DOE/FE/00016--T173

A Final Report
MAY 1990

DOE/FE/00016--T173

DE90 015501

# EVALUATE FUNDAMENTAL APPROACHES TO LONGWALL DUST CONTROL SUBPROGRAM E - LONGWALL APPLICATION OF VENTILATION CURTAINS

Contract J0318097
Foster-Miller, Inc.



BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

50272-101

| REPORT DOCUMENTATION PAGE | 1. REPORT NO. | 2. | 3. Recipient's Accession No. |
|---|---|---|---|

4. Title and Subtitle
Evaluate Fundamental Approaches to Longwall Dust Control
Subprogram E - Longwall Application of Ventilation Curtains

5. Report Date
May 1990

6.

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BMI-8148

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10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) J0318097
(G)

12. Sponsoring Organization Name and Address
U.S. Bureau of Mines
Pittsburgh Research Center
Building 20, P.O. Box 18070
Cochrans Mill Road
Pittsburgh, PA 15236

13. Type of Report & Period Covered
Final Report

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)


There are a number of applications on longwall faces where Brattice curtains they can improve face ventilation and dust control. This report describes the laboratory development and/or field evaluation of several longwall ventilation curtains, including:

"Wing curtains." The headgate "cut-out" provides a source of extreme dust concentrations for shearer operators. A wing curtain in the headgate, which shields the headgate drum from the ventilation airstream as the drum cuts out, can reduce the operator's dust exposures during the cutout by 50 to 60%.

"Gob curtains." A significant amount of ventilating air can be lost to the gob in the headgate area. A gob curtain between the first shield and the chain pillar rib can block much of the leakage and increase the volume of air supplied to the face by approximately 10%.

"Walkway curtains." Curtains in the walkway, perpendicular to the airflow, were evaluated for their potential to reduce the migration of dusty face air into the walkway. Unfortunately they proved ineffective.

"Extended spillplate." A vertical extension to the existing spillplate was evaluated for its potential to partition the clean and contaminated airflow. Unfortunately, only a full-height spillplate (impractical for actual application), showed appreciable reductions in walkway dust levels.


17. Document Analysis a. Descriptors
Dust control, Longwall dust, Brattice curtain, Wing curtain, Gob curtain, Walkway curtain, Face ventilation, Auxiliary ventilation, Extended spillplate

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

| 18. Availability Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| | Unclassified | |
| | 20. Security Class (This Page) Unclassified | 22. Price |

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

# FOREWORD

This report was prepared by Foster-Miller, Inc., Waltham, MA under United States Bureau of Mines Contract No. J0318097. This contract was initiated under the Health and Safety Technology Program. It was administered under the technical direction of the Pittsburgh Research Center with Mr. Robert Jankowski acting as Technical Project Officer. Mr. Louis Summers was the contract officer for the Bureau. This report summarizes the work completed on Subprogram E of the contract during the period July 1981 to March 1985. This report was submitted by the authors in February 1990.

The technical effort was performed by the Mining Division of the Engineering Systems Group under the direction of Mr. Terry L. Muldoon, with Mr. Steven K. Ruggieri as Program Manager and Mr. Charles Babbitt as Subprogram E Principal Investigator.

The authors would like to extend their special appreciation and acknowledgment to the numerous mining industry representatives who provided valuable input to the program and who provided valuable assistance during the underground evaluations. The assistance, guidance, and cooperation extended by Dr. Frederick Kissell and his staff are especially appreciated.

# CONTENTS



# ILLUSTRATIONS

ILLUSTRATIONS--Continued

ILLUSTRATIONS--Continued



TABLES

# EXECUTIVE SUMMARY

Brattice curtains are extensively used in underground mines for directing and controlling ventilation airflow. There are a number of applications on longwall faces where curtains may improve ventilation and dust control.

Foster-Miller, Inc., under Bureau Contract J0318097, evaluated the potential effectiveness of four ventilation curtain concepts, including:

a. A "wing" curtain to provide localized control of ventilating air during the headgate cut-out

b. A "gob" curtain at the headgate shield line to minimize short-circuiting of primary ventilation into the gob

c. "Walkway" curtains along the face suspended from shields perpendicular to the airflow, keeping shearer generated dust near the face

d. An "extended spillplate" technique used to partition the contaminated face air from the walkway.

## WING CURTAINS

One source of extreme concentrations of respirable dust for longwall shearer operators is the shearer headgate drum as it cuts through into the headgate entry. As the drum cuts into the entry, it is exposed to the primary ventilation airstream as shown in figure 1. The high velocity air passes around and over the rotating drum, picking up large quantities of dust. The dust is then carried by the airstream over the shearer operators. Although this operation is usually of short duration, the resultant 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's position. The cumulative effect on full-shift exposure levels, therefore, can be significant, particularly on high production faces where this operation can be performed six to eight times per shift.

Some coal mine operators use a curtain in the headgate to shield the drum from the ventilation airstream as the drum cuts out. The curtain redirects the primary air so it flows parallel to the face rather than through the drum as shown in figure 2. It is suspended from the roof between the rib and the stageloader. The curtain is usually located 4 to 6 ft back from the corner of the face

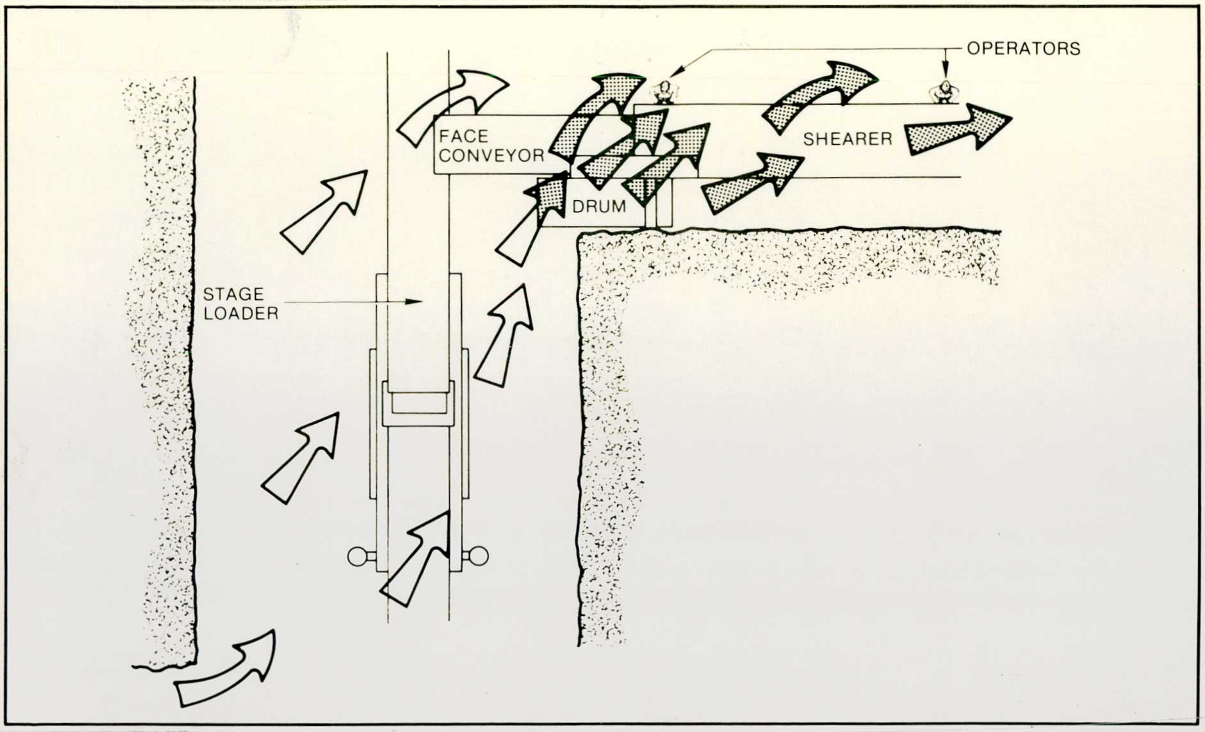


FIGURE 1. - Primary ventilation blows dust from shearer drum over the operators.

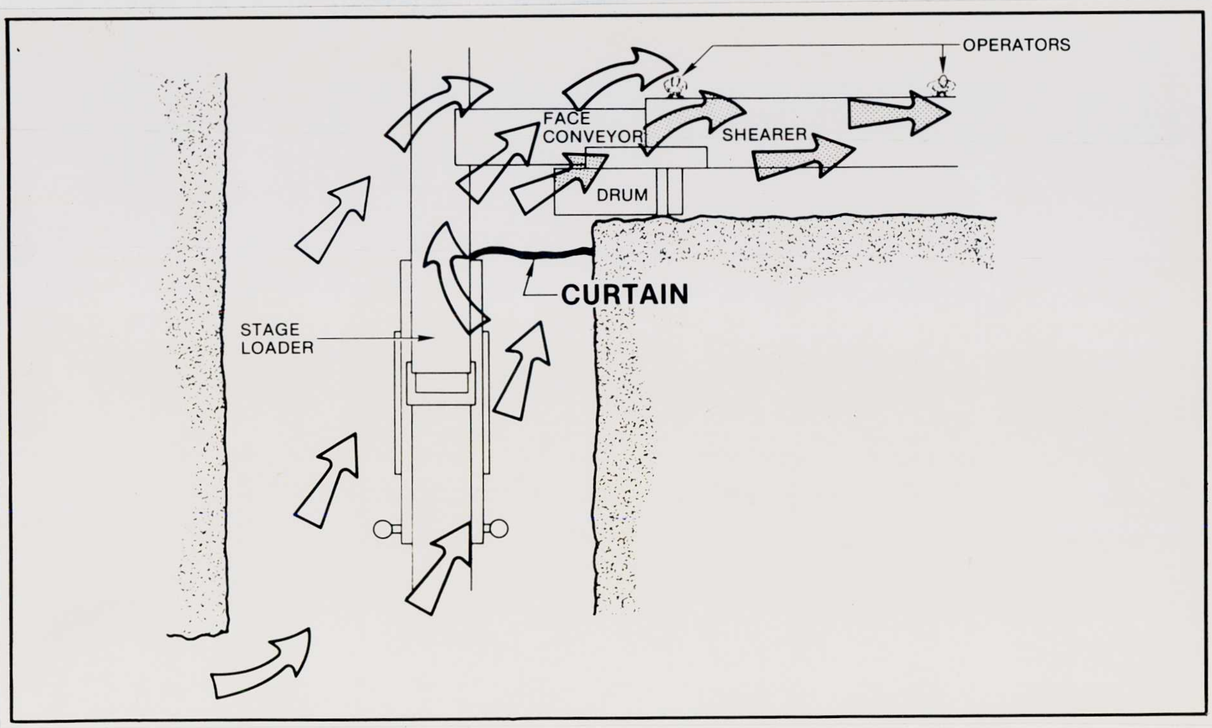


FIGURE 2. - Curtain shields shearer drum from primary ventilation.

so that maximum shielding is provided without interference with the drum. It only has to be in place during the actual cut-out operation and is usually advanced every other pass.

Underground testing of the wing curtain showed that it can reduce shearer operator's respirable dust exposures by 50 to 60% during the headgate cutout.

## GOB CURTAINS

On many longwall faces, a significant amount of ventilation air is lost to the gob in the headgate area (as shown in figure 3). This is caused by the gob remaining open due to roof bolts in the headgate entry and the large gap between the number one shield and the rib. This loss of air reduces airflow along the face, particularly over the first 25 to 30 shields, significantly increasing dust concentrations.

A brattice curtain (gob curtain), hung between shield No. 1 and the rib in the headgate entry, forces the ventilating air to make the 90 deg turn and stay on the face side of the shields (figure 4).

The curtain is advanced with the shield line each pass and helps to maintain sufficient air quantity along the face. Tests by FMI on one face showed that the volume of air on the face increased by 10% from the headgate to nearly mid-face with the curtain installed.

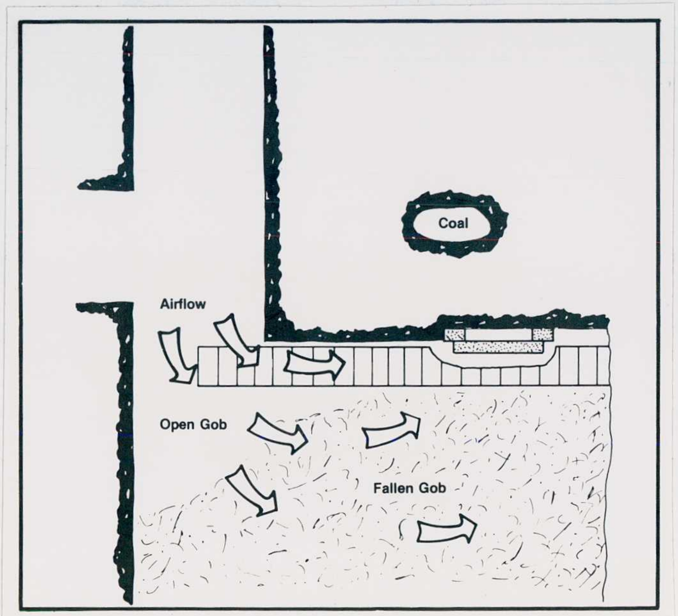


FIGURE 3. - A portion of the ventilation air from the headgate entry leaks into the gob, lowering the airflow along the longwall face.

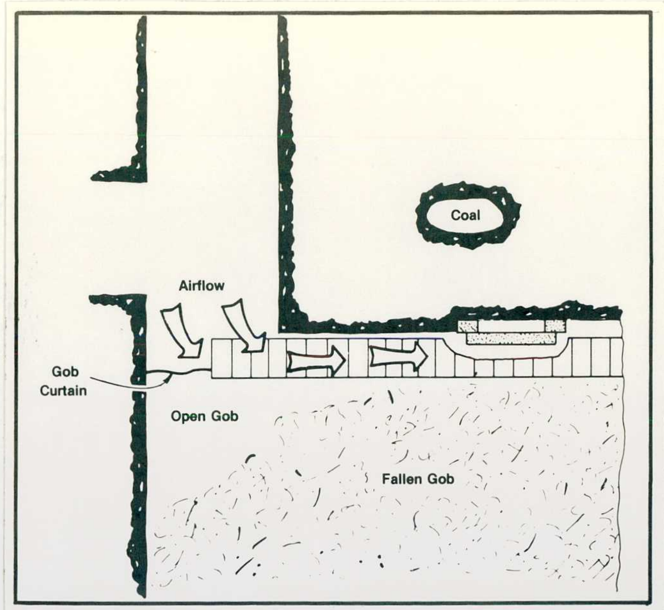


FIGURE 4. - Gob curtain closes gap between shield No. 1 and the adjacent rib, forcing more air along the longwall face.

The gob curtain is a simple method of effectively reducing leakage of primary ventilating air into the gob area on longwall faces. By significantly reducing leakage and making the most of available airflow on the face, dust concentrations will be reduced by direct dilution. The gob curtain is easy to install and maintain, and is fabricated from materials which are readily available in all mines. This simple, cost-effective ventilation control technique should be a part of normal operating practice on all longwalls.

## WALKWAY CURTAINS

On longwall faces where the shearer cuts bi-directionally, support personnel have to work downwind of the shearer when it cuts from the tailgate to the headgate. During this time, these personnel are often exposed to high levels of shearer-generated dust which spreads from the face into the walkway downwind of the shearer.

To reduce the mixing of contaminated face air into the cleaner walkway, one mine had installed walkway curtains. These curtains were hung at right angles to the face, filling the entire walkway space on the gob side of the spillplate. The curtains were spaced along the length of the face.

This curtain concept was evaluated under typical underground conditions in a full scale longwall test facility. As expected, the curtains increased face air velocities while decreasing walkway velocities. The curtains, however, caused severe eddying of the contaminated face airflow into the walkway between the curtains. Tests clearly showed that the baseline condition (no walkway curtains) caused the least rapid mixing of contaminated air into the walkway. Any attempt to prevent the natural mixing process by adding walkway curtains actually accelerated the mixing process. The use of the walkway curtain concept, therefore, is not recommended.

## EXTENDED SPILLPLATE

The extended spillplate concept is another technique aimed at portioning the contaminated face air from the walkway. It is installed parallel to the face and is simply a vertical extension of the existing spillplate between the walkway and the face conveyor. This extended spillplate technique was reportedly being used at several German coal mines.

The concept was installed and tested in a full-scale longwall test facility. Results showed no improvement in walkway contamination levels when using an extended spillplate, unless the spillplate was extended to full height and touched the underside of the roof supports. Practical limitations, however, would make a full height barrier difficult, if not impossible to apply underground. Application of this technique, therefore, is not recommended.

# 1. INTRODUCTION

In 1981 the United States Bureau of Mines (the Bureau) awarded Foster-Miller, Inc. (FMI) Contract J0318097 - "Evaluate Fundamental Approaches to Longwall Dust Control." The overall objective of the contract was to evaluate the effectiveness of available dust control technology for double-drum shearer longwall sections in a coordinated, systematic program at a few longwall test sections and to make the results available to the entire coal mining industry.

This program investigated ten different dust control techniques within nine subprograms. The subprograms included:

a. Subprogram A - Passive Barriers/Spray Airmovers for Dust Control

b. Subprogram B - Practical Aspects of Deep Cutting

c. Subprogram C - Stageloader Dust

d. Subprogram D - Longwall Automation Technology

e. Subprogram E - Longwall Application of Ventilation Curtains

f. Subprogram F - Reversed Drum Rotation

g. Subprogram G - Reduction of Shield Generated Dust

h. Subprogram H - Air Canopies for Longwalls

i. Subprogram I - Mining Practices
Division I - Homotropal Ventilation
Division II - Ventilation Parameters

These nine subprograms encompassed a broad range of dust control techniques ranging from administrative controls to new hardware. They spanned not only presently employed methods but also those recently adopted in the United States and those proposed for the future.

This report constitutes the Final Technical Report for Subprogram E - "Longwall Application of Ventilation Curtains," summarizing the effort expended and the results obtained.

Companion volumes document the results of the other subprograms.

## 1.1 BACKGROUND

Brattice curtains are extensively used in underground mines for directing and controlling ventilation airflow. There are a number of applications on longwall faces where curtains may improve ventilation and dust control. They include:

a. A "wing" curtain to provide localized control of ventilating air during the headgate cut-out

b. A "gob" curtain at the headgate shield line to minimize short-circuiting of primary ventilation into the gob

c. "Walkway" curtains along the face suspended from shields perpendicular to the airflow - keeping shearer-generated dust near the face

d. An "extended spillplate" technique used to partition the contaminated face air from the walkway.

## 1.2 SUBPROGRAM OBJECTIVE

The objective of this subprogram was to evaluate the effectiveness of various ventilation curtain applications in improving ventilation and reducing dust concentrations on longwall shearer faces.

## 2. INDUSTRY INVESTIGATION (TELEPHONE SURVEYS)

The initial task on the program was a survey of longwall operators. The objectives of the survey included:

a. Locating mines using ventilation curtain techniques

b. Soliciting information on the use, effectiveness, worker response, and operational and maintenance problems associated with the techniques

c. Seeking potential sites for future field visits and an underground evaluation.

A questionnaire was drafted for the surveys, with specific questions pertaining to the use of wing, gob and walkway curtains.

Nineteen mines were contacted and seventeen participated in the survey with the following results:

a. Six used wing curtains

b. Thirteen used gob curtains

c. None used walkway curtains.

North American Coal Company's Florence No. 1 Mine had been using walkway curtains but had discontinued them due to a perceived lack of effectiveness. The survey indicated that most longwalls were aware of the gob curtain concept and were using it effectively and several were using a wing curtain.

Detailed results of the industry investigation (telephone surveys) are shown in table 1.

TABLE 1. - Telephone survey results

| Company | Gob curtains | Wing curtains | Walkway curtains |
|---|---|---|---|
| 1. Kaiser Steel Corp., NM | X | | |
| 2. Kentucky Carbon | X | | |
| 3. CF&I Steel Corp. | No curtains in use | | |
| 4. Carbon Fuel Co. | X | X | |
| 5. Southern Ohio Coal Co., OH | X | X | |
| 6. Southern Ohio Coal Co., WV | X | X | |
| 7. Jones & Laughlin Steel Corp. | X | | |
| 8. Island Creek Coal Co. | No curtains in use | | |
| 9. Snowmass Coal Co. | X | X | |
| 10. Carbon County Coal Co. | No curtains in use | | |
| 11. Clinchfield Coal Co. | X | | |
| 12. Consol - Blacksville Div. | X | | |
| 13. Price River Coal Co. | X | | |
| 14. Kaiser Steel Corp., UT | No curtains in use | | |
| 15. Quarto Mining Co. | X | X | |
| 16. Florence Mining Co. | X | X | |
| 17. Western Slope Carbon, Inc. | X | | |
| Totals | 13 | 6 | 0 |

## 3. WALKWAY CURTAIN LABORATORY EVALUATION

The walkway curtain concept was tested in a full scale model longwall test facility. The evaluation was conducted along a straight section of the facility without the shearer in place. The objective of the testing was to determine the fundamental effects of walkway curtains on airflow velocities and air movement patterns along the face.

Curtains were hung at right angles to the face, filling the entire walkway space on the gob side of the spillplate (see figures 5 and 6). Testing variables included:

a. Average primary airflow velocities of 175, 300 and 450 fpm

b. Curtain spacings of 15, 25 and 40 ft

c. Curtain angles to the face of 90 and 45 deg

d. Curtain widths of 33, 56 and 77 in.

e. Curtains with perforations (to lessen the effect of downwind eddying).

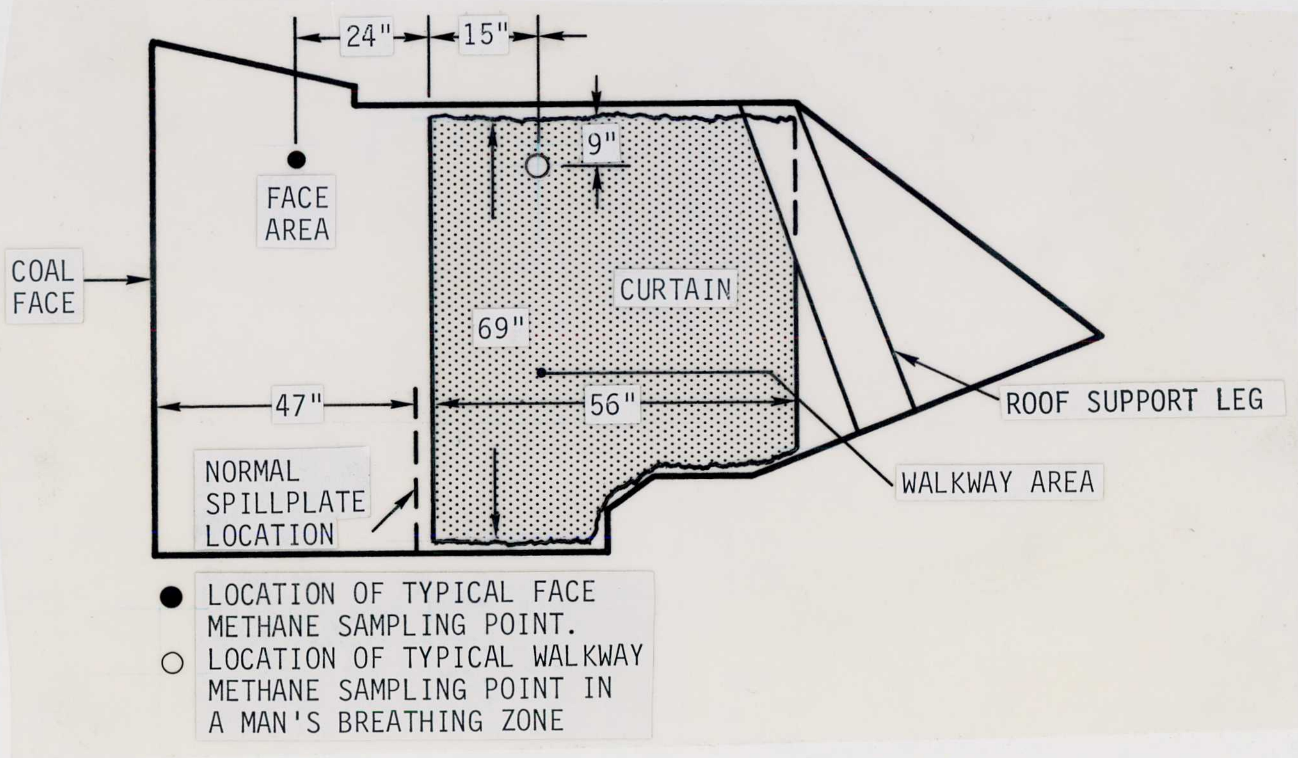


FIGURE 5. - Walkway curtain installation - section view of longwall gallery.

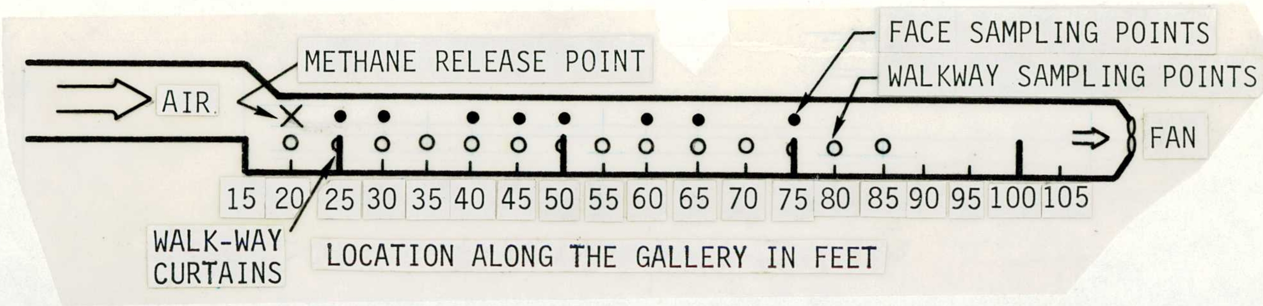


FIGURE 6. - Plan view of the longwall gallery.

Tests conducted included smoke traces, velocity profiles and methane gas concentration maps.

As expected, the curtains did increase face air velocities while decreasing walkway velocities. However, the curtains caused severe eddying of the airflow into the walkway space. Contaminated face air was drawn into the walkway between the curtains, where it lingered. Figure 7 compares a baseline smoke trace with that of a 25-ft curtain spacing.

To quantify the observed effect on airflow patterns, tracer gas concentration tests were conducted. Methane was released and gas concentrations were measured at the points indicated in figure 6. The results of these tests are shown in figure 8 and figure 9. Each figure compares gas concentrations sampled at regular intervals along the

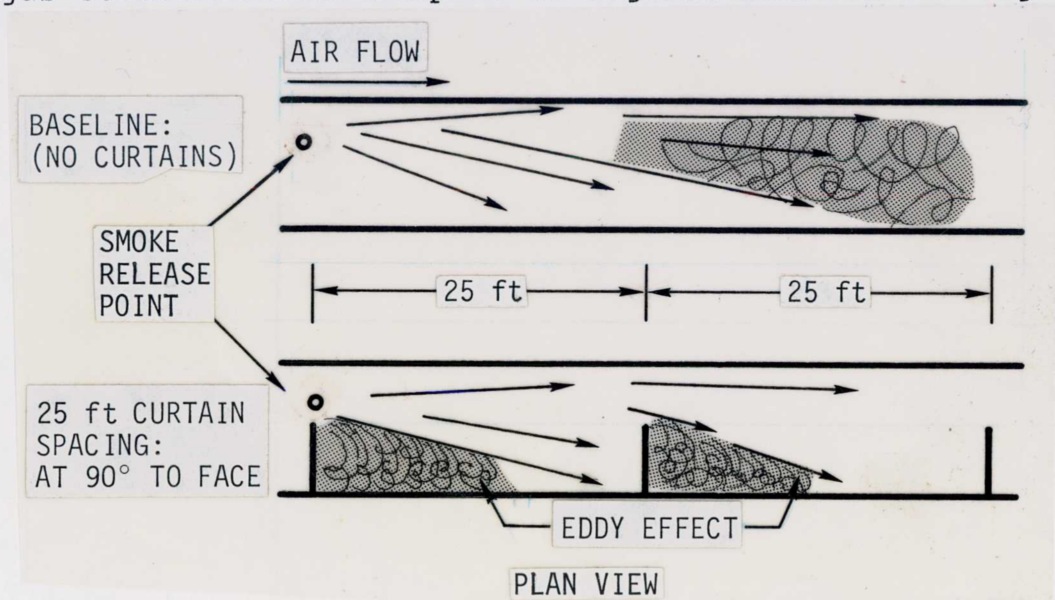


FIGURE 7. - Ventilation map comparing airflows - baseline conditions versus 25-ft curtain spacing.

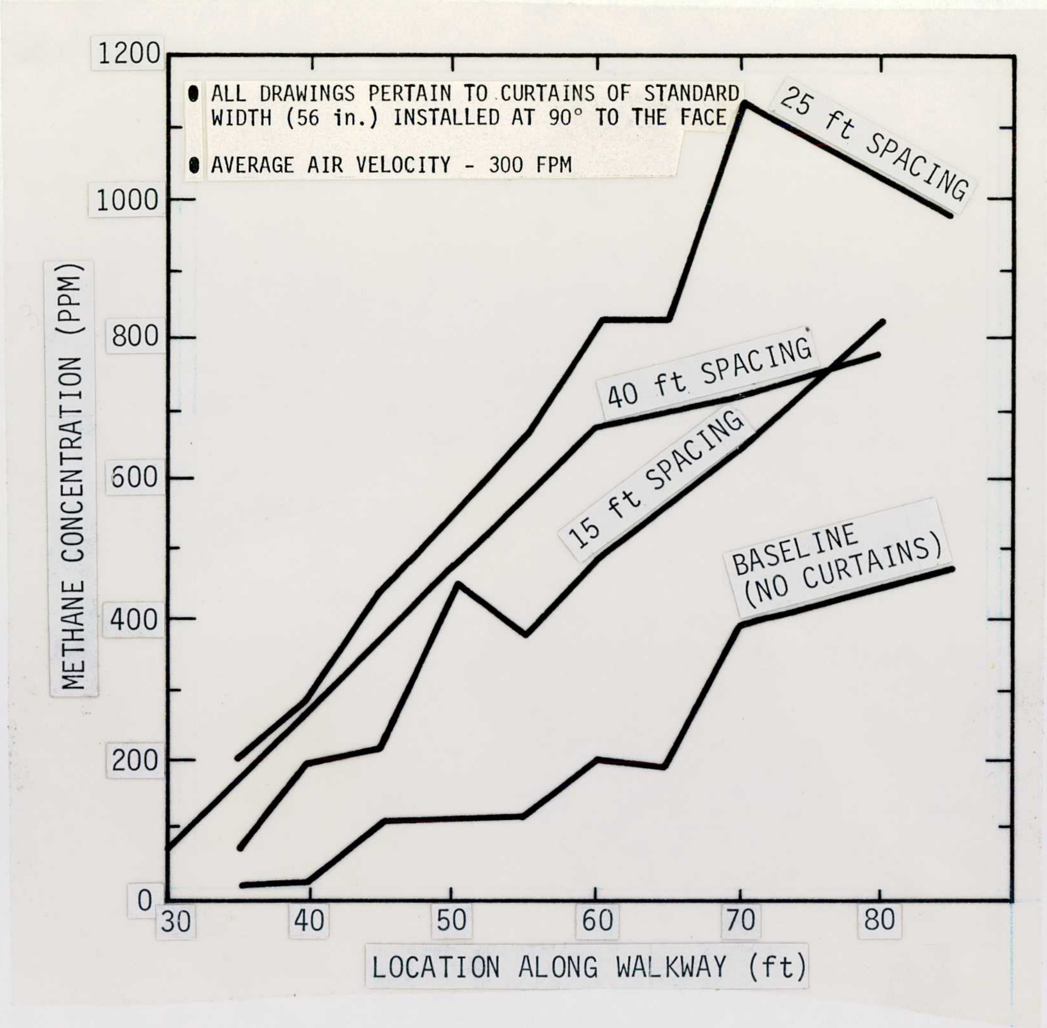


FIGURE 8. - Methane gas concentrations of 90-deg curtain configurations along walkway.

walkway for various curtain configurations against baseline conditions. Table 2 lists the rank of effectiveness of all curtain configurations tested.

Test results clearly indicated that the baseline condition (no curtains) caused the least rapid mixing of contaminated air into the walkway. Any attempt to prevent the natural decay of contaminated air into the walkway by increasing face side velocities actually accelerated the mixing process. While at least one longwall operation - North American's Florence No. 1 Mine - had employed the

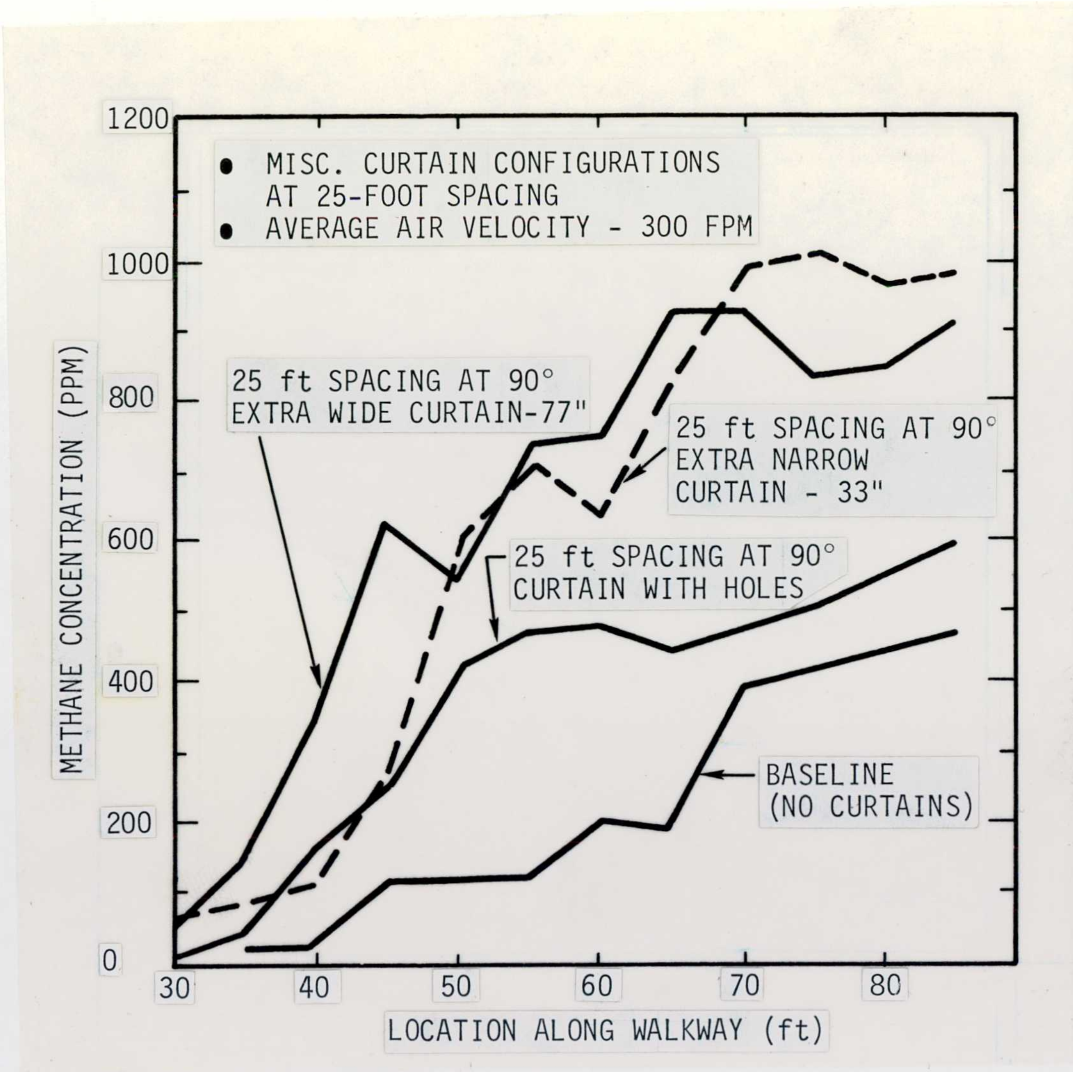


FIGURE 9. - Methane gas concentrations of different curtain configurations along walkway.

walkway curtain concept as a dust control measure, they have abandoned this technique. For these reasons, additional effort to study the walkway curtain concept was terminated.

TABLE 2. - Rank of curtain effectiveness

| | | |
|---|---|---|
| Best: | 1. | Baseline - no curtains |
| | 2. | 25 ft spacing at 90 deg (with perforations) |
| | 3. | 15 ft spacing at 45 deg |
| | 4. | 15 ft spacing at 90 deg |
| | 5. | 40 ft spacing at 45 deg |
| | 6. | 25 ft spacing at 90 deg (extra-narrow) |
| | 7. | 40 ft spacing at 90 deg |
| | 8. | 25 ft spacing at 45 deg |
| | 9. | 25 ft spacing at 90 deg |
| Worst: | 10. | 25 ft spacing at 90 deg (extra-wide) |

## 4. EXTENDED SPILLPLATE LABORATORY TESTING

A brief preliminary laboratory study was completed during December, 1981, on a concept which would partition the contaminated face air from the walkway. It is installed parallel to the face and is simply a vertical extension of the existing spillplate between the walkway and the panline (see figure 10). This "extended spillplate" technique was reportedly being used at several German mines.

Three different spillplate heights were tested: 33 in. (standard), 48 in. and a full height spillplate to the underside of the roof supports. Testing took place over a portion of the face which was in the "snaked" condition (worst case). Initial results showed no difference in the amount of walkway contamination between a 33 and 48 in. spillplate. Full height results (as expected) were very good, but did pose serious practical considerations.

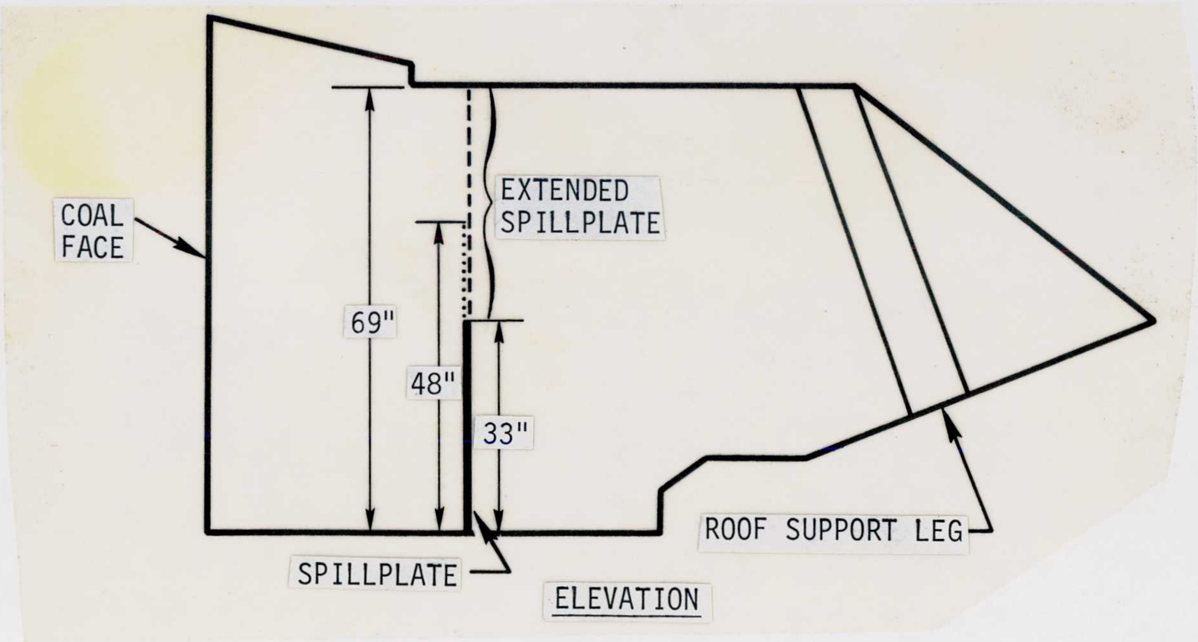


FIGURE 10. - Extended spillplate.

## 4.1 EXTENDED SPILLPLATE - WITHOUT SHEARER CONTROL TECHNIQUE

Additional testing of the extended spillplate concept was conducted in the longwall facility under more realistic conditions with the shearer in position followed by a long straight section of gallery.

The first series of tests were conducted with the shearer drum and "plume" sprays operating without any additional dust control techniques. Three different spillplate heights were tested: 33 in. (standard), 48 in., and a full height to the roof supports. The spillplate was installed over a 140 ft section of the gallery extending from approximately 15 ft upstream of the shearer (cutting against the airflow) to 10 ft downstream of the beginning of shield advance. In a practical underground situation, a full height spillplate would have to be held away from the shearer as it passed by. To produce this condition in the gallery, the spillplate (plastic curtain) was rolled up and secured to the underside of the roof supports above the shearer as shown in figure 11.

Methane gas concentration maps reflecting contamination levels in the walkway for three spillplate heights are shown in figure 12. Highlights of the testing results include:

a. Walkway contamination levels around the shearer were similar for both the 48 in. and full height spillplates. Both, however, were considerably higher than levels for the 33-in. spillplate (154% and 73% higher at the lead and trailing drum operators' positions, respectively). The higher spillplate helped to contain contaminated air within the headgate drum region. Without a control technique on the shearer, contamination simply poured over the edge of the shearer into the operator's position, producing higher levels.

b. Levels downstream of the shearer were considerably lower for the full height spillplate than for the 33- and 48-in. spillplates (average reductions of 50 and 60%, respectively). The full height spillplate prevented any further mixing of face-side contamination into the walkway.

The test results around the shearer (as discussed above) showed the need for a final series of tests <u>with</u> a control technique in operation on the shearer.

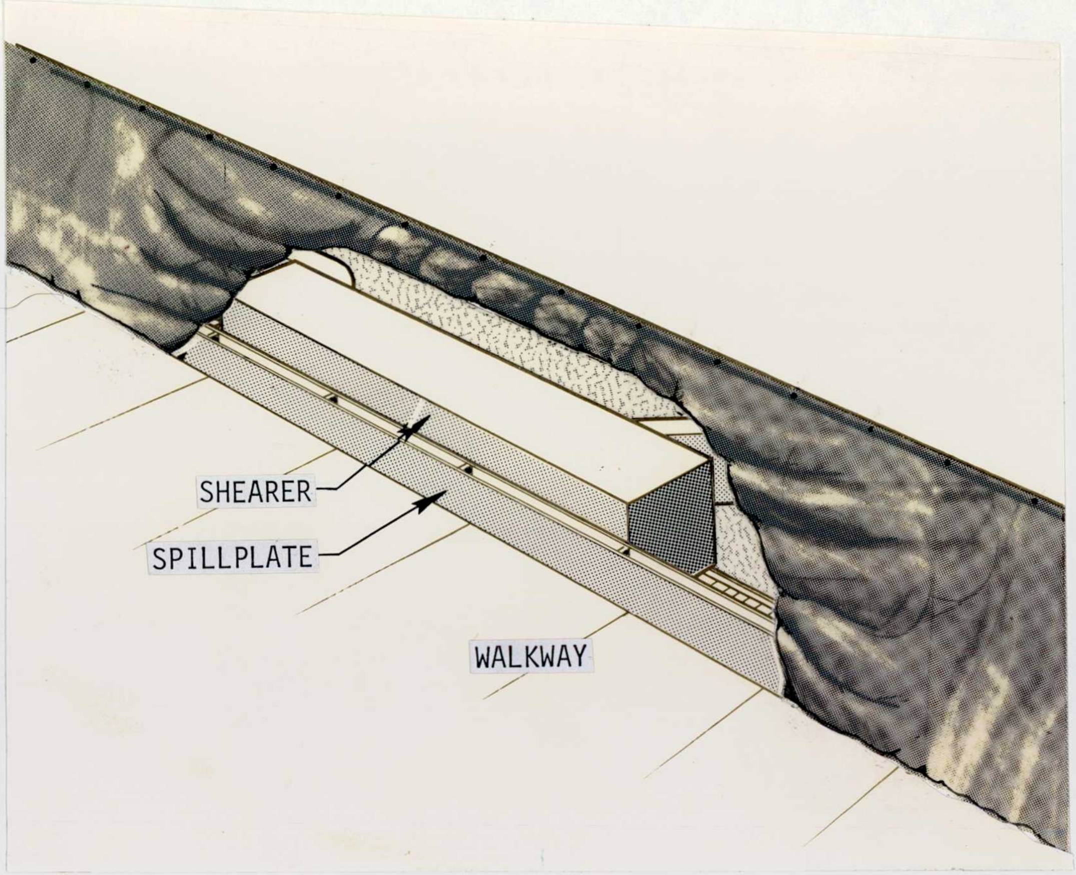


FIGURE 11. - Sketch of "full height" extended spillplate installed in longwall gallery.

### 4.2 EXTENDED SPILLPLATE - WITH SHEARER CONTROL TECHNIQUE

Tests were performed on the 33- and 48-in. spillplate heights to determine their effectiveness when combined with a complete combination Shearer Clearer/passive barrier dust control system. Tests without the combination system in operation were repeated for A-B comparison purposes. Although it showed promise in reducing contamination levels downstream of the shearer, the full height

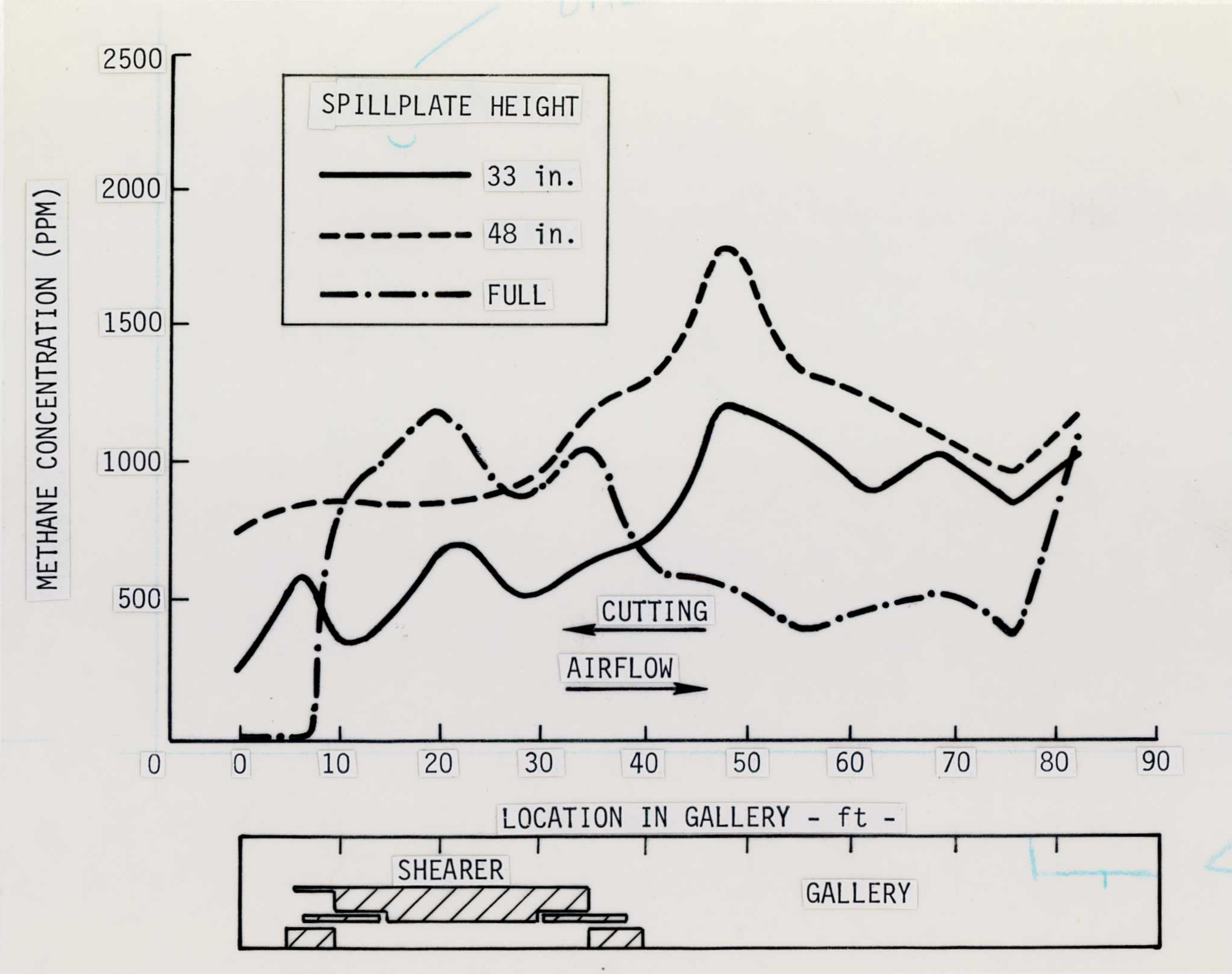


FIGURE 12. - Contamination profiles around shearer with extended spillplates.

spillplate was not tested due to its impracticality underground.

Methane gas concentration maps reflecting contamination levels in the walkway for both spillplate heights, with and without the control technique in operation, are shown in figure 13. Following are highlights of the testing results:

a. For each test condition, virtually no difference was recorded in system effectiveness either over the shearer or downstream when comparing the 33- and 48-in. spillplate heights.

b. Overall system performance was greatly improved by the addition of the Shearer-Clearer/passive barrier system.

At this point no further studies were performed on the extended spillplate concept under this subprogram for the following reasons:

a. Laboratory testing results showed no improvement in walkway contamination levels when using an extended spillplate (other than full height).

b. Practical limitations would make use of the technique underground difficult, particularly at a full height.

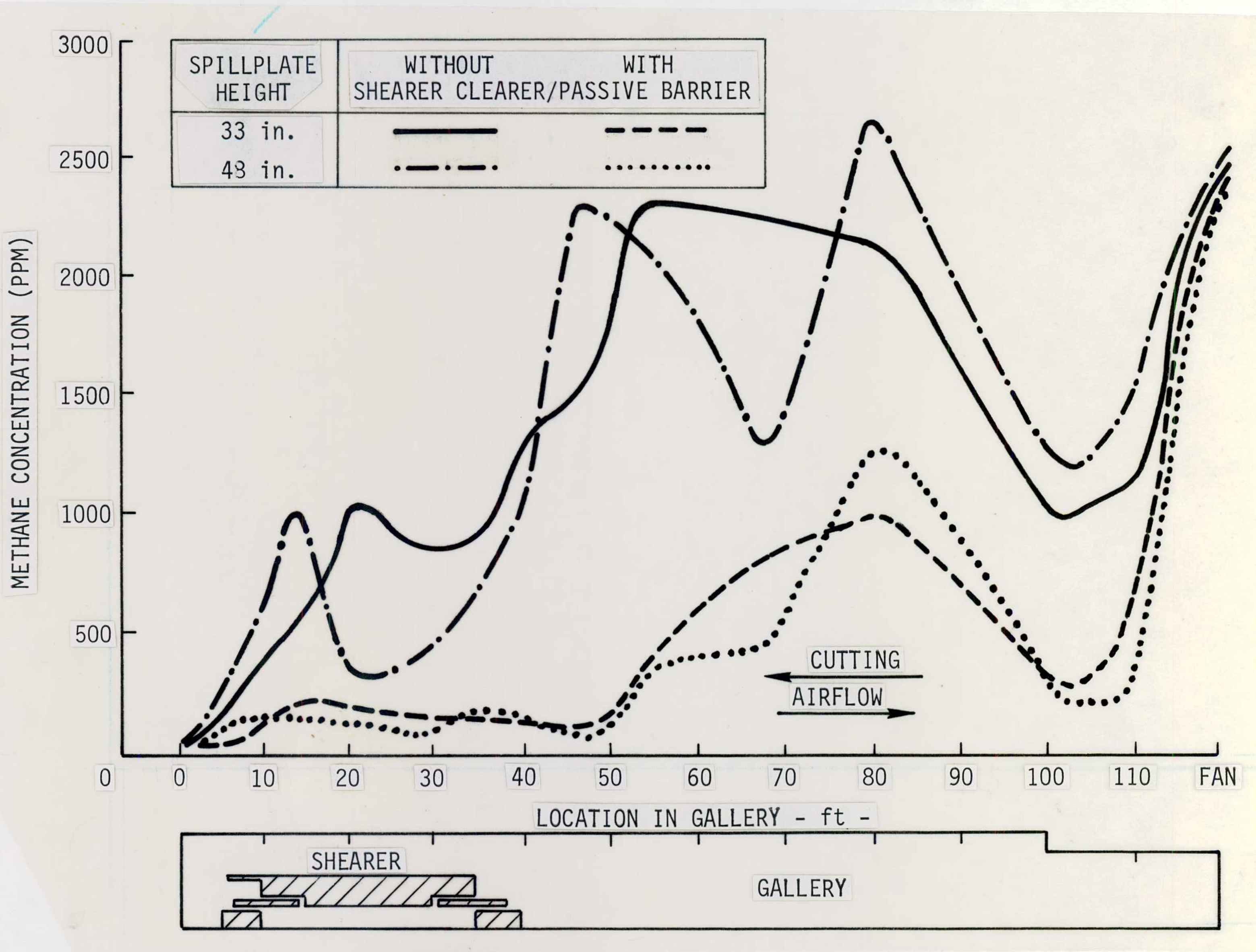


FIGURE 13. - Contamination profiles with extended spillplate and shearer dust control techniques.

# 5. GOB CURTAIN TESTING

During December, 1981, a brief underground test of the effect of gob curtains was performed at Emery Mining Corporation's Deer Creek Mine in Huntington, UT. The gob curtain was installed at the headgate shield line to minimize "short-circuiting" of primary ventilation into the gob (see figure 14).

The tests conducted at Deer Creek consisted of air velocity profiles at every tenth shield with and without the gob curtain installed. The comparative test showed that the volume of air on the face increased by 10% from the headgate to nearly mid-face with the curtain installed. This increased air volume provides additional dilution, thereby lowering dust concentrations.

The industry investigation had indicated that most longwalls were already using the gob curtain on a routine basis. Underground ventilation surveys had documented the effect that the gob curtain alone had on airflow. Further field tests were conducted to document the interaction of the gob and wing curtains. This effort is discussed in the following section.

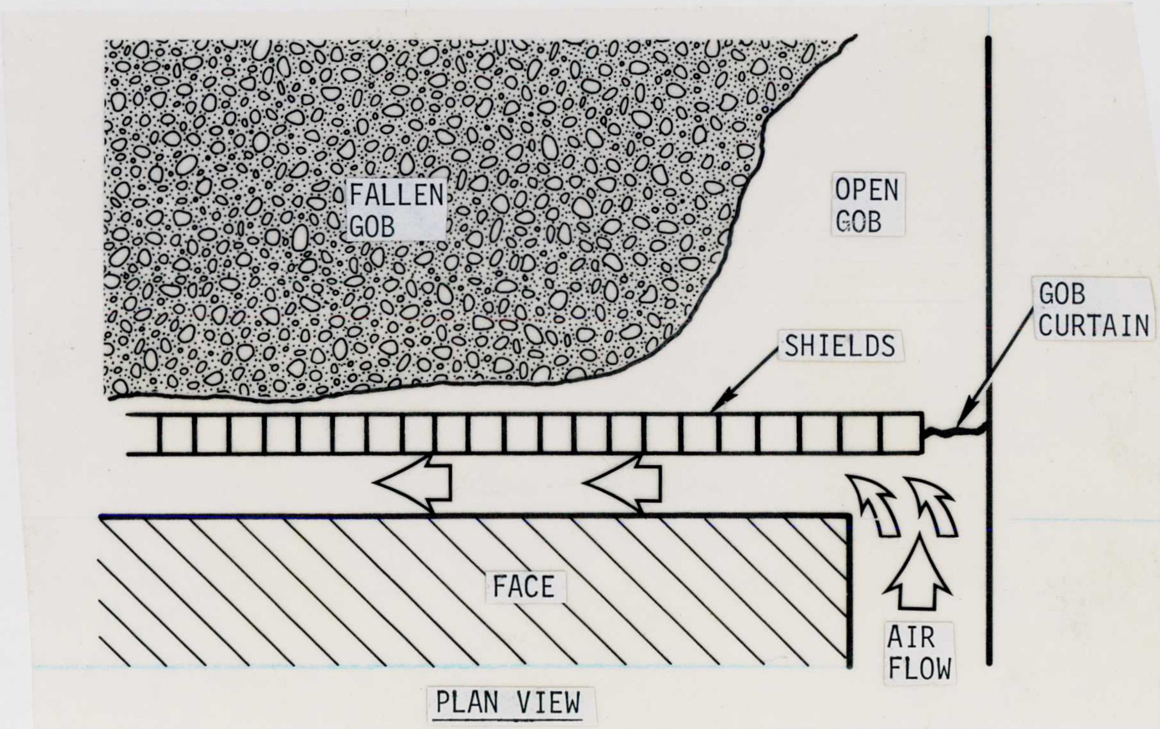


FIGURE 14. - Gob curtain.

# 6. FIELD EVALUATIONS OF WING CURTAINS

Two underground evaluations of wing curtains for providing localized control of ventilating air during the headgate "cut-out" were conducted. Details of these evaluations are presented in the following subsections.

## 6.1 FIELD SURVEYS

Three mines were visited to gain information on the use of wing and gob curtains and to search for suitable evaluation sites. Each visit is briefly discussed below.

### 6.1.1 Price River Coal Company, No. 5 Mine, Helper, UT

Although no wing curtain was used on the 8th West panel, several headgate cutout dust concentrations were monitored to determine if a wing curtain could be beneficial. The average of the highest reading of each cutout (measured at the headgate shearer operator's position) was 10.4 $mg/m^3$ compared with average readings along the face of approximately 6.0 $mg/m^3$ (tail-to-head cut). During the visit, a modified wing curtain was constructed along the stageloader in the headgate. Velocity surveys showed that the curtain significantly affected airflow patterns in the headgate, but time did not permit dust sampling of cutouts with the curtain installed. It was therefore not possible to determine the curtain's effect on the shearer operator's dust exposure at this site.

### 6.1.2 U.S. Steel Corporation, Morton Mine 34A, Chesapeake, WV

Two wing curtain configurations were studied, including the configuration typically used by U.S. Steel. Velocity surveys and smoke tube traces showed that both curtains significantly affected airflow patterns in the headgate. With a wing curtain in place, the intake air could be channeled out and around the corner of the face, increasing in velocity across the end of the curtain. Unfortunately, start-up problems for the new panel during the visit did not allow valid dust sampling.

The headgate layout, current interest in wing curtains and willingness to cooperate made Morton Mine a suitable evaluation site.

### 6.1.3 Southern Ohio Coal Company, Meigs No. 1 Mine, Athens, OH

Although Southern Ohio had used wing curtains in the past, they were not using one on No. 0135 panel since the shearer was equipped with a remote control umbilical cord. The umbilical cord is intended to keep the headgate operator out of the headgate cutout dust.

Several cutout dust concentrations were monitored to determine if a wing curtain could offer any additional improvement to the umbilical cord. The average of the highest cutout dust concentrations at the headgate shearer operator's position was 8.8 $mg/m^3$. A wing curtain was installed during the second day of the visit. Velocity profiles and smoke tube surveys showed that the curtain affected airflow patterns in the headgate, but time did not permit dust sampling of cutouts with the curtain installed.

## 6.2 WING CURTAIN FIELD EVALUATION - U.S. STEEL CORPORATION

The first field evaluation of the wing curtain technique took place at U.S. Steel Corporation's No. 34A Mine near Chesapeake, WV. Objectives of this evaluation included:

a. Test the effectiveness of wing curtains in reducing the dust exposures of shearer operators during headgate cutouts

b. Recommend improvements in the designs, applications and construction techniques of wing curtains.

### 6.2.1 Evaluation Strategies

The test plan for the evaluation at U.S. Steel focused on two wing curtain configurations: the novel design used by U.S. Steel and the traditional design more commonly used in the industry (refer to figure 15). Other tasks in the test plan included:

a. A special study of the interactive effects of using both wing curtains and gob curtains

b. Implementing "pogo sticks" for simplified curtain installation

c. Conducting discussions with mine management and underground personnel regarding more elaborate designs, such as permanent curtain installations mounted on stageloaders, extensible brattice techniques, etc.

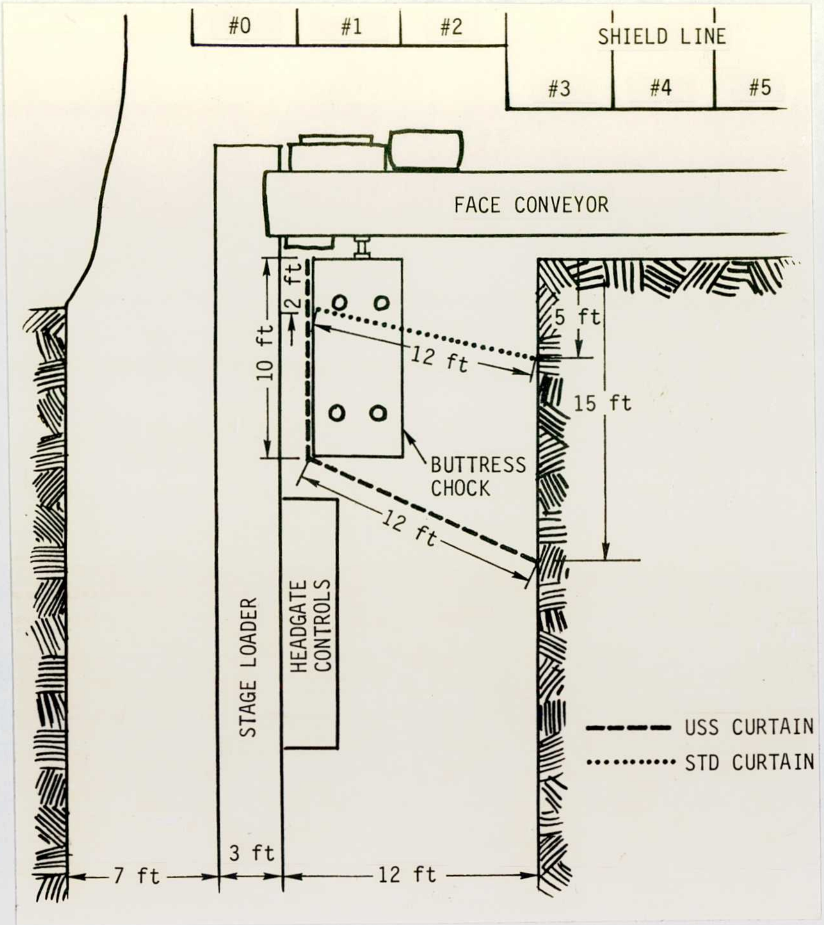


FIGURE 15. - Wing curtain configurations.

Testing methodology consisted of:

a. Dust sampling of the headgate shearer operator's position during headgate cutouts

b. Air velocity and smoke trace surveys around the wing curtain

c. Air volume surveys in the headgate and along the face

d. A daily headgate area survey to document changing conditions, including locations of the last open crosscut and headgate equipment.

### 6.2.2 Respirable Dust Concentration Survey

As planned, the evaluation focused on two wing curtain configurations; sketches of the headgate layout on 8th West showing both of the configurations are given in figure 15.

A variety of mechanical breakdowns and other related problems resulted in poor coal production throughout the week. For this reason, greater effort was directed toward smoke traces and airflow profiles than toward headgate cutout dust surveys.

Respirable dust levels during two headgate cutouts were monitored during the trial:

a. Without a wing curtain installed

b. With the U.S. Steel wing curtain installed.

No gob curtain was installed in either case.

Figure 16 indicates the instantaneous dust concentrations monitored at the operator's position during the two cutouts. With the U.S. Steel wing curtain removed, high "peak" dust concentrations were monitored as the headgate drum cut into the headgate entry. Use of the U.S. Steel curtain reduced the peak readings considerably (by 70% at Shield No. 4). These reductions were seen despite the higher levels recorded between Shield Nos. 19 and 6 when the curtain was installed. The higher levels between Shield Nos. 19 and 6, with the wing curtain installed, appeared to be caused by greater entrainment of transfer point dust from increased air velocities around the end of the face conveyor. This effect may be peculiar to No. 34A Mine due to low headroom and the height of the panline-to-stageloader discharge point above the floor. Poor coal production precluded confirming this phenomenon through additional cutout comparison testing; however, fixed-point dust sampling was performed at Shield Nos. 1 and 8 to determine the effect of the wing curtain on intake contamination levels during normal panline coal loading. The results showed an increase in dust levels from 0.2 $mg/m^3$ to 0.6 $mg/m^3$ at Shield No. 8 when the curtain was installed.

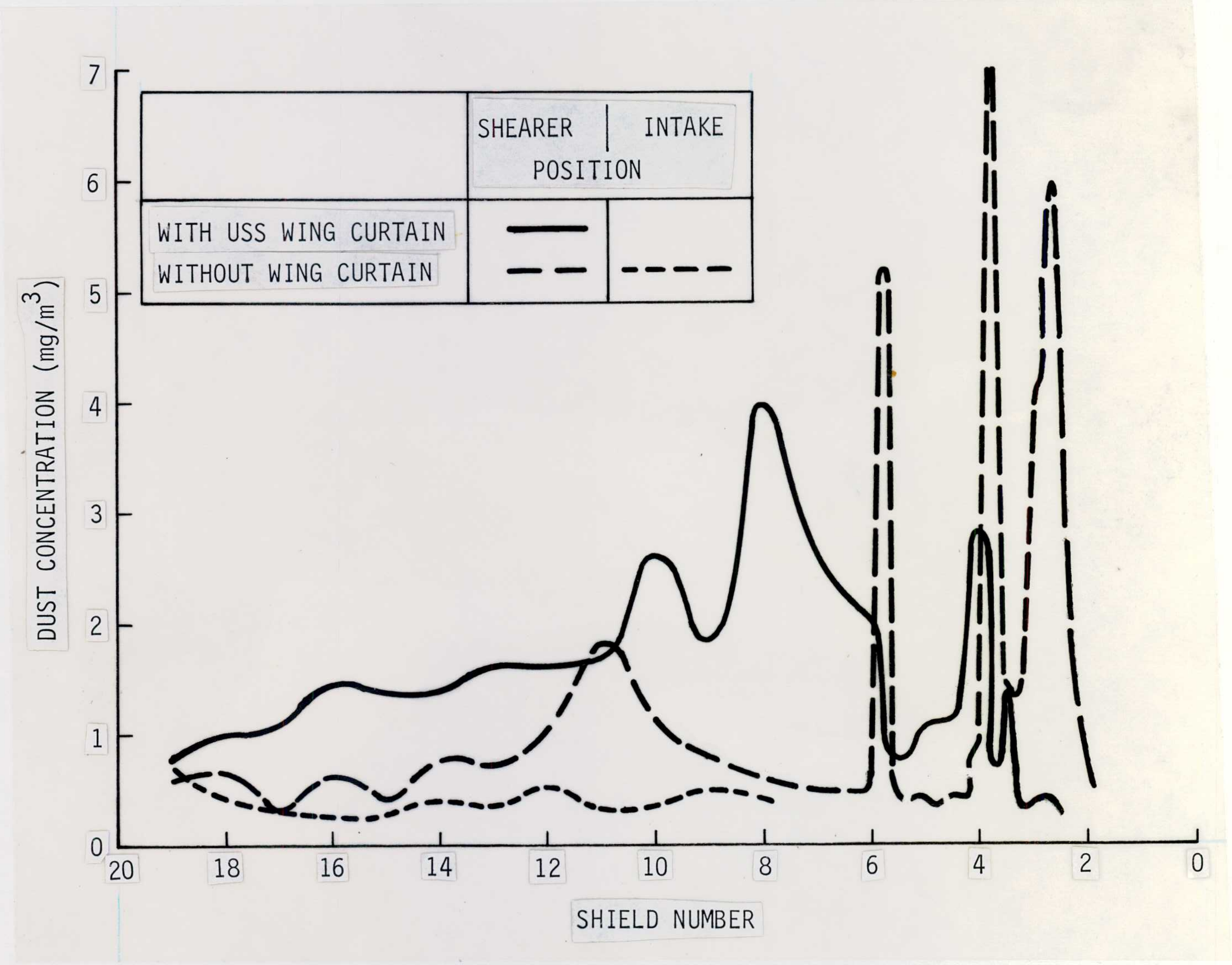


FIGURE 16. - Respirable dust concentrations at the shearer operator's position during headgate cutouts

### 6.2.3 Smoke Trace and Air Velocity Surveys

Surveys were performed on a systematic grid pattern throughout the headgate area on the following curtain conditions:

a. Baseline (no wing curtain; no gob curtain)

b. U.S. Steel and standard wing curtains; no gob curtain

c. U.S. Steel and standard wing curtains with gob curtain.

Figure 17 shows the results of surveys performed with and without the U.S. Steel wing curtain installed (no gob curtain used). The surveys demonstrated the wing curtains' effectiveness in channeling intake air around the headgate cutout region and producing an even distribution of air velocity over the panline and walkway along the headgate end of the face.

### 6.2.4 Air Volume Surveys

Total air volume was measured at every fifth shield between the headgate and Shield No. 50 for the following curtain conditions:

a. Baseline (no wing curtain; no gob curtain)
b. Gob curtain alone (no wing curtain)
c. U.S. Steel and standard wing curtains (no gob curtain)
d. U.S. Steel and standard wing curtains with gob curtain.

Plots of air volume measurements at specified intervals along the face for several curtain conditions are presented in figure 18. The results indicated that the use of wing and/or gob curtains made very little difference in the amount of air volume available at specified locations along the face. This was an unexpected result; surveys at other mine sites have shown gob curtains to increase airflow along the face. The gob may have been sufficiently consolidated at No. 34A to explain the little difference with or without the curtain installed. The effect of wing and/or gob curtains on face air volumes was investigated more thoroughly on the second evaluation.

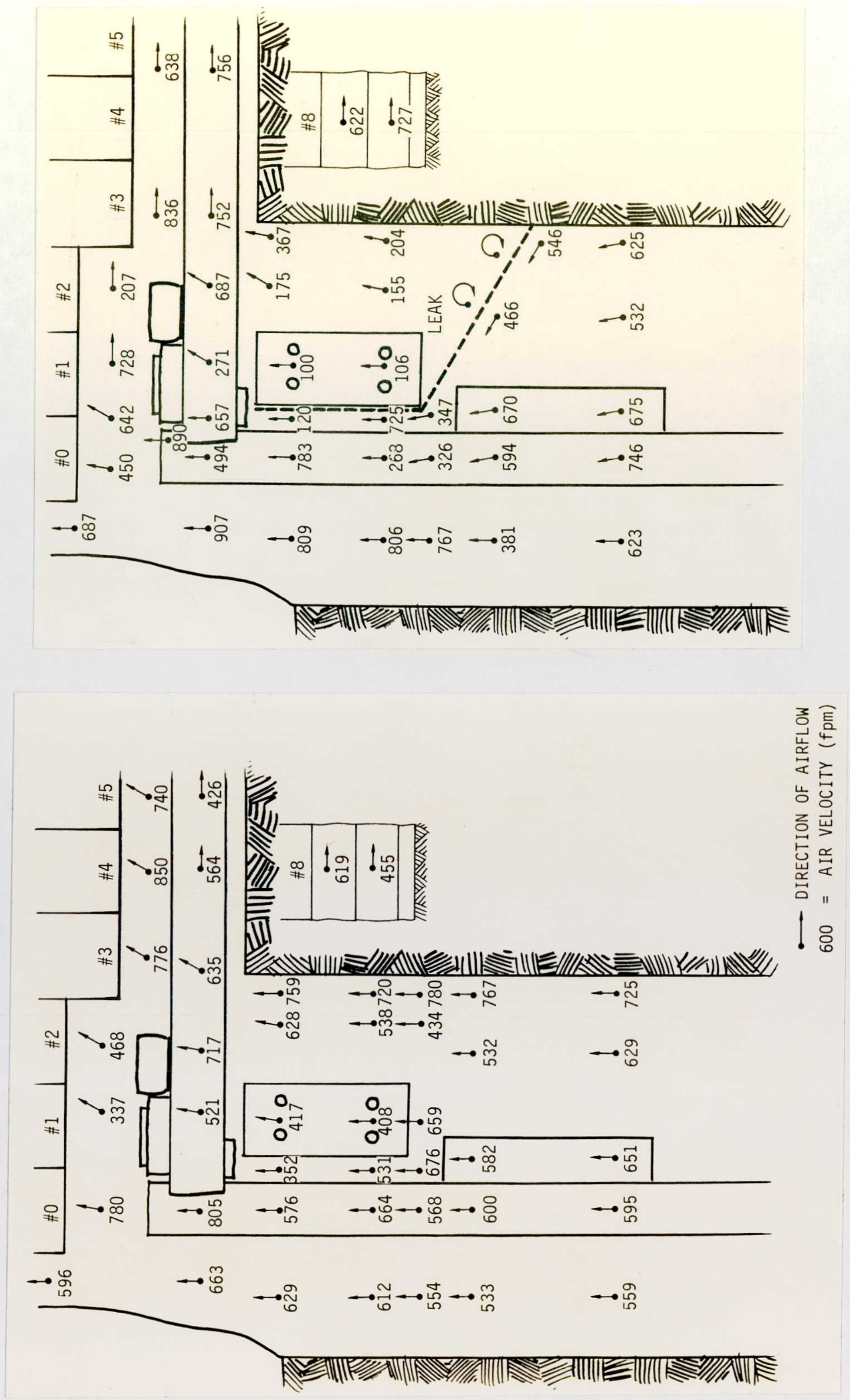


FIGURE 17. - Smoke trace and air velocity survey.

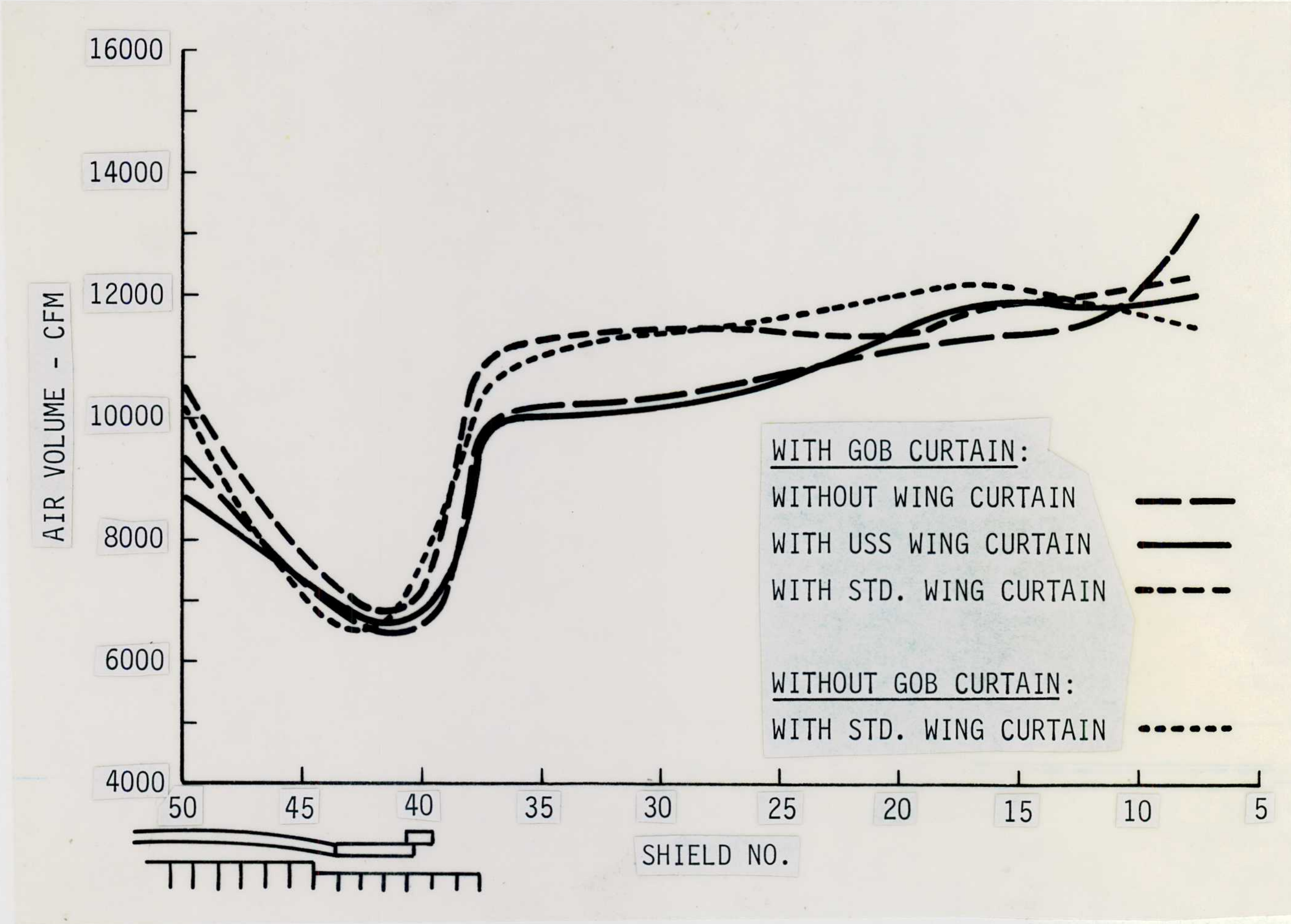


FIGURE 18. - Air volume readings along face.

### 6.2.5 Installation Techniques and Curtain Designs

Throughout the testing, "pogo sticks" were implemented as a simplified curtain installation tool. The commercially available "pogo sticks" (simple spring-loaded expanding sections of PVC pipe) proved to be an excellent, mineworthy means of very quickly installing the curtains under a variety of heights and roof/floor conditions. Figure 19 shows photographs of the sticks in use during the evaluation.

A discussion with mine management about permanent curtain installations showed their interest in the concept and yielded the design ideas shown in figures 20 and 21. Both designs have the following advantages:

a. Permanent installation, requiring little or no repair maintenance

b. Attachment to moving face equipment, requiring no curtain removal and resetting.

The wing curtain design has the additional advantage of being partially removable by sliding the curtain to one side. This allows the headgate operator to see the face area and work near the face corner when the shearer is not cutting out at the headgate. The wing curtain design shown in figure 20 is site-specific to the No. 34A Mine due to the buttress chock. The feasibility of a similar design attached to the stageloader, with a sliding curtain to the face rib would need to be investigated.

Both designs have the disadvantage of greater complexity and would require more extensive repairs if severe damage did occur.

### 6.2.6 Summary of Recommendations

The results acquired under the evaluation at U.S. Steel have led to the following recommendations for further testing:

a. Emphasis should be placed on the wing curtain configuration used by U.S. Steel; it offers the following advantages:

   1. A more streamlined design, allowing for more uniform flow of air around the curtain corner

   2. An ability to "peel back" the curtain over several cutouts before needing to completely reposition it.

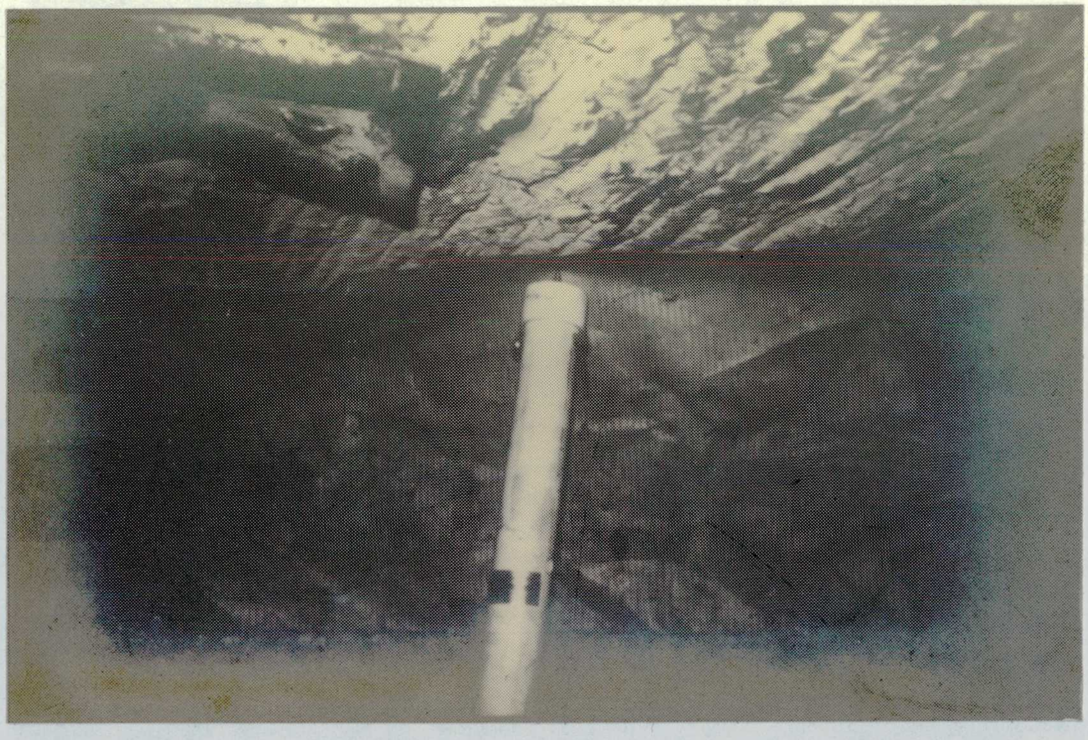

FIGURE 19. - Use of "Pogo Sticks" for wing curtain installation.

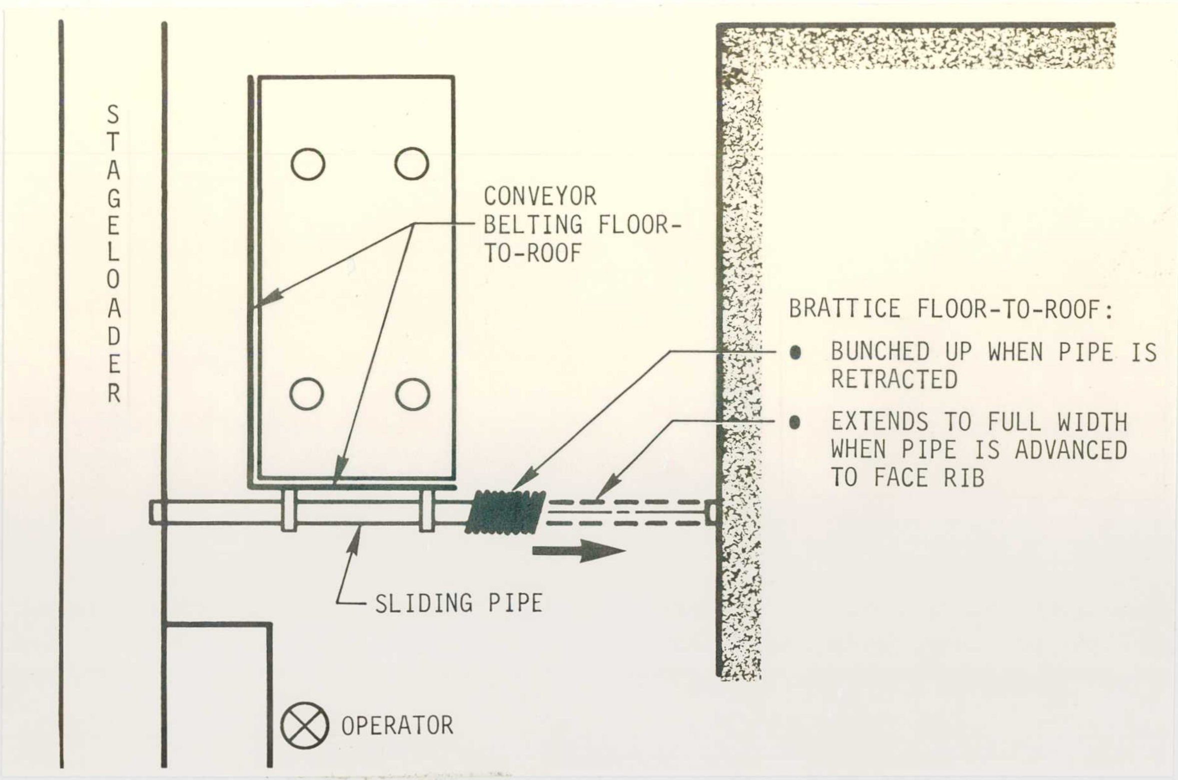


FIGURE 20. - Permanent wing curtain design advancing with buttress chock.

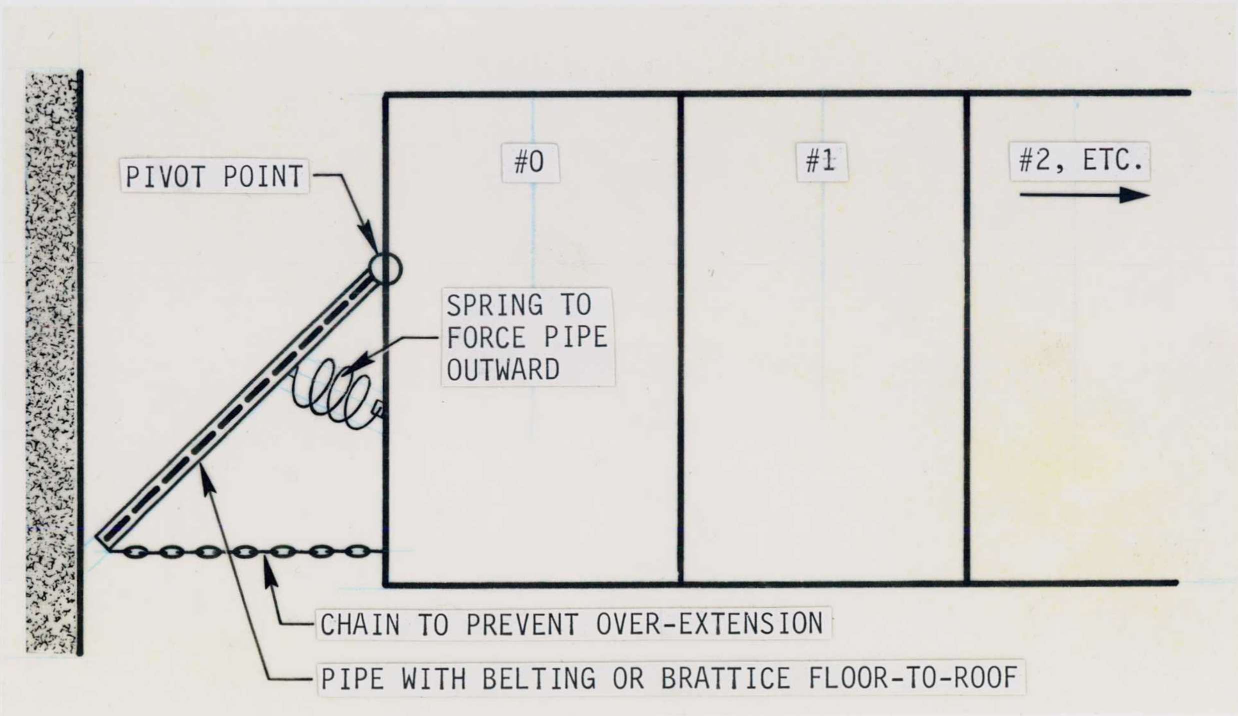


FIGURE 21. - Permanent gob curtain design advancing with first shield support.

b. Temporary installations should be performed with the "pogo sticks"

c. Permanent installations attached to the stage-loader should be investigated for their performance, practicality and mineworthiness

d. Removal of the wing curtain (or part of it) while the shearer is not cutting out at the headgate should be studied for its effects on face airflow and intake dust levels

e. Further investigation should be made into the interactive effects of wing and gob curtains on headgate cutout dust levels and their effect on face airflow.

## 6.3 FIELD EVALUATION OF WING CURTAINS AND GOB CURTAINS

Two ventilation curtain field evaluations were called for under this subprogram. The results of the first evaluation at U.S. Steel pinpointed several areas of study on which the second evaluation should focus:

a. A-B comparison dust data during headgate cutouts

b. Further investigation of the interactive effects of wing and gob curtains on face velocities and airflow volumes

c. Further studies on the effects of wing and gob curtains on transfer point dust entrainment

d. The feasibility of a permanent wing curtain design which advances with headgate equipment.

### 6.3.1 Site Selection

Screening surveys were conducted at three mines as part of general program dust source surveys or during other evaluations. Sites visited included:

a. Price River Coal Company; No. 5 Mine; Helper, UT

b. ARMCO Steel; No. 7 Mine; Montcoal, WV

c. Kaiser Steel; York Canyon Mine; Raton, NM.

#### 6.3.1.1 Price River Coal Company - Helper, UT

During a field survey at Price River's 10th West longwall in July 1983, the headgate was analyzed as a potential site for the second ventilation curtain evaluation. The results of the analysis showed that shearer-generated dust levels were too low under present face conditions to permit a ventilation curtain evaluation at that site. The maximum headgate cutout dust level recorded was approximately 2.5 mg/m$^3$. Figure 22 shows plots of dust concentration versus face location (shield number) for two headgate cutouts monitored during the survey on tail-to-head cutting passes. Both plots illustrate consistent shearer operator dust concentrations of approximately 0.5 mg/m$^3$ approaching the cutouts, with peak cutout concentrations of only 2.0 mg/m$^3$ and 2.5 mg/m$^3$. The low concentrations were the result of high face air velocities, high shearer water pressure and flow, low tramming speed and low intake contamination levels.

6.3.1.2 ARMCO Steel - Montcoal, WV

A major evaluation in progress under another subprogram precluded consideration of ARMCO as a ventilation curtain test site. A period of downtime during the other

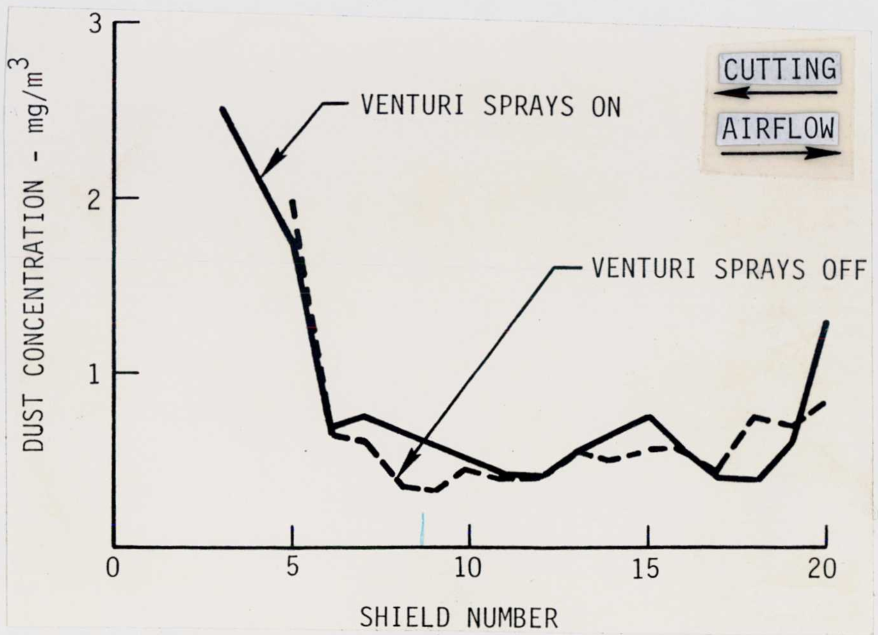


FIGURE 22. - Dust concentrations at headgate shearer operator's position during headgate cutout, tail-to-head cutting - Price River Coal Company.

evaluation, however, provided an opportunity to document ARMCO's use of brattice and belting to control headgate-to-face airflow patterns. As shown in figure 23, an angled curtain on the off-face side of the stageloader, combined with belting hanging into the face conveyor from the tips of the second and third shields, helped divert intake air away from the gob and direct it over the top of the shearer. Smoke traces showed the system to be very effective in rerouting air patterns as illustrated in figure 23. Very little gob leakage occurred between Shield No. 1 and the chain pillar rib. However, significant gob leakage did occur between Shields 1 and 2 due to the gap between the curtain and the belting and the large gap between Shields 1 and 2. When the curtain was removed, airflows of 200-300 fpm short-circuited directly to the gob between Shield 1 and the chain pillar rib as well as between Shields 1 and 2.

During the headgate cutout, the belting on Shield 2 and 3 appeared visually to help reduce the amount of dust and spray mist impacting the headgate shearer operator.

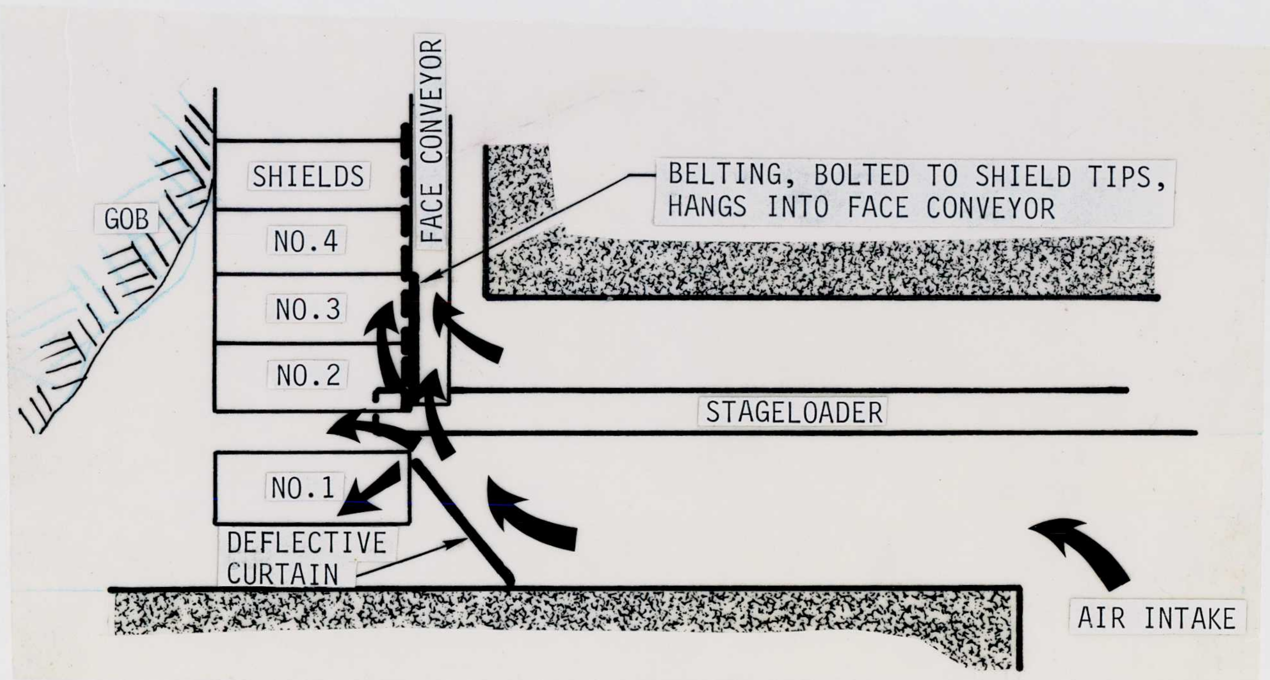


FIGURE 23. - ARMCO's use of brattice and belting to control headgate airflow patterns.

### 6.3.1.3 Kaiser Steel Corporation, York Canyon Mine - Raton, NM

A general dust source survey was performed on the longwall at Kaiser's York Canyon Mine during February, 1984. The purpose of the survey was to delineate dust sources and pinpoint appropriate control techniques, which would coincide with subprograms in need of evaluation sites. During the survey, it was noted that Kaiser had designed and used a unique combination of the wing curtain/gob curtain ventilation techniques. As shown in figure 24, the system consisted of three separate components:

a. A removable gob curtain positioned at the traditional location between the first shield and the chain pillar rib

b. A semi-permanent "stageloader" curtain located along the off-face side of the stageloader extending for about 36 ft from the inby end of the stageloader past the crusher

c. A sliding "shower-curtain" wing curtain extending from the face rib, over the stageloader, and intersecting with the stageloader curtain.

During the majority of Kaiser's cutting sequence (head-to-tail primary cut with a tail-to-head clean-up pass), the gob curtain was installed and the wing curtain retracted ("bunched up" against the face rib). This allowed the primary airflow to pass around the face corner while being blocked from short-circuiting to the gob. As the shearer approached the headgate cutout during the tail-to-head pass, the headgate operator pulled the wing curtain tight across the stageloader and removed the gob curtain. This effectively blocked nearly all of the intake air from passing over the headgate drum during the cutout and purposely short-circuited a portion of the primary airflow to the gob. The short-circuited airflow reentered the face downstream of the headgate.

During dust monitoring, as the shearer approached the headgate for a cutout, the shearer operator's dust concentration started to increase. When the shearer was at Shield No. 10, the wing curtain was installed and the gob curtain removed. This resulted in a dramatic decrease, approximately 55%, in the dust concentration at the shearer operator's position, as illustrated in the plot of dust concentration versus face location (shield number) shown in figure 25.

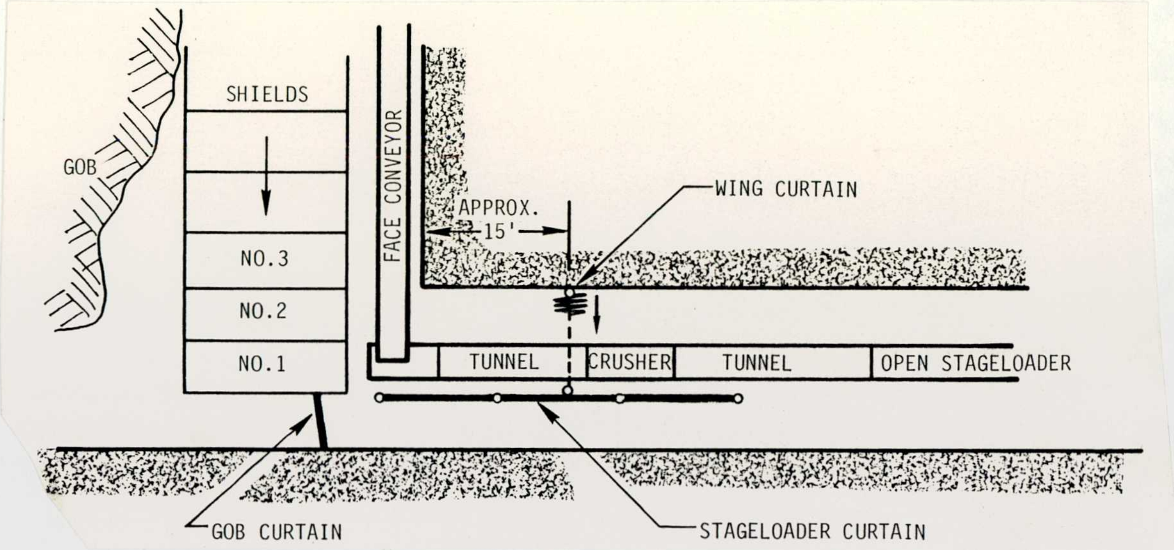


FIGURE 24. - Kaiser's use of a unique wing curtain - gob curtain - stageloader curtain system for headgate cutout dust control.

The preliminary survey at Kaiser showed the potential of their unique curtain system to control headgate airflow patterns and reduce headgate cutout dust concentrations at the shearer operator's position.

### 6.3.2 <u>Field Evaluation at Kaiser Steel</u>

The second field evaluation of the headgate ventilation curtain dust control techniques took place at Kaiser Steel Corporation's York Canyon Mine near Raton, NM from May 7 to 11, 1984. Testing took place on the No. 2 right longwall panel.

The objective of the evaluation was to document a unique and novel headgate curtain arrangement used by Kaiser and to test its effectiveness at redirecting the primary ventilation airstream to provide dust control benefits to the shearer operators.

Originally scheduled for 2 weeks, the evaluation was shortened to 1 week due to operational problems at the mine site. Kaiser was unable to mine coal on the No. 2 right panel which contained the unique wing/gob curtain system to be evaluated. Instead, coal was mined on a

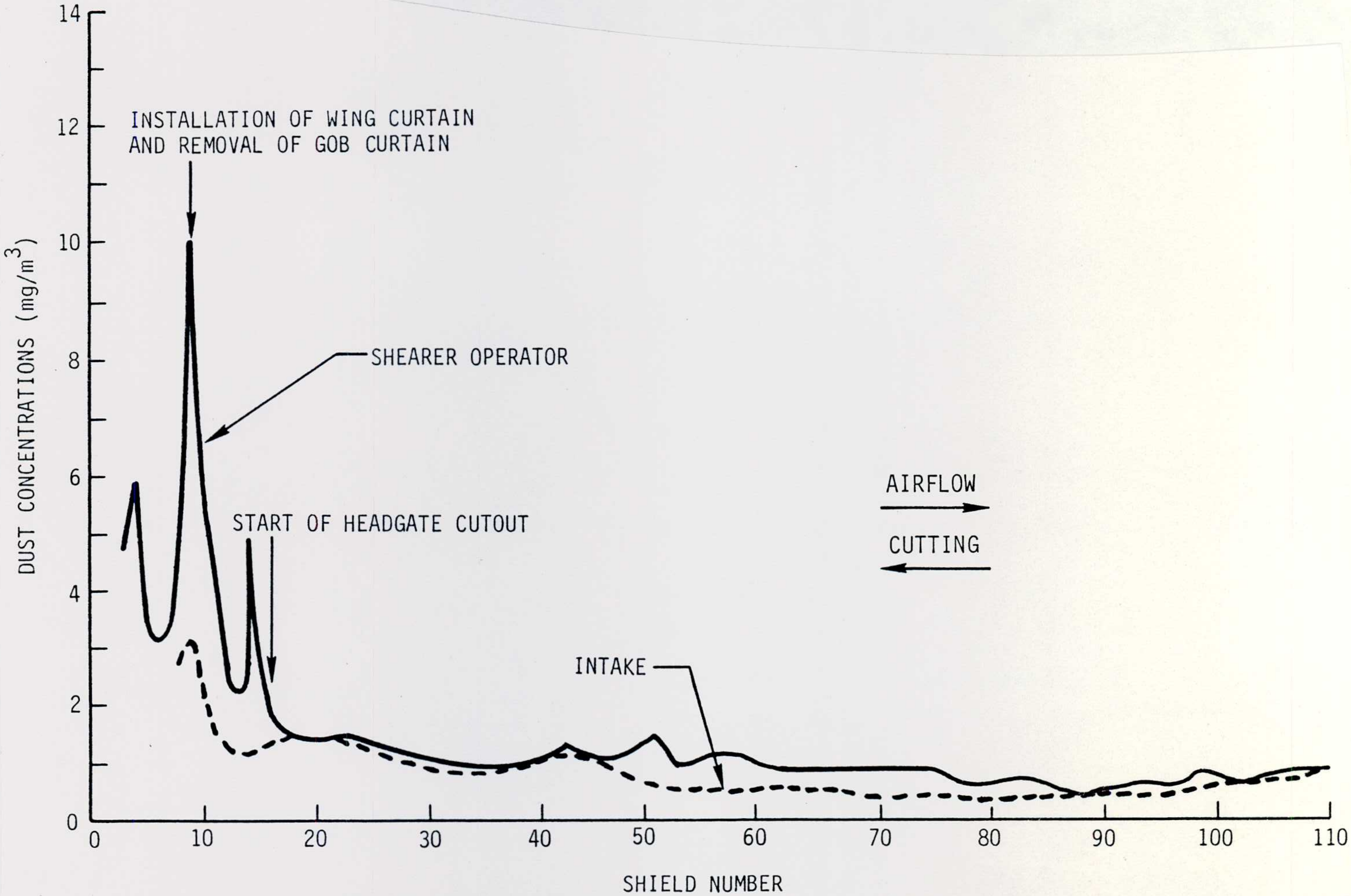


FIGURE 25. - Dust concentration versus shield number; tail-to-head cutting - Kaiser Steel Corporation, York Canyon Mine.

different panel containing no ventilation curtains, and operational problems on that panel precluded requesting mine personnel to install a curtain system.

Consequently, comparative headgate cutout dust data, with and without curtains in use, could not be obtained. Test personnel were, however, able to conduct detailed smoke trace and air velocity surveys on a grid pattern throughout the headgate area of the idle panel which contained the curtain system. The following sections discuss the testing strategies, the results of the evaluation, and a summary of recommendations.

#### 6.3.2.1 Testing Strategies

Kaiser Steel Corporation used a unique combination of the wing curtain/gob curtain ventilation techniques. As shown in figure 24, the system consists of three separate components:

a. A removable gob curtain positioned at the traditional location between the first shield and the chain pillar rib

b. A semipermanent "stageloader" curtain located along the off-face side of the stageloader extending for about 36 ft from the inby end of the stageloader past the crusher

c. A sliding "shower curtain" wing curtain extending from the face rib, over the stageloader, and intersecting with the stageloader curtain.

The test plan focused on four different configurations of the curtain components shown in figure 24.

a. Kaiser's existing procedure during the headgate cutout: wing curtain pulled tight, gob curtain removed

b. Wing curtain tight, gob curtain remaining intact

c. Kaiser's procedure while the shearer is away from the headgate: wing curtain retracted, gob curtain intact

d. Both curtains removed.

The purpose of testing was to investigate the interactive effects of wing and gob curtains on face velocities and airflow volumes. This was accomplished by conducting air velocity surveys on a grid pattern throughout the headgate area and around the curtains. In addition, smoke trace surveys were taken on the same grid pattern to delineate patterns of air movement and confirm flow directions during the air velocity surveys.

A secondary test objective was to study the feasibility of a permanent wing curtain design which advances with headgate equipment.

6.3.2.2 Testing Results

The results of the smoke trace and air velocity surveys are presented in figures 26 through 29 and are summarized in table 3. The values for "average air velocity around the face corner" presented in table 3 represent the average velocity within the dotted line regions delineated in figures 26 through 29. The percentages shown in parentheses indicate the increase (+ values) or decrease (- values) in air velocity compared to the baseline condition of no curtains in use.

Following are highlights of the observations and conclusions drawn from the results:

a. The use of Kaiser's wing curtain significantly reduced the average air velocity around the face corner, particularly when the gob curtain was removed (Kaiser's existing procedure). The velocity reduction will result in a lessened tendency for headgate cutout dust to be blown directly into the walkway, increasing the operator's exposure. Dust will be more effectively channeled around the face corner and downstream past the shearer body. Care should be taken, however, when applying this technique on "gassy" faces. Testing should be conducted to ensure that the reduced air velocities are still adequate to dilute and carry away face methane and that methane-laden air does not recirculate on the downstream side of the wing curtain.

b. The use of gob curtains on longwall faces often affects face airflow levels a considerable distance downstream of the headgate. This "zone of influence" will depend on the extent of gob consolidation (the better the consolidation, the lesser the effect). At Shield 10 on the No. 2 right panel, average air velocities were within 15% of each other over all four of the curtain configurations tested. This indicated that curtain usage had a minimal effect on airflow levels beyond Shield 10 for Kaiser's given condition of gob consolidation (the gob was well consolidated beyond Shield 4).

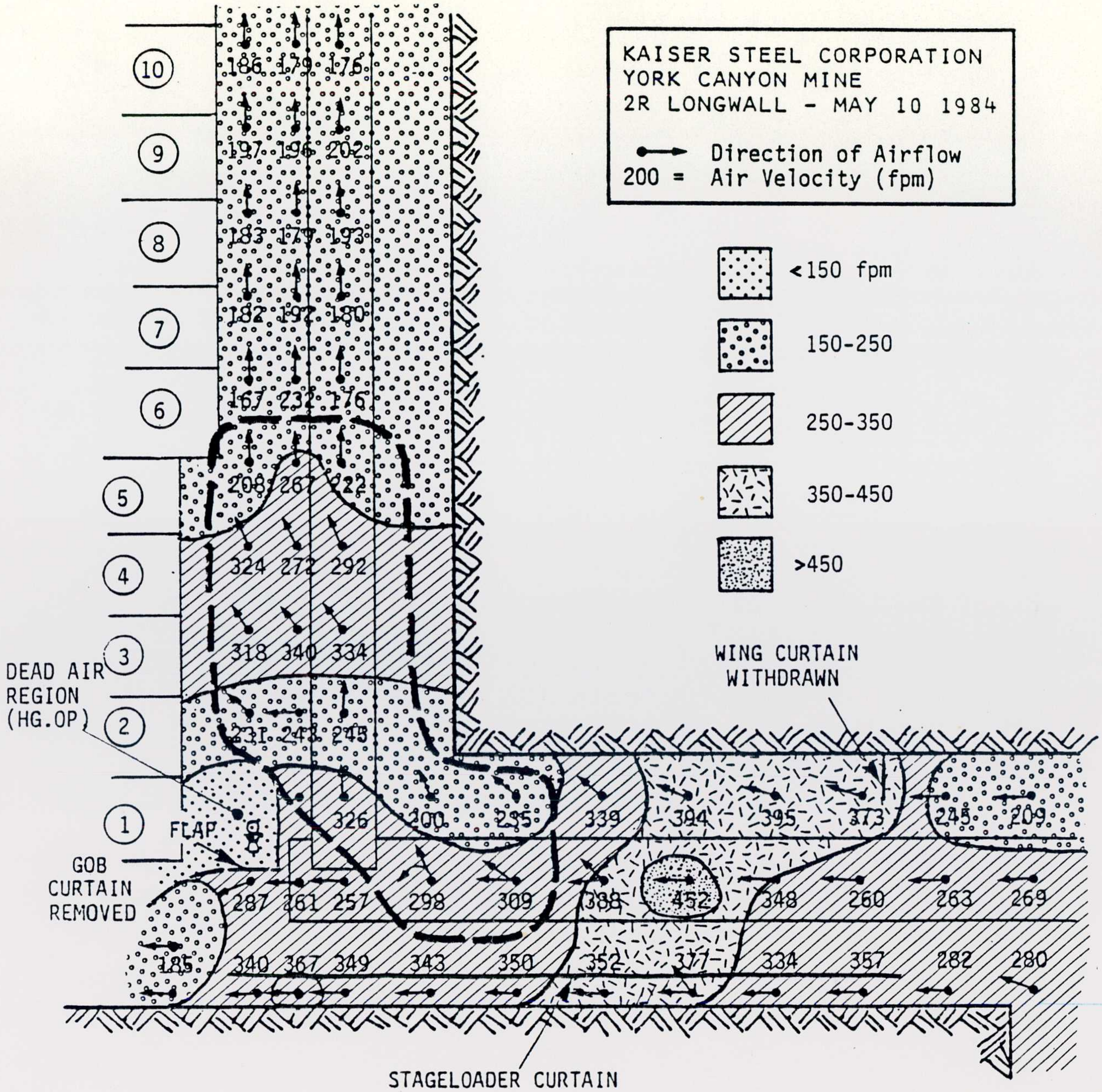


FIGURE 26. - Smoke trace and air velocity survey - wing curtain withdrawn, gob curtain removed.

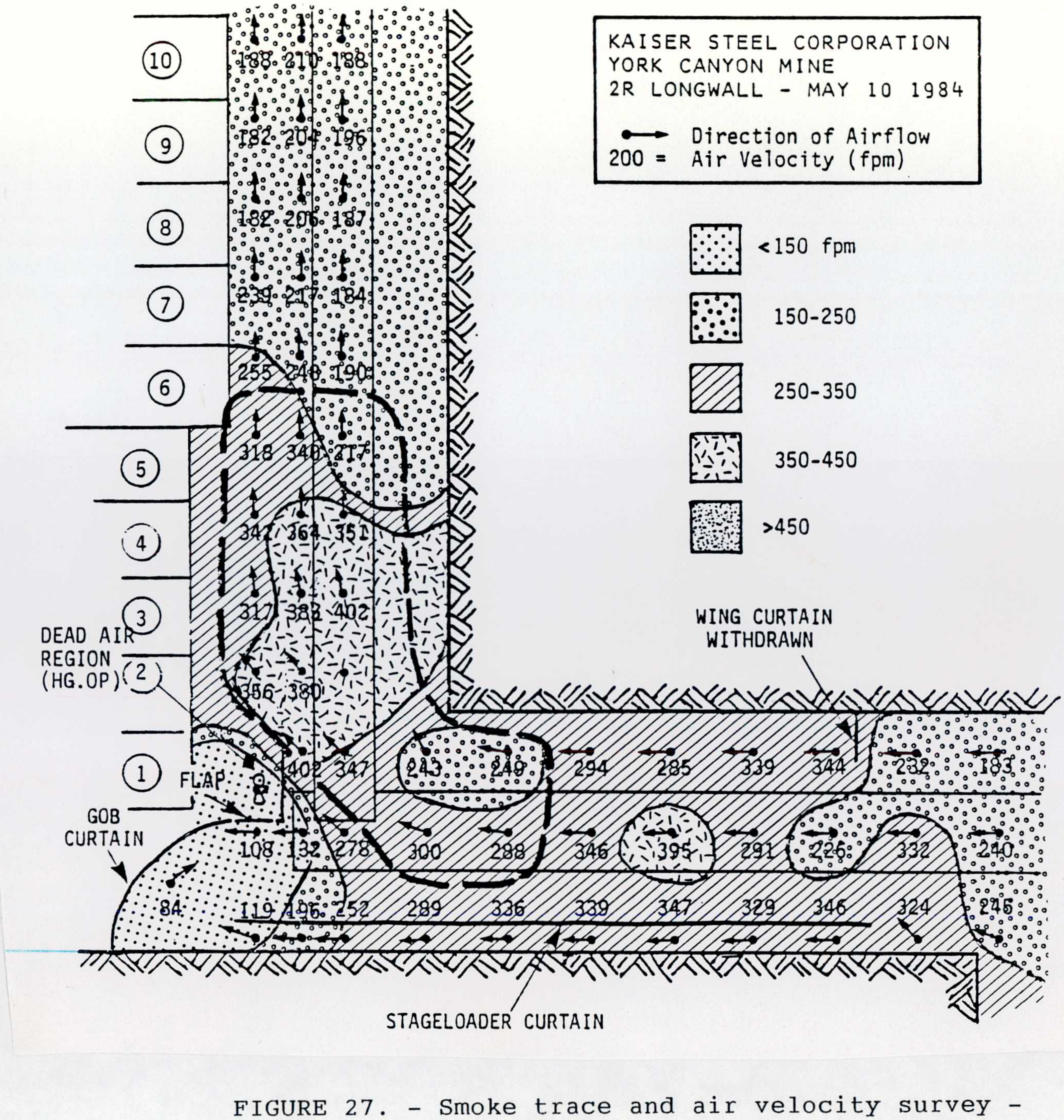


FIGURE 27. - Smoke trace and air velocity survey - wing curtain withdrawn, gob curtain in place.

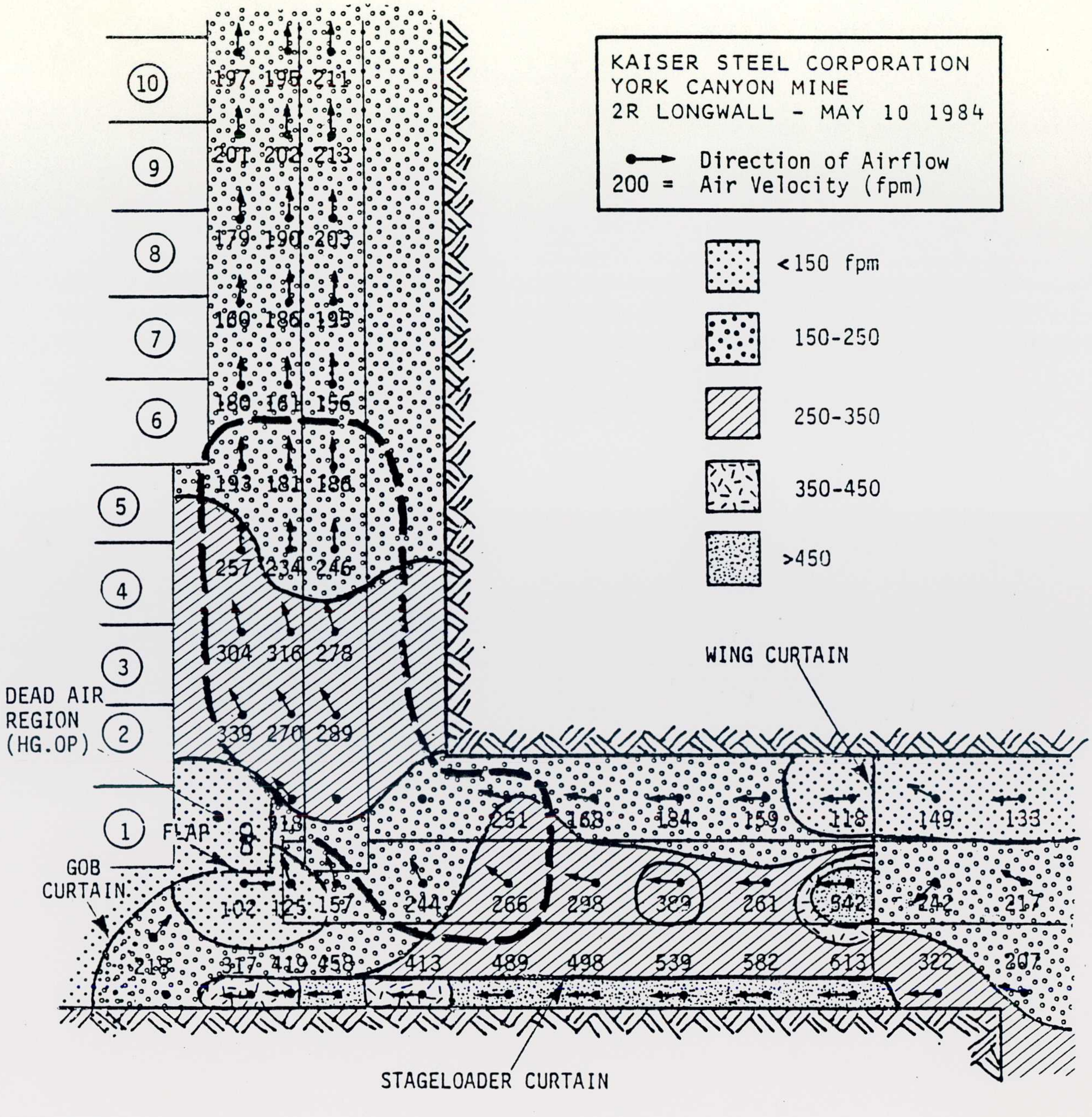


FIGURE 28. - Smoke trace and air velocity survey - wing and gob curtains in place.

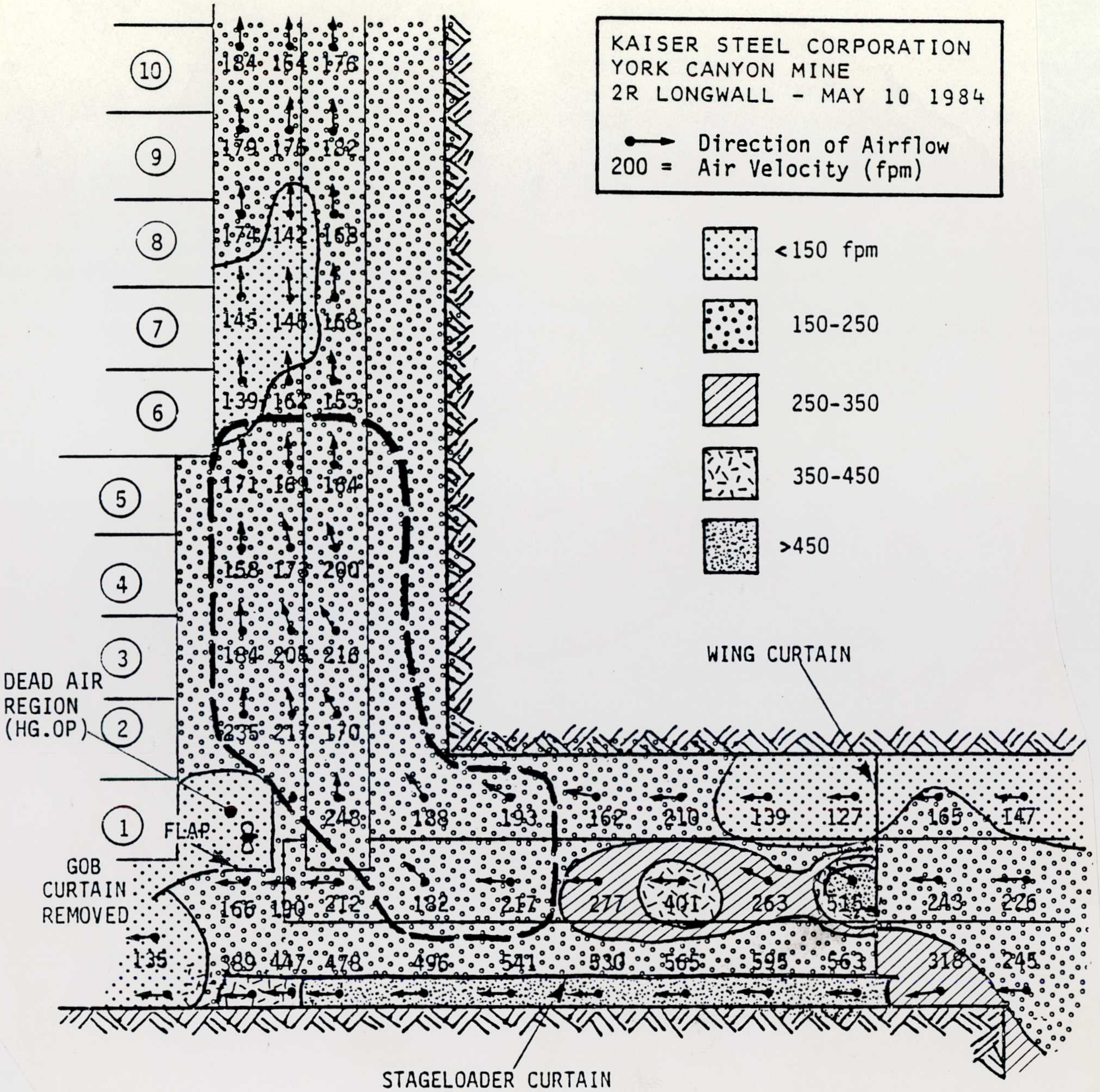


FIGURE 29. - Smoke trace and air velocity survey - wing curtain in place, gob curtain removed.

TABLE 3. - Summary of results - ventilation curtain evaluation

| Condition | No curtains in use (baseline) | Gob curtain in use no wing curtain | Gob and wing curtains in use | Wing curtain in use, but gob curtain removed |
|---|---|---|---|---|
| Air velocity to gob | 185 | 0 | 0 | 135 |
| Avg. velocity around face corner (see dotted region) | 274 | 329 (+20%) | 261 (-15%) | 194 (-29%) |
| Avg. velocity at Shield 10 | 180 | 194 (+8%) | 201 (+12%) | 175 (-3%) |

c. The high air velocity (spot) readings occurring just downstream of the installed wing curtain were due to leakage through gaps in the curtain around the stageloader. The volume of leakage was not significant, but proved to be helpful in sweeping the downstream headgate region clean of contaminants and preventing recirculation. This condition should be monitored, however. High velocity air passing over conveyed coal can entrain dust into the airstream and cause increased intake dust concentrations along the face. If this occurs, an attempt should be made to reduce these leakage velocities.

d. Kaiser's curtain system design has proven to be very rugged, practical, and effective, and would be suitable for use in many coal mines. Used in conjunction with the semipermanent stageloader curtain, the wing curtain can remain in position for nearly 30 to 40 ft of face advance before needing to be repositioned. The stageloader curtain itself could be flexibly mounted to the stageloader for automatic advance with headgate equipment. This would only be feasible if the headgate roof horizon was consistent. Kaiser hangs the curtain independently and repositions it as required.

In addition to the headgate smoke trace and air velocity mapping, an air volume survey was conducted at every tenth shield along the face with the gob curtain in place and the wing curtain retracted (see figure 30). As shown, air volumes were very stable along the entire face, averaging about 22,000 cfm. This indicates the gob curtain's effectiveness in minimizing air loss to the gob along the headgate end of the panel. The shearer was parked near Shield 70. While air velocities will increase around the shearer due to the reduced cross-section, air volumes generally remain stable. The "dip" in readings at Shield 70 in figure 30 was probably due to measurement error caused by the contorted cross section at that location.

#### 6.3.2.3 Summary of Recommendations

The headgate curtain system existing on the No. 2 right panel proved to be very mineworthy, practical, and effective. Kaiser's procedure for using the curtains appeared to be the most effective method of controlling face airflow patterns both during the headgate cutout and while mining the remainder of the face. That procedure is summarized below:

a. During the majority of the cutting sequence, the gob curtain should be installed and the wing curtain should be retracted to allow the primary airflow to pass easily around the face corner while being blocked from shortcircuiting to the gob.

b. As the shearer approaches the headgate cutout, the wing curtain should be pulled tight and the gob curtain should be removed. This will effectively channel most of the intake air away from passing over the shearer's headgate drum.

The effect of gob curtains on face airflow volumes has extended nearly to midface under many of the gob consolidation conditions encountered by FMI on field tests at other mines. The use of the curtains has reduced the loss of face air to the gob and substantially increased the amount of fresh air available to the headgate half of the face. Under the gob consolidation conditions present during the evaluation at York Canyon (tightly packed), the loss of air to the gob beyond Shield 10 was negligible during the headgate cutout portion of the above procedure. However, the effects of the procedure on face airflow levels under less tight consolidation conditions might be investigated in the future.

The curtain system's design is extremely practical and need not be modified. However, to minimize the setup labor required, consideration should be given to a permanent stageloader curtain flexibly mounted to the stageloader.

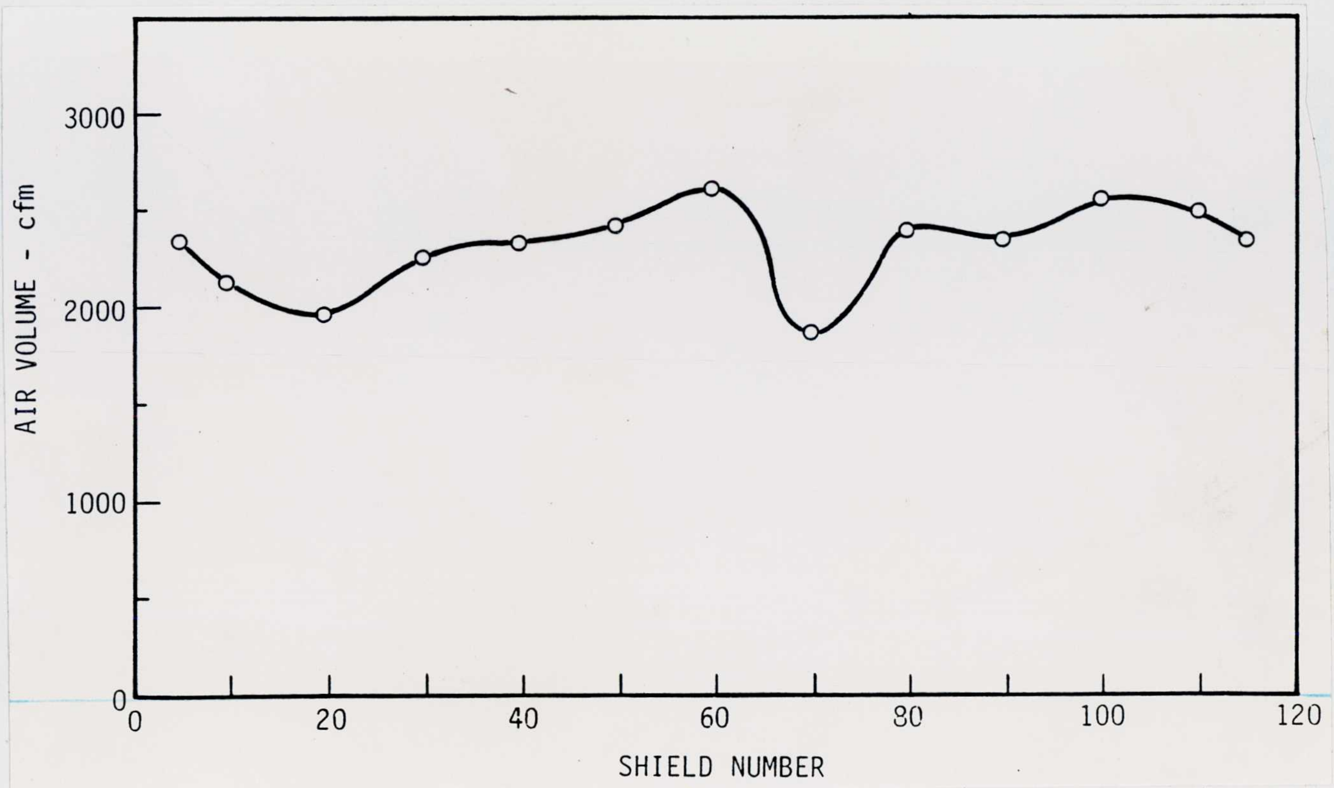


FIGURE 30. - Air volume survey along face - gob curtain in use, wing curtain retracted.