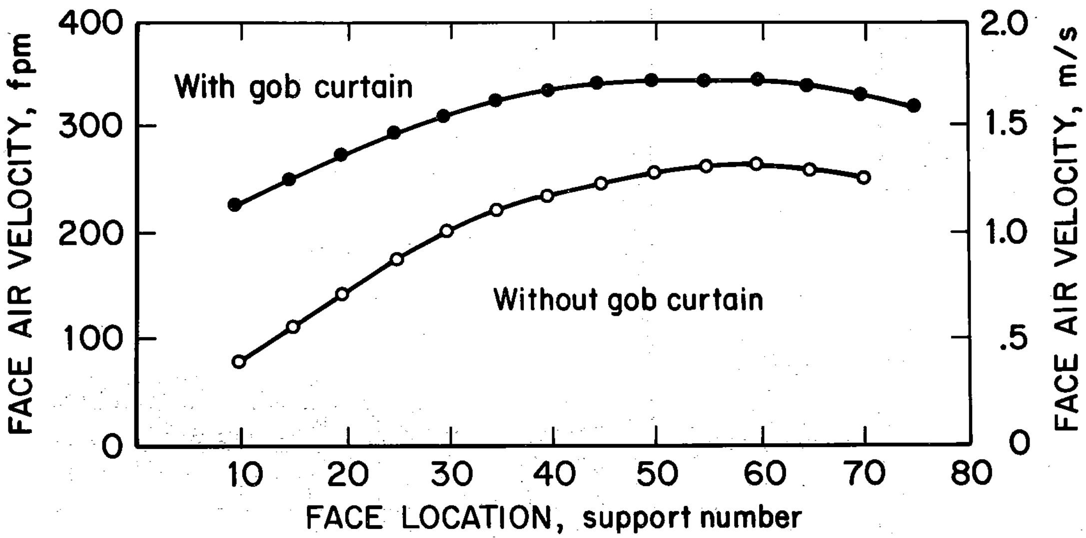

Figure 6.—Comparison of changes in face airflow due to installation of gob curtain.

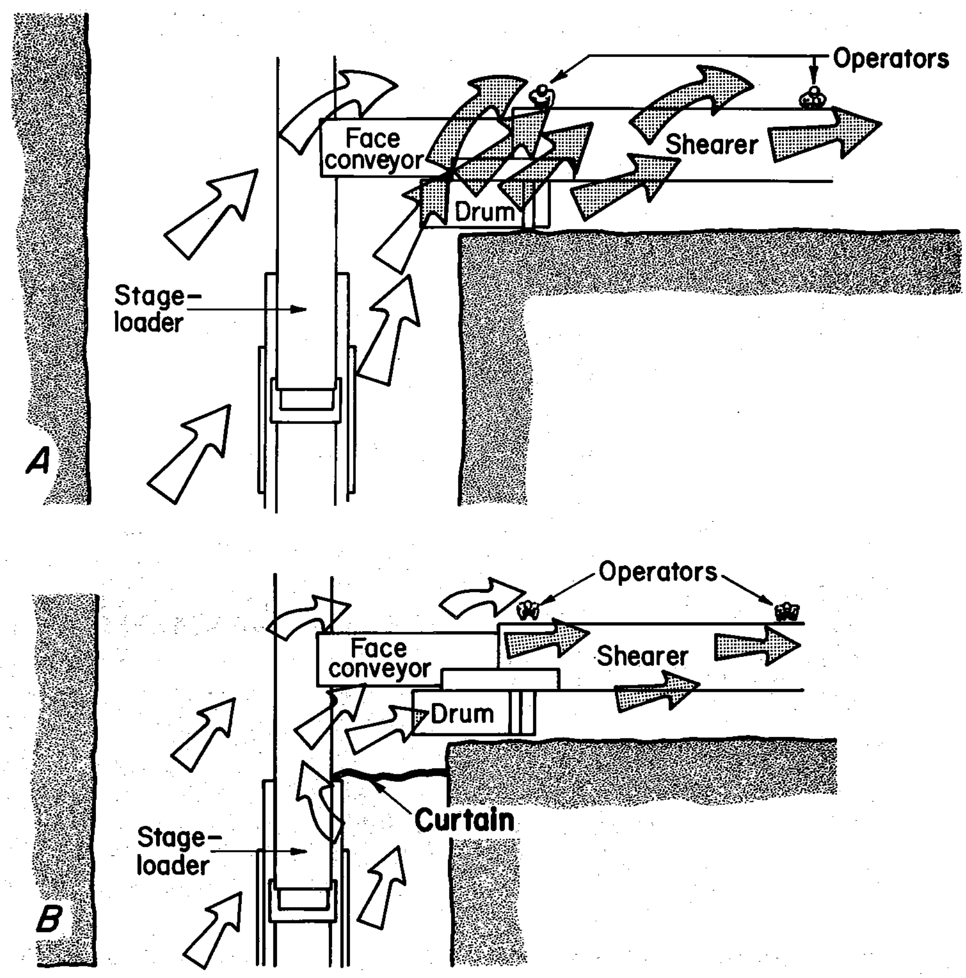

Figure 7.—Effect of cutout curtain on dust levels at headgate shearer drum. *A*, Primary ventilation often carries dust from lead drum out into walkway, over shearer operators; *B*, curtain installed in headgate shields lead drum from primary airflow.

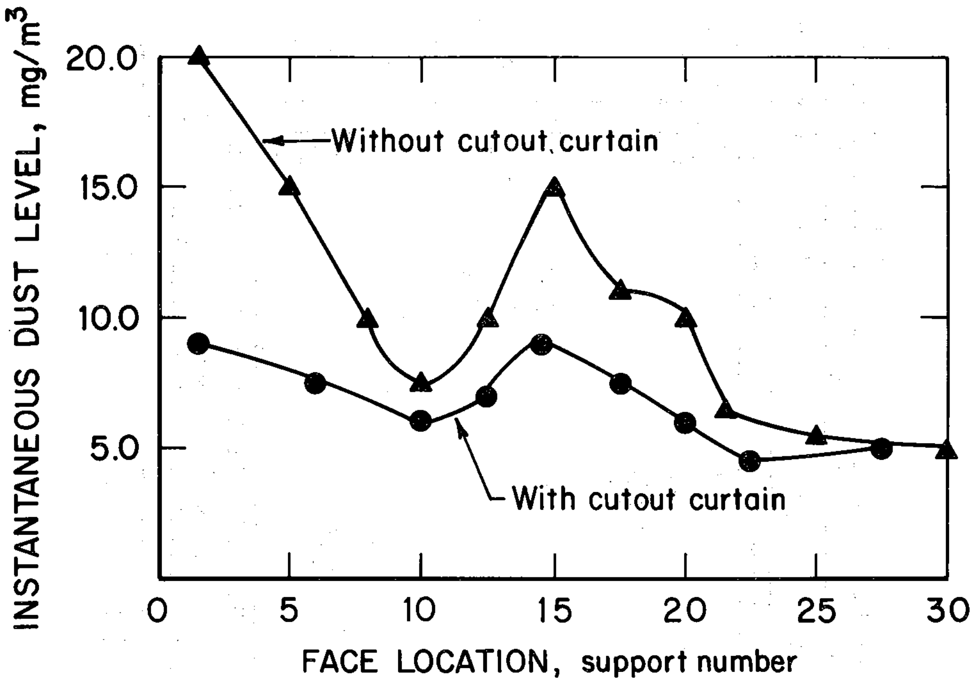

Figure 8.—Comparison of changes in dust levels measured at shearer midpoint caused by installation of cutout curtains.

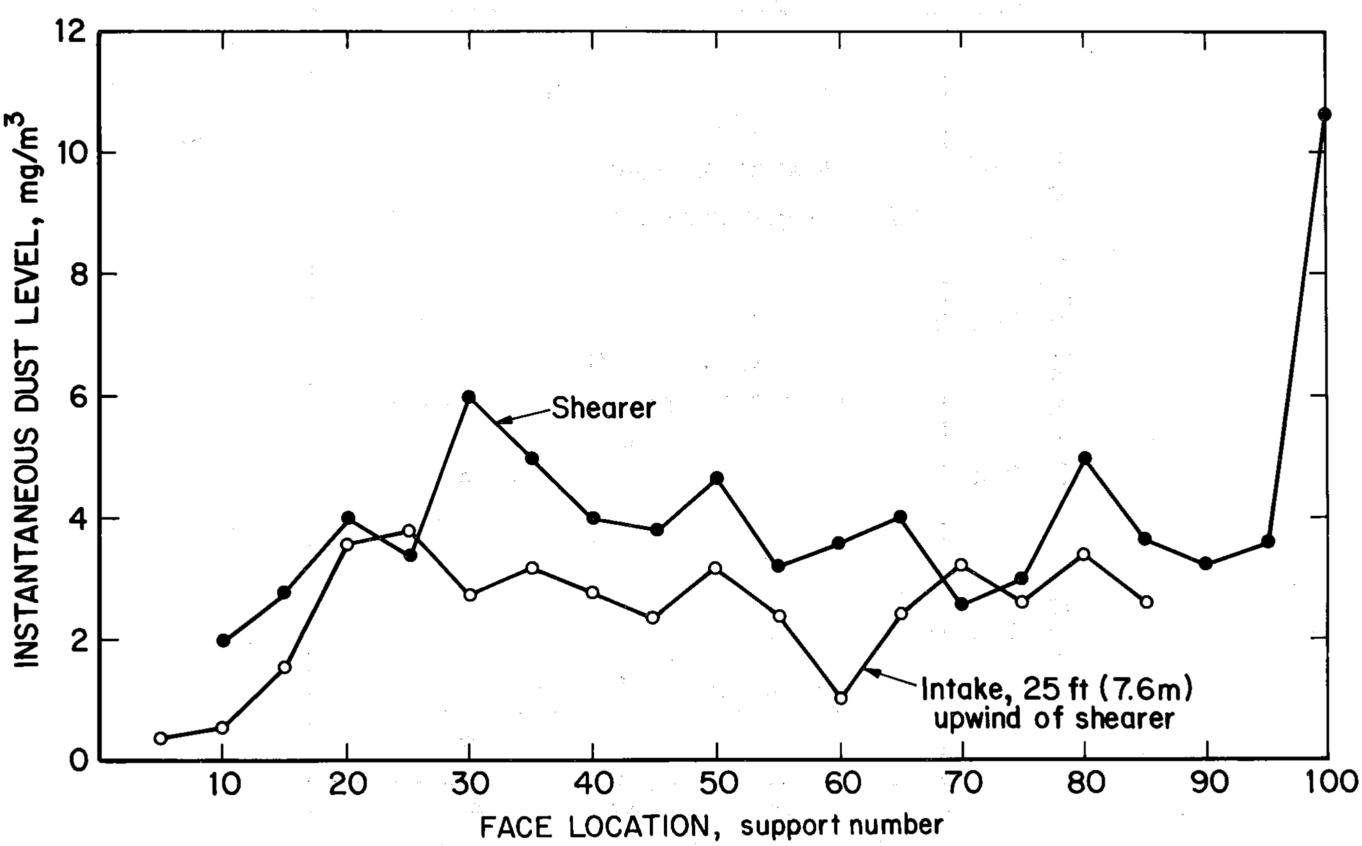

Figure 9.—Typical instantaneous dust levels measured on longwall operations with high levels of intake contamination due to stage-loader and crusher. Shearer average = 4.0 mg/m^3; intake average = 2.4 mg/m^3.

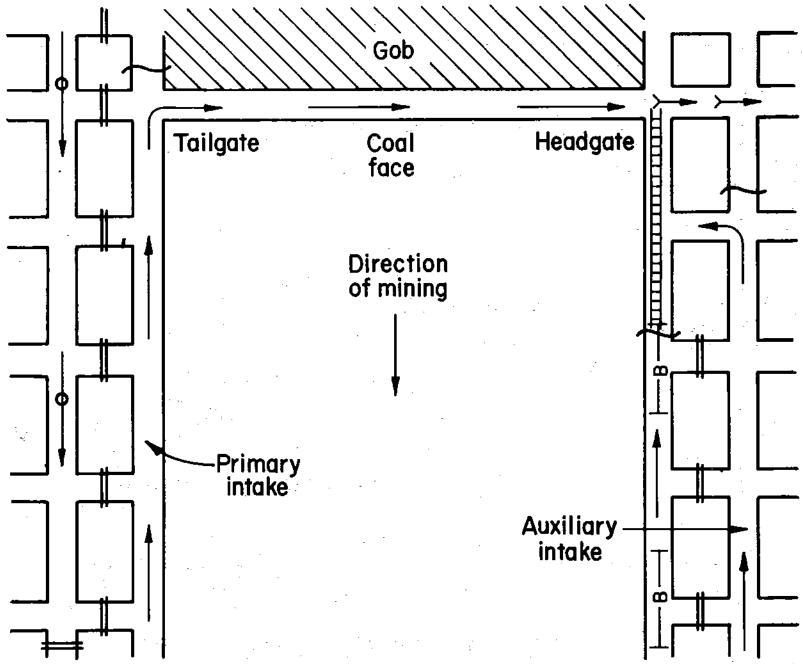

Figure 10.—Typical longwall panel layout for tailgate-to-headgate face airflow.

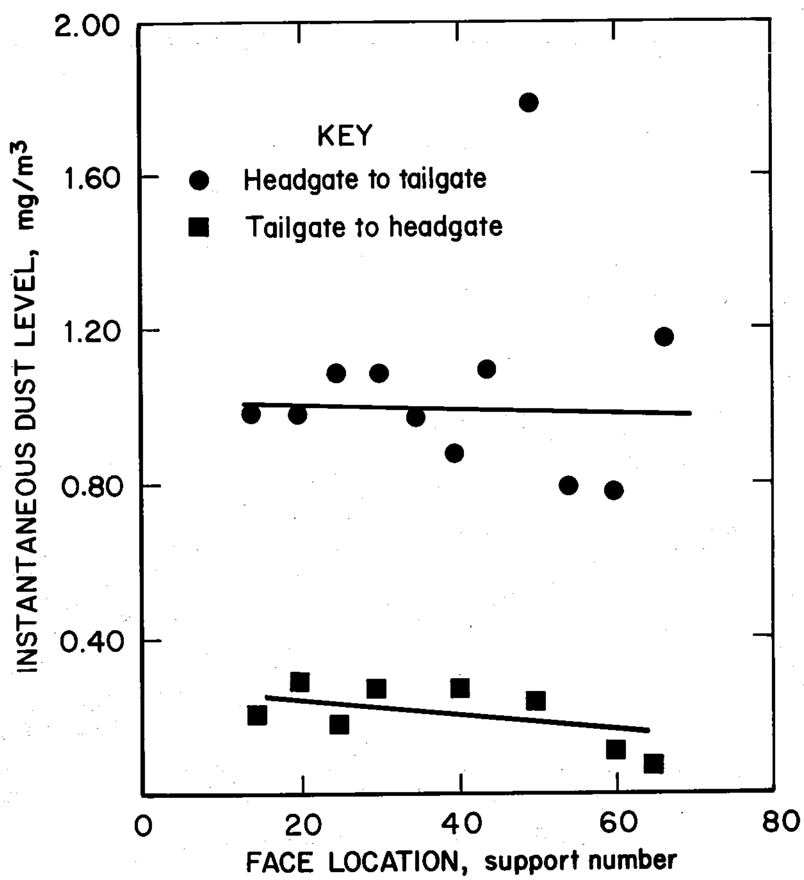

Figure 11.—Typical instantaneous intake dust levels measured on longwall faces ventilated headgate to tailgate and tailgate to headgate.

REFERENCES

1. Mundell, R. L. Respirable Dust Control on Longwall Mining Operations in the United States. Paper in Proceedings, Second International Mine Ventilation Congress (Reno, NV, Nov. 1979). 1979.

2. Tomb, T. F. Evaluation of Respirable Dust Control on Longwall Mining Operations. Trans. Soc. Min., Metall., and Explor., v. 288, 1992, pp. 1874-1878.

3. Jayaraman, N. I., R. A. Jankowski, and F. N. Kissell. Improved Shearer-Clearer System for Double-Drum Shearers on Longwall Faces. BuMines RI 8963, 1985, 11 pp.

4. Jankowski, R. A. Longwall Dust Control, An Overview of Progress in Recent Years. Min. Eng., v. 38, No. 10, Oct. 1986, pp. 953-958.

5. Potts, J. D., and R. A. Jankowski. Dust Considerations When Using Belt Entry Air To Ventilate Work Areas. BuMines RI 9426, 1992, 12 pp.

6. Mine Safety and Health Administration (Dep. Labor). Belt Entry Ventilation Review: Report of Findings and Recommendations. 1989, 42 pp.

7. Organiscak, J. A., R. A. Jankowski, and J. S. Kelly. Dust Controls To Improve Quality of Longwall Intake Air. BuMines IC 9114, 1986, 8 pp.

8. Page, S. J., and R. A. Jankowski. How To Evaluate Longwall Dust Sources With Gravimetric Personal Samplers. BuMines IC 8894, 1982, 14 pp.

9. Taylor, C. D., and R. A. Jankowski. How the Six Cleanest U.S. Longwalls Stay in Compliance. Min. Congr. J., v. 68, No. 5, May 1982, pp. 76-78.

INT.BU.OF MINES,PGH.,PA 29815

*U.S.G.P.O.: 1993--709-008/80038