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EVALUATE FUNDAMENTAL APPROACHES TO LONGWALL DUST CONTROL SUBPROGRAM A - PASSIVE BARRIERS/ SPRAY AIR MOVERS FOR DUST CONTROL

Contract J0318097
Foster-Miller, Inc.

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. DEPARTMENT OF THE INTERIOR ★ BUREAU OF MINES ★ SAFETY EFFICIENCY MINERAL INDUSTRIES

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One method to control shearer-generated dust on longwall faces is to confine the dust cloud to the face area and keep it away from face personnel as it travels downstream over the shearer body and beyond. Passive barriers can help this process by partitioning the airflow around the shearer into a clean split and a contaminated split. In addition, water sprays used as air movers (such as the Shearer Clearer developed on another USBM contract) aid the air partitioning process.

A variety of passive barrier designs were developed and evaluated in the laboratory, tested in conjunction with the Shearer Clearer. The results showed that a headgate "splitter arm" to begin the airsplitting process is a vital part of a passive barrier system, whether or not a spray air moving system is also used on the shearer. A simple gob-side passive barrier along the edge of the shearer was also shown to help partition the airflow.

Underground evaluations were conducted on a combination passive barrier/spray air moving system. The results confirmed the importance of the headgate splitter arm and showed that a gob-side barrier was very effective when used on shearers with ineffective external spray systems. The gob-side barrier was unnecessary, however, on shearers equipped with effective external air moving systems such as the Shearer Clearer.

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FOREWORD

This report was prepared by Foster-Miller, Inc. (FMI), 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 A of the contract during the period July 1981 to March 1983. 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 A 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

TABLES--Continued

EXECUTIVE SUMMARY

On most longwall faces, shearer-generated dust from coal cutting provides the largest contribution to the respirable dust exposures of face personnel. Typically, dust concentrations at the shearer operators' locations are highest during tail-to-head cutting (against the direction of airflow), because the upwind headgate drum cuts most of the coal. In addition, the rotation of the headgate drum and its drum sprays tends to push dust generated by the drum a considerable distance upstream against the airflow, forming an upstream "plume." The dust cloud is then captured by the oncoming intake air and pushed out into the walkway over the operators. This phenomenon is illustrated in figure 1.

One method to control shearer-generated dust is through dust avoidance, in which the dust cloud is confined to the face area and kept away from face personnel as it travels downstream over the shearer body and

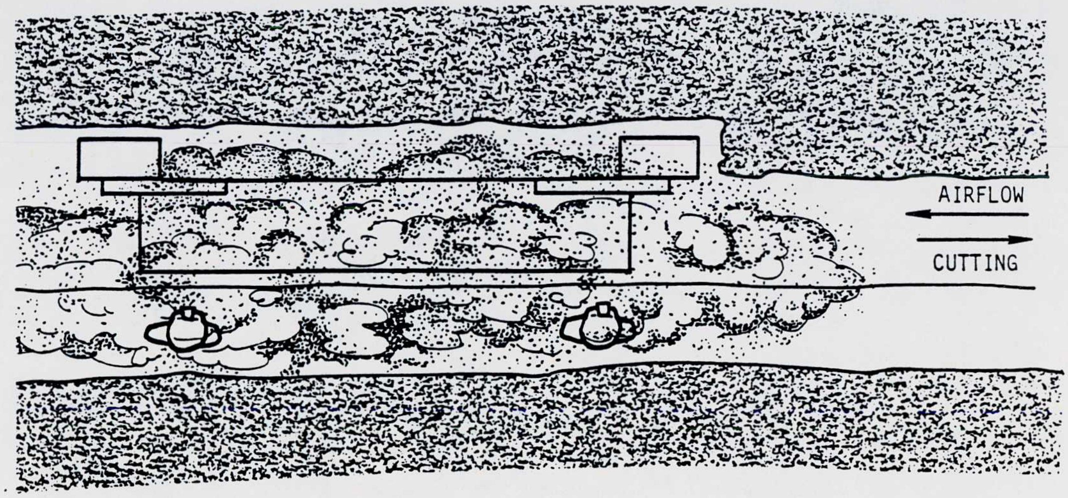


FIGURE 1. - Typical patterns of dust migration to the walkway -- no barriers or external sprays in use except drum and cooling sprays.

beyond. Passive barriers (screens made of conveyor belting) can be used to help enhance the dust avoidance process by partitioning the airflow around the shearer into a clean split and a contaminated split as illustrated in figure 2.

A number of mines have adopted the passive barrier concept to longwall shearers to help control shearer-generated dust. Foster-Miller, Inc. (FMI), under Bureau of Mines Contract No. J0318097, has investigated the dust control effectiveness of barrier systems seen in the field and has designed and evaluated novel new barrier configurations. This report summarizes the laboratory development and field evaluations which comprised this effort and presents the resulting conclusions.

Laboratory Development

Preliminary laboratory development focused on the effectiveness of a variety of barrier system designs to confine contamination to the face area. All testing was conducted in a full-scale longwall test facility. The facility contained a full-size mockup of an Eickhoff 300L

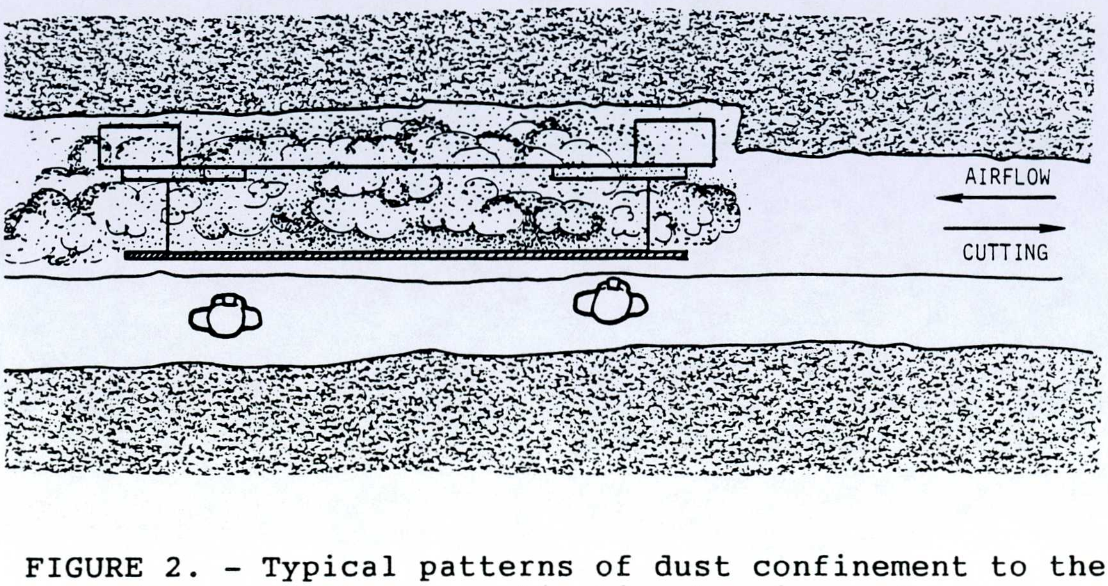


FIGURE 2. - Typical patterns of dust confinement to the face area when a combination barrier and spray airmoving system is in use.

double drum shearer with rotating cutting drums sumped into a simulated coal face. The facility cross section reflected both advanced and retracted shields, a walkway area, a spillplate and face conveyor. Seam height was 7 ft. Actual mining conditions were simulated, including realistic face airflow quantities and either tail-to-head or head-to-tail cutting geometries. Methane tracer gas was released from both cutting drums at controlled rates to represent dust generation. Methane gas concentrations were then measured on a grid pattern throughout the facility (around the shearer, in the walkway and downstream) to determine the patterns of gas movement. Comparisons of grid patterns produced by different passive barrier systems indicated their relative effectiveness in air channeling and "dust" control.

Several barrier designs were studied during the preliminary tests. Some represented systems previously seen in the field, while others represented novel designs developed as testing progressed.

The results of the preliminary testing revealed an important fact: the majority of walkway contamination was introduced at the leading end of the shearer, particularly the headgate end during tail-to-head cutting (against the airflow). When cutting tail-to-head, the upwind dust "plume" created by the action of the headgate drum encountered the constriction of the shearer body. Taking the "path of least resistance," the dust cloud poured out into the walkway at the headgate end of the shearer. To prevent this phenomenon and force the dust cloud up and over the top of the shearer, it proved vital to utilize a headgate splitter arm with passive barriers extending downward into the panline and upward toward the roof support canopies.

An additional result of preliminary testing revealed that the dust cloud, once channeled to the top of the shearer body, tended to remain there as it traveled downstream. Barrier configurations with straight sections parallel to the walkway performed best in maintaining the dust cloud confined to the top of the shearer. A simple, gob-side passive barrier system proved as effective and more practical than the more complex designs evaluated.

Further testing focused only on the straight, gob-side passive barrier design and involved evaluating it in combination with water spray airmoving systems. The water spray systems chosen were variations of the widely adopted Shearer Clearer system developed by the Bureau on another contract. Briefly, the Shearer Clearer consists of several water sprays strategically mounted on the headgate and tailgate splitter arms and along the shearer body.

The sprays are oriented in a manner which helps redirect the airflow around the shearer into clean and contaminated splits.

Testing was conducted on the theory that passive barriers and a spray airmoving system would complement each other and work together harmoniously to create the desired airsplit, particularly under conditions where either technique alone would be less effective.

The combination barrier/Shearer Clearer system resulted in a significant reduction in methane tracer gas levels in the walkway of the test facility and up to 50 ft downstream compared to the baseline condition (which included no barriers or spray air movers; it contained only a headgate splitter arm with a barrier extending into the panline). Barriers alone reduced methane concentrations in the walkway around the shearer by approximately 50% over the baseline condition. The combination barrier/spray system further reduced the concentrations by an additional 90% for a total reduction in methane concentrations in the walkway around the shearer of 95% over the baseline condition.

Underground Evaluation

Following the laboratory development, the combination passive barrier/Shearer Clearer spray system was installed and evaluated over 15 operating shifts in a western mine cutting 10 ft of coal. The purpose of the evaluation was threefold:

a. To compare the new combination system against the mine's existing "conventional" system of drum and cooling water sprays

b. To evaluate the effectiveness of the gob-side passive barrier, as applied to the mine's conventional spray system as well as the Shearer Clearer

c. To directly compare the effectiveness of the Shearer Clearer against that of the conventional spray system.

The testing methodology consisted of alternating the barrier/spray system combinations on a pass-by-pass basis while monitoring dust concentrations. Dust levels were measured each 5 ft of shearer advance at the leading shearer operator's position and at an intake position (approximately 30 ft upstream of the headgate drum). Measurements were taken only as the shearer cut and loaded coal.

Following are highlights of comparisons drawn from the test results.

a. Combination Shearer Clearer/passive barrier system versus conventional spray system (without barriers)

   1. Over all cutting passes, the combination system reduced the levels of shearer-generated dust by 35% when compared to the conventional system (38% for the headgate cutouts).

b. Effects of passive barriers on each spray system

   1. Shearer-generated dust levels increased by 40% when passive barriers were added to the Shearer Clearer system (42% during headgate cutouts)

   2. Shearer-generated dust levels decreased by 27% when passive barriers were added to the conventional system (but showed no significant difference during headgate cutouts)

c. Shearer Clearer spray system versus conventional spray system

   1. In all cases, the Shearer Clearer reduced the levels of shearer-generated dust when compared to the conventional system

   2. The greatest reductions were realized when the passive barriers were removed: 53% reduction versus an 11% reduction with the barriers installed (56% versus 35% during headgate cutouts).

In summary, the conclusions reached during the evaluation were that a passive barrier system is most effective when used with an ineffective spray system containing improperly oriented nozzles which cause dust to boil out into the walkway over the top of the shearer. An effective spray system, using nozzles properly oriented in the direction of the primary airflow, will provide sufficient control of the dust cloud over the shearer body. Such a system will not benefit from a passive barrier on the gob-side edge of the shearer. Very similar results were obtained during a second underground evaluation of passive barriers in a low coal eastern mine.

1. INTRODUCTION

In 1981 the Bureau (USBM) awarded 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 10 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 Control

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.

The report constitutes the Final Technical Report for Subprogram A - "Passive Barriers/Spray Airmovers for Dust Control," summarizing the effort expended and the results obtained.

Companion volumes document the results of the other subprograms.

1.1 BACKGROUND

Longwalling has been the primary technique for underground coal mining in Europe for many years. With the impetus for increased coal production, the trend to high production longwalling has firmly taken root in the United States. Increased levels of coal production on longwalls has brought with it higher levels of dust generation and most United States longwalls have had difficulty complying with federal dust standards.

On most longwall faces, shearer-generated dust from coal cutting provides the largest contribution to the respirable dust exposures of face personnel. Typically, dust concentrations at the shearer operators' locations are highest during tail-to-head cutting (against the direction of airflow), because the upwind headgate drum cuts most of the coal. In addition, the rotation of the headgate drum and its water sprays tend to push dust generated by the drum a considerable distance upstream against the airflow, forming an upstream "plume." The dust cloud is then captured by the oncoming intake air and pushed out into the walkway over the operators. This phenomenon is illustrated in figure 3.

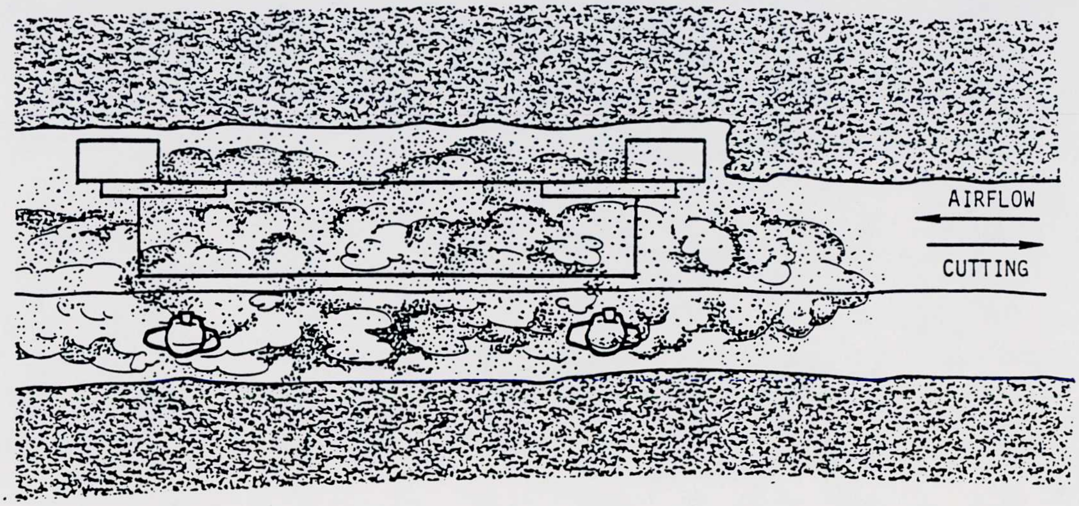


FIGURE 3. - Typical patterns of dust migration to the walkway -- no barriers or external sprays in use except drum and cooling sprays.

One method to control shearer-generated dust is through dust avoidance, in which the dust cloud is confined to the face area and kept away from face personnel as it travels downstream over the shearer body and beyond. Passive barriers (screens made of conveyor belting) can be used to help enhance the dust avoidance process by partitioning the airflow around the shearer into a clean split and a contaminated split as illustrated in figure 4.

Passive barriers have been used for many years to contain dust or to shield mine personnel from exposure to it. Common applications of this concept underground include:

a. Brattice or belting to shroud conveyor belt transfer points

b. Hinged belting flaps at the inlet and outlet to stageloader crushers to confine dust within the crusher area

c. Brattice cloth used for general face ventilation or for spot applications to help control and direct airflow patterns.

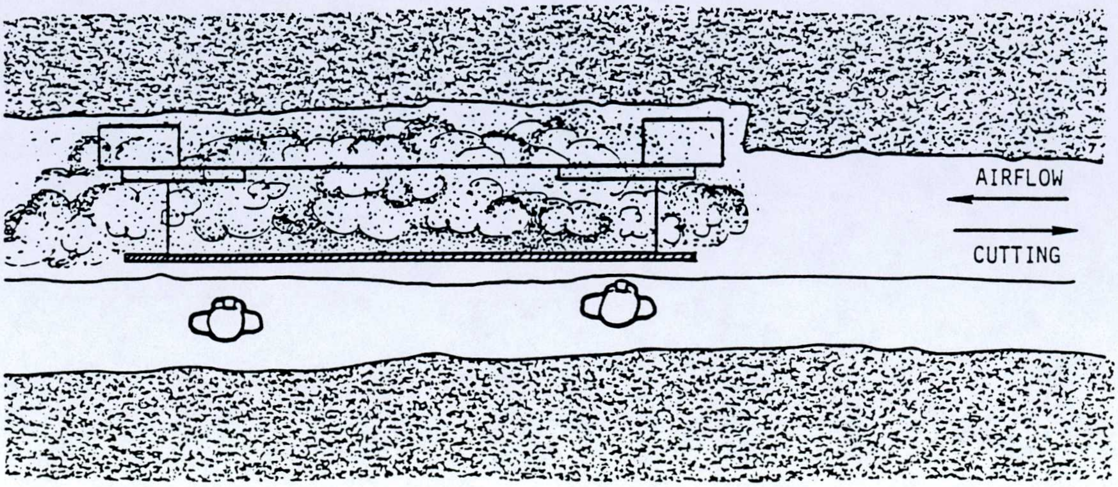


FIGURE 4. - Typical patterns of dust confinement to the face area when a combination barrier and spray airmoving system is in use.

A number of mines have adapted the passive barrier concept to longwall shearers to help control shearer-generated dust.

1.2 SUBPROGRAM OBJECTIVE

The objective of this subprogram was to evaluate the dust control effectiveness of a passive barrier blocking the area between the top of the shearer and the underside of the roof supports. The barrier was tested in combination with a modified "Shearer Clearer" air-moving spray system to screen operators from shearer generated dust.

Details of the laboratory development and testing of passive barriers/spray airmover systems are presented in Section 2. Underground evaluation of the systems are documented in Section 3.

2. DEVELOPMENT AND TESTING OF PASSIVE BARRIERS/ SPRAY AIRMOVER SYSTEMS

A survey of United States longwalls showed that a number of mines had adapted the passive barrier concept to longwall shearers to help control shearer generated dust. The objective of the effort described in this section was to investigate the effectiveness of barrier systems seen in the field and to design and evaluate novel new barrier system configurations.

Details of a telephone survey to locate mines using various barrier and water spray systems, the results of field surveys to three mines using shearer mounted barriers, and the details of the laboratory development and testing effort are presented in the following sections.

2.1 PRELIMINARY INVESTIGATIONS

The objectives of the preliminary investigations were to:

a. Locate mines using various barrier and water spray techniques

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

c. Locate potential sites for future field visits and underground demonstrations.

The investigation was conducted by telephone survey using a questionnaire pertaining to the use of:

a. Barriers on the top of the shearer to block the area between the shearer and the underside of the roof supports

b. Splitter arms extended from one or both ends of the shearer to divide the airflow into a "clean" walkway split and a "dirty" face split

c. Barriers mounted on the splitter arms to aid the development of the splits

d. Barriers used to block the gap in the underframe of the shearer on the walkway side

e. Water sprays used as airmovers mounted on top of the shearer, on the splitter arms, or elsewhere.

The surveys were completed and the results tabulated in January, 1982.

Twenty mines were contacted and 17 participated in the survey with the following results: (see Table 1).

a. Three were using passive barriers on top of the shearer

b. Ten were using splitter arms (and seven of those ten used barriers hanging from the splitters)

c. One blocked the gap in the shearer underframe with a barrier

d. Eleven were using water sprays as airmovers

e. Fifteen were receptive to a field visit.

2.2 FIELD SURVEYS

Three underground field surveys were conducted at the following mines during March 1982:

a. Price River Coal Company, No. 5 Mine, Helper, Utah

b. Kaiser Steel Corporation, York Canyon Mine, Raton, New Mexico

c. Carbon Fuel Company, Morton Mine 34A, Chesapeake, West Virginia.

The objectives of the surveys were:

a. To visit mines using various barrier and water spray techniques

b. To gain detailed information on the use, effectiveness, construction, operating and maintenance problems, and worker response associated with the barrier/spray techniques

c. To assess the suitability of each mine for a demonstration site.

General tasks performed at each of the mines included:

a. An analysis of the shearer water supply system

b. A detailed study of the barrier and water spray configurations in use.

TABLE 1. - Telephone survey results

Company	Passive Barriers on Top of Machine	Splitter Arms	Passive Barriers on Splitter Arms	Block Gap in Underframe	Spray Air Movers
1. Leeco, Inc.		Not willing to discuss			
2. Kaiser Steel Corp, NM	x	x	x		x
3. Kentucky Carbon Corp.		x			x
4. CF&I Steel Corp.		x			x
5. Carbon Fuel Co.	x	x	x		x
6. Southern Ohio Coal Co., OH					x
7. Southern Ohio Coal Co., WV		x	x		x
8. Jones & Laughlin Steel Corp.		x			x
9. Island Creek Coal Co.		Barriers not in use			
10. Snowmass Coal Co.		Barriers not in use			
11. Carbon County Coal Co.		Barriers not in use			
12. Gateway Coal Co.		Not willing to discuss			
13. Clinchfield Coal Co.					
14. Consol - Blacksville Div.		x	x		x
15. Price River Coal Co.	x	x	x		x
16. Kaiser Steel Corp., UT					
17. Quarto Mining Co.		x	x		x
18. Florence Mining Co.		x	x	x	x
19. Western Slope Carbon, Inc.		Barriers not in use			
20. Jim Walters Resources, Inc.		Unable to reach			
Totals	3	10	7	1	11

c. A qualitative study of system effectiveness at controlling airflow patterns around the shearer using smoke tubes and an anemometer during face idle time

d. A quantitative study of system effectiveness at controlling operator exposure to respirable dust using RAM-I dust monitors during mining

e. A study of the shearer operator's interaction and response to the system during mining; particular emphasis was placed on visibility constraints and maintenance problems.

A discussion of the preliminary field surveys is presented in the sections which follow.

2.2.1 Price River Coal Company No. 5 Mine

The Eighth West Longwall Panel was visited on March 1 and 2, 1982. Major findings of the visit included:

a. Water to the shearer was supplied through two lines:

   1. A Roto-Jet pump developing 750 psi at 80-85 gpm provided a low pressure line to the shearer through a 1-1/4 in. diam hose. This line supplied the drum sprays, cooling water sprays and shearer-mounted sprays

   2. A Worthington pump developing 1,100 psi at 35-40 gpm provided a high pressure line to the shearer through a 1/2-in diameter hose. This line supplied the sprays mounted on the headgate splitter arm and on the tailgate coal breaker

b. The configuration of passive barriers and water sprays used on the shearer is shown in figure 5. The results of smoke traces and velocity profiles over the shearer (performed during idle time) showed that the barriers were effective in controlling ventilation patterns. Most smoke released near the upstream drum was confined to the face area with the help of the barriers mounted both on the shearer and on the splitter arm

c. Air volume measurements taken at every tenth shield along the face averaged 37,100 cfm; velocity readings averaged between 460 and 560 fpm

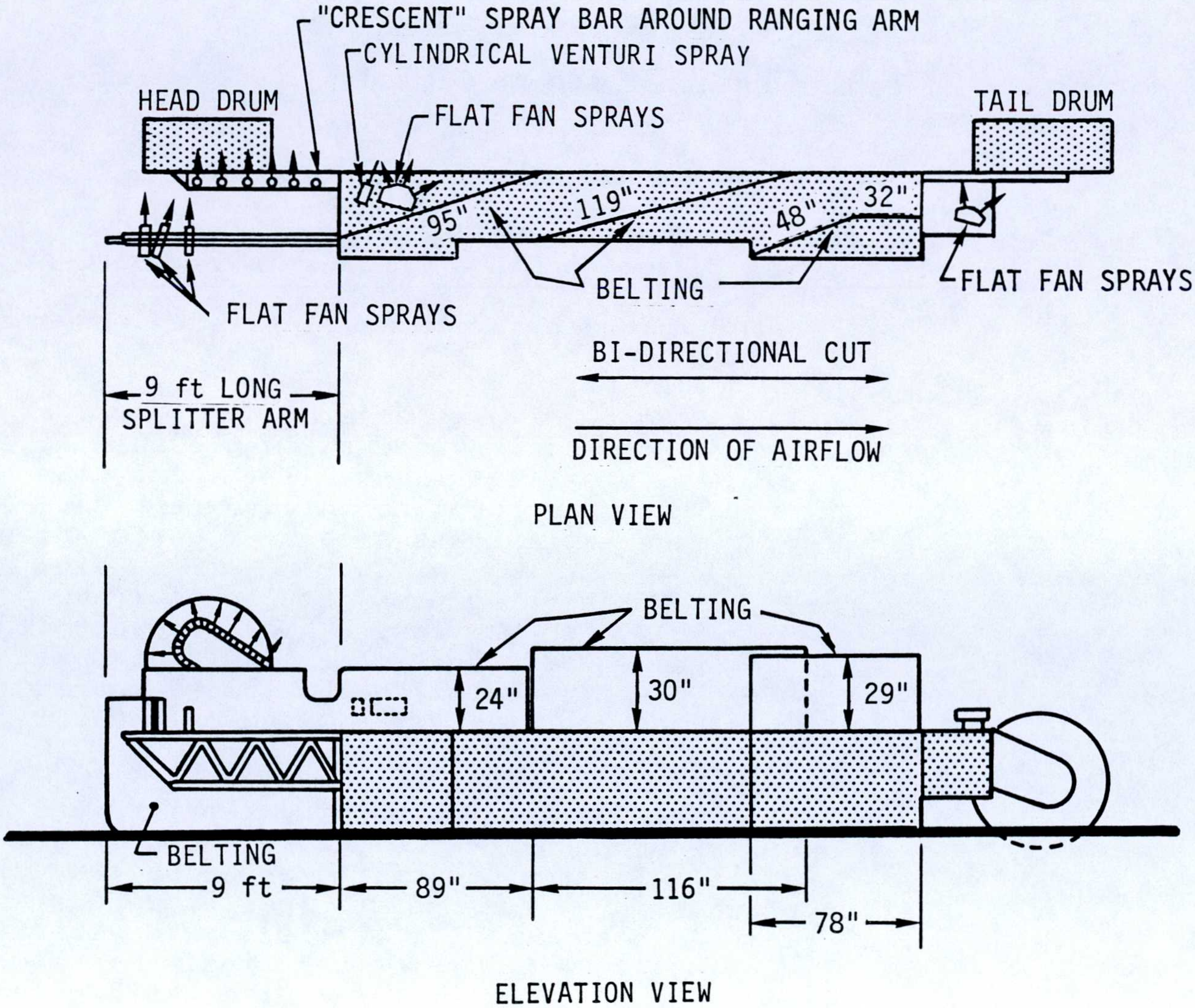


FIGURE 5. - Passive barriers and water sprays in use at Price River Coal Co., No. 5 mine.

d. The shearer operators' response to the barrier and spray system was favorable. They felt that the system did help considerably in controlling shearer-generated dust and were therefore willing to help maintain it. However, maintenance was not a major problem because clearance over the shearer rarely was less than the barrier height (maximum of 30 in.). The operators admitted that visibility was an occasional problem but they could easily compensate by moving their positions.

2.2.2 Kaiser Steel Corporation, York Canyon Mine

The Eighth Left and Ninth Left Longwall Panels were visited on March 4 and 5, 1982. The visit focused on the Eighth Left Panel with the following:

a. Face equipment included an Eickhoff-300 shearer with chain haulage, Hemscheidt shields and an extra-high spillplate (36 in.)

b. Water to the face was supplied by a Kobe Roto-Jet pump (model RGB-100) through a 2-in. supply line. Water pressure to the shearer had been previously measured by Kaiser personnel at 450 psi; dynamic pressure at the spray manifold on the headgate splitter arm was measured at 340 psi by FMI during the visit on March 5

c. The configuration of passive barriers and water sprays used on the shearer is shown in figure 6

d. An air volume traverse taken in the headgate entry inby the main intake crosscut yielded 40,552 cfm available to the face. Air velocity measurements taken upstream of the shearer over the panline averaged 540 fpm

e. The results of smoke traces over the shearer showed that barriers mounted on the shearer body aided in containing smoke to the face area. However, the majority of smoke released upstream

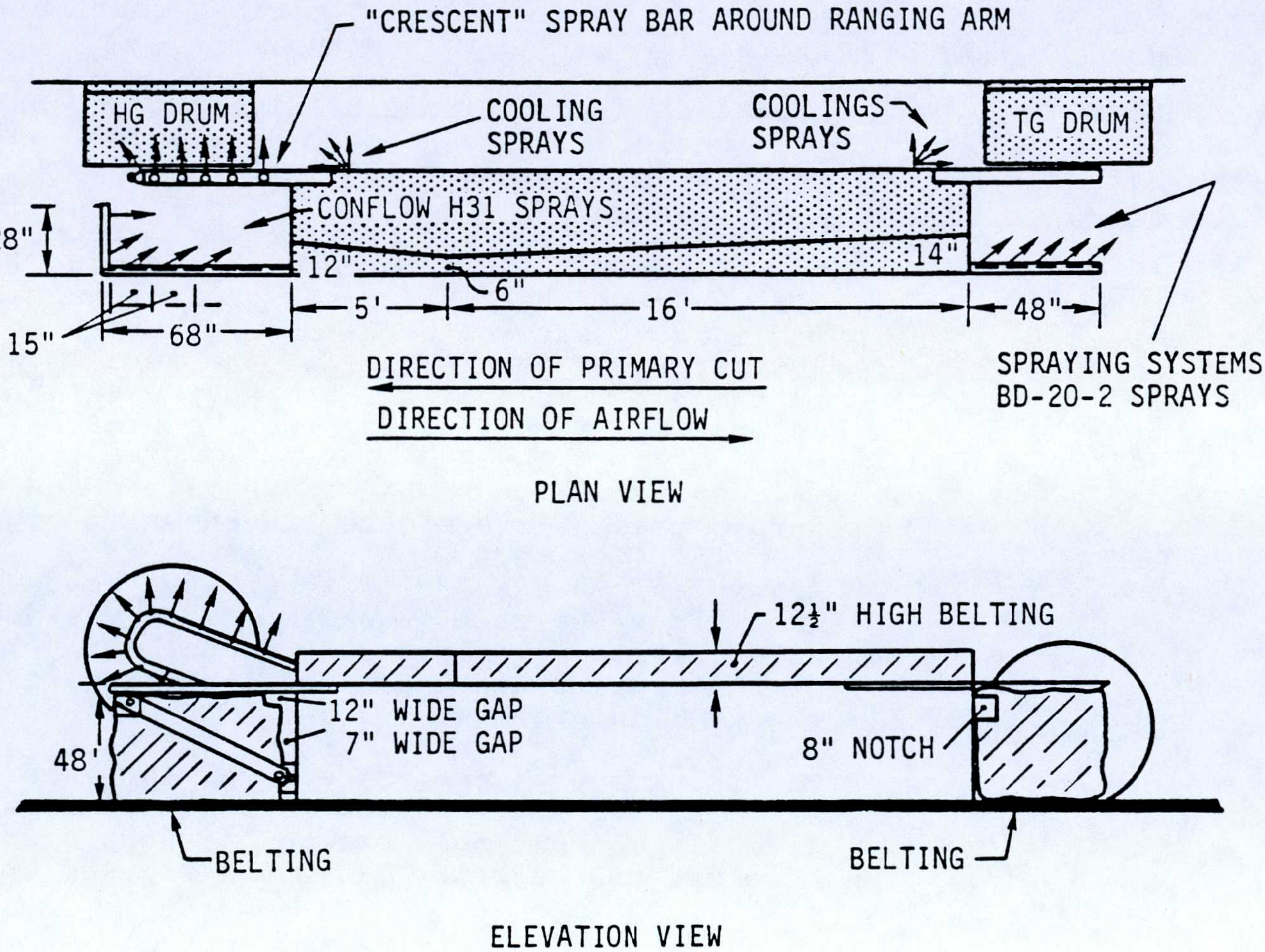


FIGURE 6. - Passive barriers and water sprays in use at Kaiser Steel Corporation, York Canyon Mine, eighth left longwall panel.

of the lead drum passed into the walkway over the top of the splitter arm or between the gap in the belting (hanging from the splitter to the pan-line). Little of the smoke was able to rise to the top of the shearer and into the face area. This effect had been previously observed during laboratory tests when smoke was released upstream of the shearer. The effective addition of barriers in the region of the headgate splitter arm could aid in forcing more contamination into the face area

f. The shearer operators' response to the barrier and spray systems was favorable. They felt that the system did help in controlling dust and maintenance of the system was minimal due to generally adequate headroom. Obstruction to visibility was rarely a problem.

2.2.3 U.S. Steel Corporation (formerly Carbon Fuel Company), Morton Mine 34A, Chesapeake, WV

The 3rd East panel was visited on March 15 and 16, 1982. Mining on this panel had only recently begun - a cave had not yet occurred and face conditions had not stabilized. This made valid dust measurements impossible. On previous panels, Carbon Fuel had used combination splitter arm, barrier and spray systems. However, due to continued maintenance problems in the past, they elected not to use the systems on this panel.

2.3 LABORATORY DEVELOPMENT AND TESTING

Preliminary laboratory development focused on the effectiveness of a variety of barrier system designs to confine contamination to the face area. All testing was conducted in a full-scale longwall test facility. Following the preliminary tests, several barrier configurations were chosen for more detailed development and testing.

The following sections describe the longwall test facility and the development and testing of passive barrier/spray airmover systems.

2.3.1 Longwall Test Facility

Laboratory testing was conducted in a full-scale model of a longwall face originally constructed under Bureau Contract JO387222 and modified under Bureau Contract JO308019. The test facility consists of the following major elements:

a. A simulated longwall face mining 7 ft coal

b. A full-scale model double-ended ranging drum shearer with 63 in. diameter drums

c. A face ventilation system capable of up to 650 ft/min face velocity (30,000 ft^3/min airflow)

d. A water system permitting simulation of cutting zone flushing drum sprays, shearer cooling water sprays, and shearer mounted dust control sprays

e. Tracer gas and smoke to simulate respirable dust.

The gallery permitted testing over a wide range of ventilation rates and operating conditions.

The following sections discuss the gallery design and testing methods in more detail.

2.3.1.1 Gallery Design and Construction

The gallery, which is constructed from lumber and plywood with plexiglass windows, is 175 ft long and simulates a 7-ft high coal face using Kloeckner 352-ton twin-leg shields. The simulated coal face represents typical cutting conditions at the middle of a shearer pass, with the drums fully sumped in modeling the majority of the shearer cutting cycle.

2.3.1.2 Longwall Shearer Model

The model shearer is a double drum Eickhoff EDW-300-L. At the time of gallery construction this was the most popular shearer in United States mines. The mockup includes drums which rotate to simulate the effect of rotation on air and dust behavior. The helical vane cutting drums have a helix angle of 20 deg at the top of the vane. Drum width is 31.5 in. (0.8m), drum diameter is 63 in. (1.6m). Each ranging arm is fitted with a loading cowl of single arm construction with a blade radius of 35.5 in. (900 mm) and an overall thickness of 5 in. For the height of seam simulated, the lead drum (the one in the raised position) takes 70% of the web and the trailing drum the remainder.

The cutting drums were mounted on a 2-in. shaft supported in either end on bearings. The shafts extend through the gallery wall and are belt-driven by an electric motor mounted on the gallery roof. The system was designed to vary drum speed from 30 to 50 rpm. The cutting drums rotate in opposite directions, with the lead drum cutting from roof to floor and the trailing drum floor to roof.

2.3.1.3 Primary Ventilation

The gallery is ventilated by a vaneaxial fan with flow capacity up to 30,000 ft^3/min (14.2 m^3/s). This range of performance gives an achievable face velocity of 620 ft/min (3.15 m/s), well in excess of that generally found on a 7-ft face. Airflow was adjusted with a choke just upstream of the fan. To simulate the shearer cutting both with and against the primary airflow, the ventilating fan was moved from one end of the gallery to the other.

2.3.1.4 Water System

Water is supplied to the shearer through three separate lines. They supply the drum sprays, the cooling water sprays, and the sprays mounted on the shearer body. Each line is fitted with a flowmeter and a pressure gauge. Water is collected from a sump in the gallery and recirculated to a 330-gal (1250-liter) holding tank.

The drum sprays are fed through a rotary union. Twelve sprays are located on the vane of each shearer drum, equispaced on the helix and fed through a high pressure hose. For most of the testing each drum employed twelve 90 deg flat fan spray nozzles which passed 1/2 gal/min each at pressures of 100 psi.

The cooling water and shearer body mounted spray system was designed to facilitate different nozzle configurations. The supply line entered a manifold which accepted a variety of spray nozzles at different angles and positions. The standard Eickhoff spray system consisted of four banks of sprays, two at each end of the machine. Each bank included three 90 deg flat fan nozzles which pass 3/4 gal/min each at 100 psi. This arrangement was duplicated on the mockup shearer. The conventional nozzle banks, located on each gearhead module, are pointed toward the drums and spray over the ranging arm to wet material within the cutting and loading zones. Movable manifolds were used to facilitate the development of novel spray systems.

2.3.1.5 Tracer Gas for Dust Simulation

The gallery is designed to model the dispersion of respirable dust using tracer gas. Natural gas (99% CH_4) was chosen as the tracer gas for the following reasons:

a. It can be piped directly into the gallery in controlled volumes

b. It is easily and rapidly monitored by a number of standard instruments.

The gas was released in the gallery through manifolds designed to simulate the cutting and loading zones at the two drums. Four release manifolds were used including:

a. Lead drum - At the top section of the raised buttock, where the drum is cutting the face

b. Lead drum - At the base of the raised buttock where the coal is loaded off the shelf onto the conveyor

c. Trailing drum - At the buttock where the drum is cutting the coal shelf left by the lead drum

d. Trailing drum ranging arm - At the point where coal is thrown over the ranging arm as it is loaded onto the face conveyor.

The gas release rate at each manifold can be independently controlled. When all four manifolds were operated, to simulate the total dust produced by the shearer, the flows were proportioned between the two drums: 70% being released from the leading drum, and 30% from the trailing drum. These proportions match the ratios of the coal cut by each drum.

2.3.1.6 Smoke Generation

To aid visualization of both the distribution of dust and the primary airflow patterns, a smoke generator was added to the gallery. This consisted of a canister in which smoke bombs could be safely ignited, and valved ducting to inject smoke into the gallery at desired points. Smoke was sometimes liberated from the tracer gas manifolds, making the dispersion of "dust" visible. Alternatively, smoke could be injected into the entering airstream to observe airflow around the shearer body. This technique was frequently used for preliminary evaluation of a barrier system before large numbers of gas samples were taken.

2.3.1.7 Flow Measurements

Airflow through the gallery was determined using turbine anemometer traverses, and confirmed with pitot tube measurements downstream of the fan. Water flows to the sprays and drums were monitored using a spring-loaded variable orifice flowmeter. Total methane flow was measured with a 60-ft^3/min (28 liter/sec) Brooks rotameter. Flow then divided through 30-ft^3/min rotameters to each gas release manifold. Rotameter measurement accuracy is ±5% and repeatable.

2.3.1.8 Tracer Gas Measurements

Tracer gas concentrations were measured at several locations in the gallery using a Horiba gas analyzer. The instrument was calibrated regularly using a standard calibration mixture. Gas sample locations were selected with a valved manifold. The manifold also provided a fresh air sample from outdoors. After each sample, the instrument was flushed with fresh air, giving a zero check. Gas concentration readings fluctuated due to the airflow patterns within the gallery. To minimize the effect of those fluctuations on the data quality, a number of readings were taken and averaged. Sampling points within the gallery normally included the face ventilation duct and the tail and lead drum operators' positions. Additional points were sampled as needed.

2.3.2 Preliminary Laboratory Testing

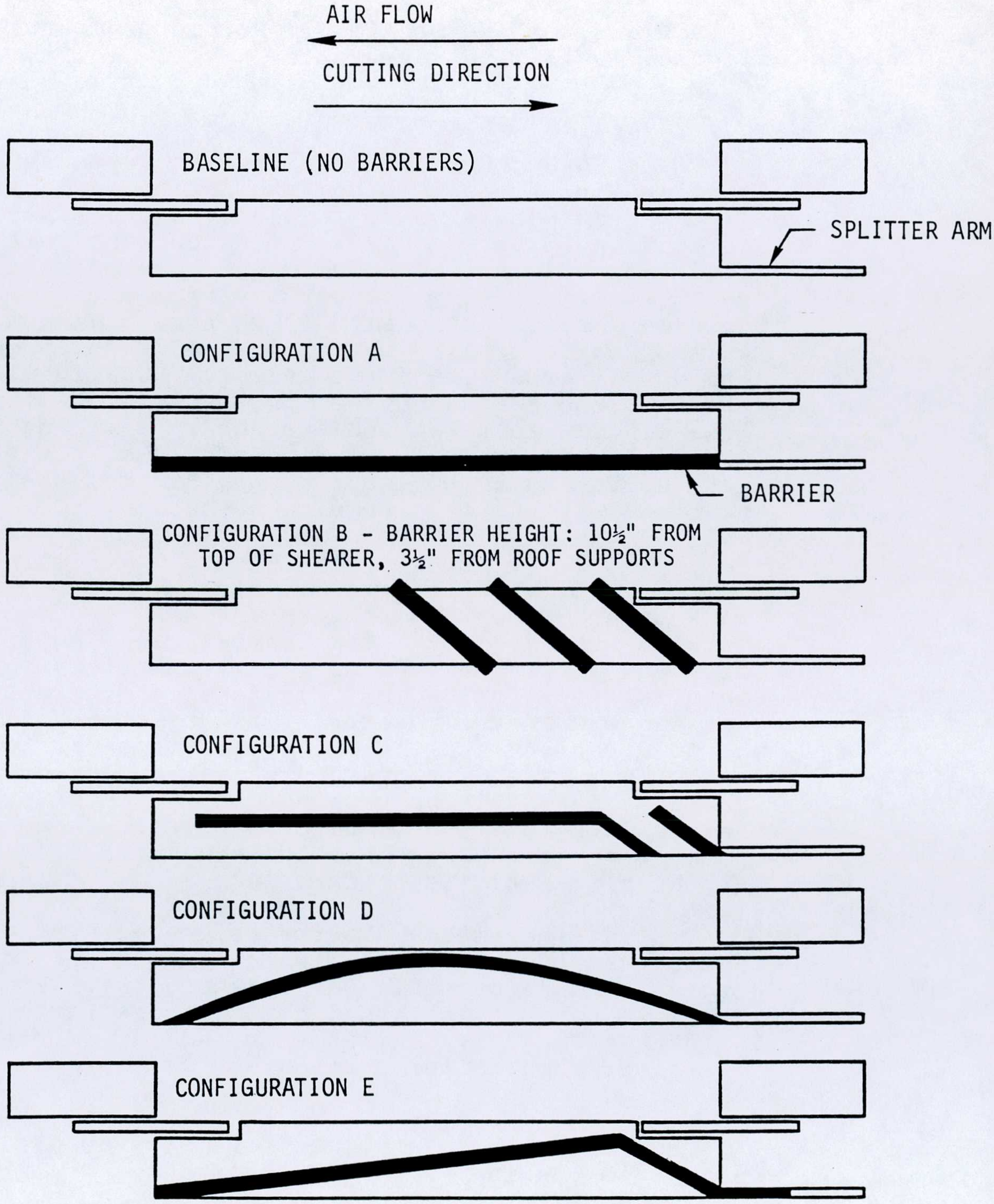
A brief series of laboratory tests were completed during February, 1982. The tests focused on several different configurations of passive barriers mounted on top of the shearer and on a splitter arm extending from the lead end of the shearer. The objective of the testing was to determine the effect that various barrier locations, heights and lengths have on the movement of airflow over the shearer. The testing was completed prior to any field visits in order to better understand and predict air movement patterns which will be encountered on passive barrier systems in use underground.

Testing included smoke traces, velocity profiles and methane gas concentration maps on a total of 20 different barrier configurations. Barrier heights of 7 in., 10-1/2 in. and 14 in. (full height) were tested in a variety of lengths, positions and angles to the face. Several of the barrier configurations tested are shown in figure 7.

The following is a summary of major observations made during the testing:

a. The majority of the walkway contamination is introduced at the lead end of the shearer

b. Contamination in the airstream over the top of the shearer and near the face tends to remain there as it travels downstream, and does not provide a significant contribution to the walkway contamination.



NOTES:
1. CUTTING DIRECTION AND AIRFLOW AS INDICATED ON ALL CONFIGURATIONS.
2. BARRIER HEIGHTS 14½" FROM TOP OF SHEARER, WITH NO GAP BETWEEN BARRIERS AND ROOF SUPPORTS, UNLESS OTHERWISE NOTED.
3. SPLITTER ARM 79" LONG WITH BRATTICE TO PANLINE FOR ALL CONFIGURATIONS.

FIGURE 7. - Barrier configurations.

The above two observations demonstrated the need for effective control of contaminated air immediately upstream of the lead end of the shearer. The majority of the walkway contamination can be eliminated by channeling the air over the top of the shearer to the face area before it enters the walkway. This can be accomplished by the use of a splitter arm with barriers extending down toward the panline and up toward the roof supports, combined with a short barrier angled toward the face located at the lead end, gob side corner of the shearer.

Walkway velocity plots for several of the barrier configurations tested are shown in figure 8. Methane gas concentration plots (showing contamination levels in the walkway) for two barrier configurations are compared with baseline (no barriers) in figure 9. Following are additional observations made during the preliminary test series:

a. Straight barriers at an angle to the airflow caused eddy currents and backward flows. This problem was solved in part by using curved barriers

b. Breaks or gaps between barrier sections (for operator visibility) caused leakage. The extent of leakage was dependent on the barrier configuration in use. Barriers with gaps oriented parallel to the airflow had the least leakage

c. Barriers covering the full height between the shearer and supports performed considerably better than barriers less than full height

d. Velocity profiles around the shearer showed that barrier effectiveness is related to the walkway air velocity. Barrier configurations which caused the greatest reductions in walkway velocities were the most effective. This was confirmed by the smoke and methane gas test results.

2.3.3 Longwall Gallery Extension

The preliminary testing results highlighted the need to develop systems capable of maintaining low contamination levels downstream to protect jacksetters following the shearer. Therefore, a task to study the effectiveness of various shearer dust control techniques on walkway contamination levels downstream of the shearer was added to the laboratory effort. In order to study this effect, the longwall gallery was extended to provide an uninterrupted region of airflow beyond the shearer. The region of retracted shields downstream from the trailing drum was

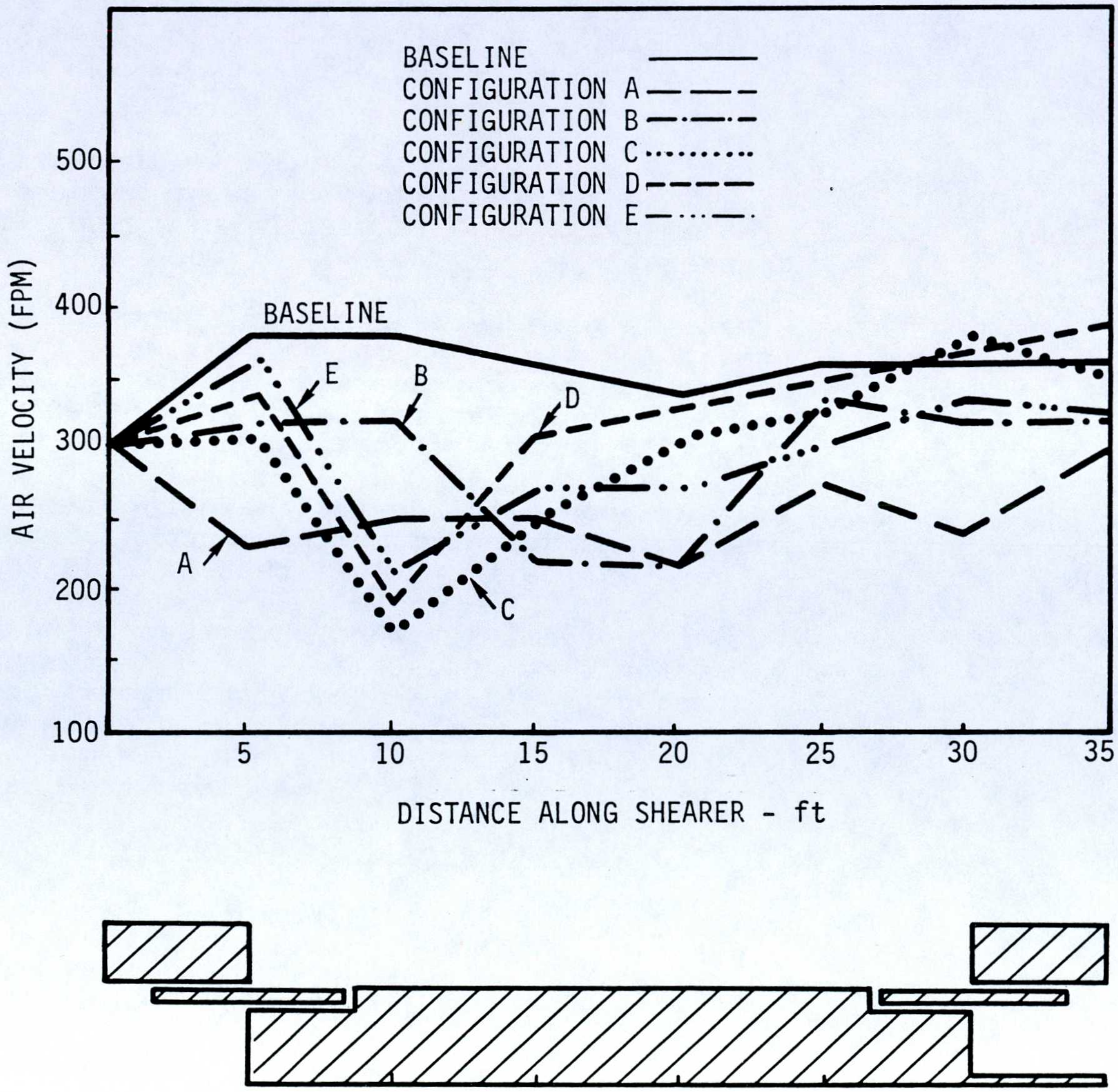


FIGURE 8. - Comparison of walkway air velocities.

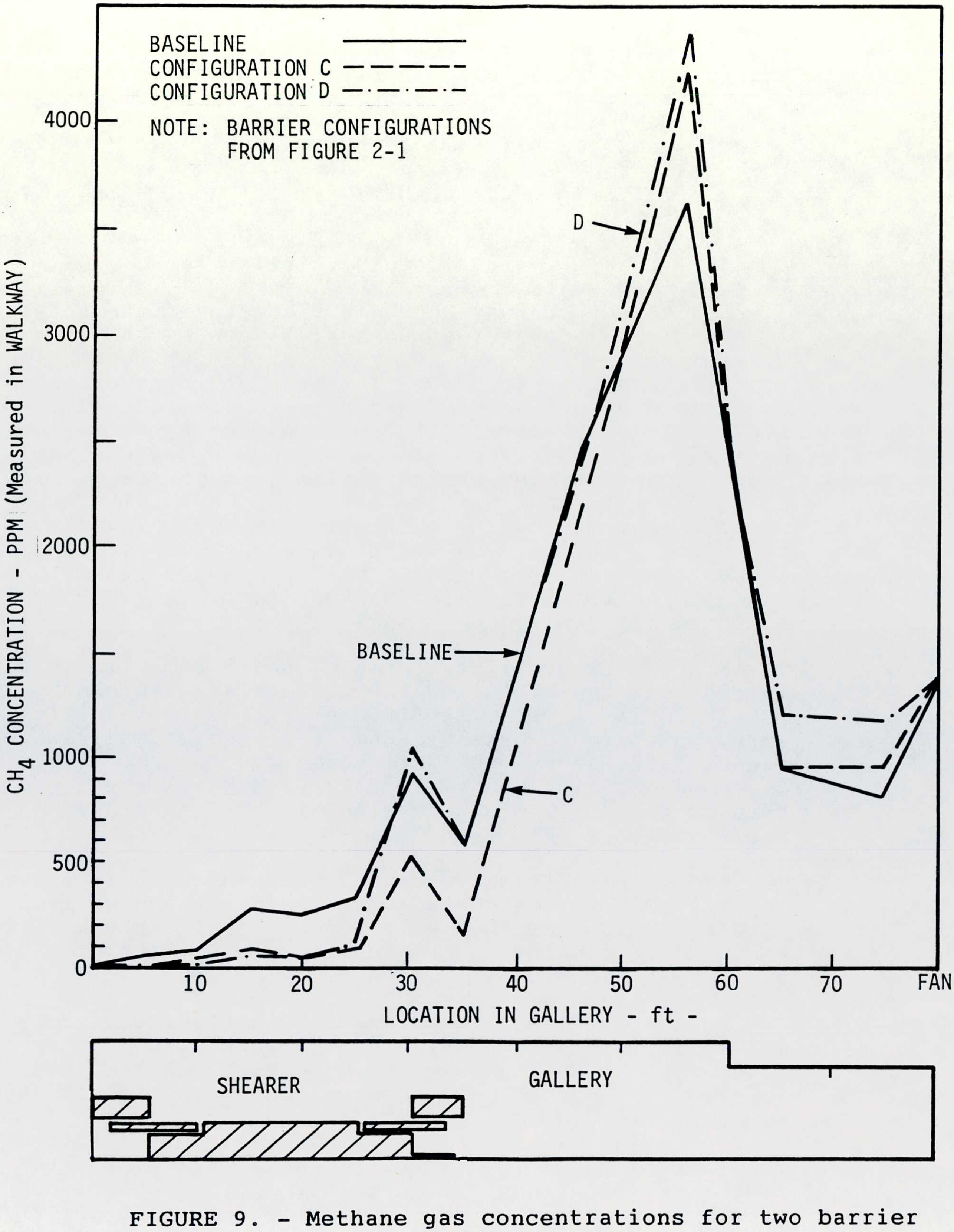


FIGURE 9. - Methane gas concentrations for two barrier configurations.

extended by 50 ft. Methane gas sampling points were installed over a distance 90 ft downstream of the shearer. Two sampling locations beyond the point of shield advance were also installed. Data was gathered over this region for all subsequent spray/barrier testing to provide a data base for the evaluation of system effectiveness downstream of the shearer.

2.3.4 Detailed Development and Testing

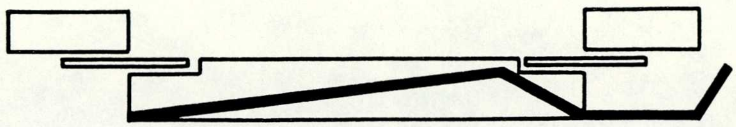
2.3.4.1 Passive Barrier Development - "Dry" Testing against the Airflow

Control of walkway contamination around the shearer with an improved water spray system such as the Shearer Clearer had been proven effective in medium seam heights (7 ft) where the gap between the top of the shearer and the underside of the roof support canopies is relatively small. In these cases, the power of the spray system is sufficient to modify the airflow pattern through the "duct" formed by the shearer and roof supports. In thick seams (<9 ft), however, the airmoving capability of the water sprays may not be sufficient to control and modify the airflow through the larger volume over the shearer. It was surmised that passive barriers could help to maintain an airflow split (walkway/face), especially in thick seams.

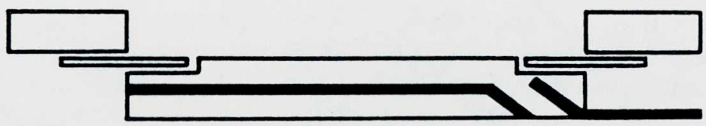
However, the ability to model passive barrier systems in high seams was limited in the 7-ft seam thickness of the longwall gallery. Additionally, the introduction of spray power would make assessment of the effectiveness of the barriers even more difficult. Due to these limitations, a decision was reached to first evaluate the effect that barriers alone can have on airflow pattern modification.

Preliminary testing results had indicated that the majority of walkway contamination was introduced from the leading end of the shearer. Hence, testing began with an emphasis on control of the "upwind plume" without the use of spray airmovers.

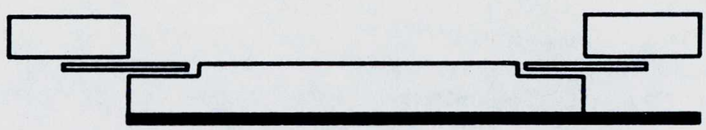
Approximately 12 novel barrier configurations were initially modeled and evaluated. Ineffective and impractical systems were eliminated. Testing efforts then focused on the four most promising configurations, shown in figure 10. Figure 10(a) illustrates a novel configuration based on fluid flow theory. The system provides for a clean air split in the walkway under a higher pressure than the dirty air split in the face area. This causes a steady migration of clean air from walkway to face. The diagrams of figure 10(b, c) are



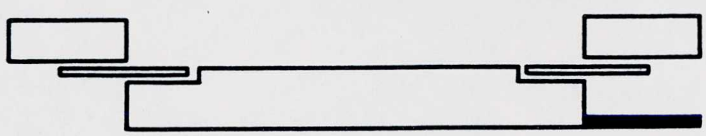
a) NOVEL CONFIGURATION BASED ON FLUID FLOW THEORY



b) MODIFICATION OF ACTUAL SYSTEM OBSERVED UNDERGROUND



c) TRADITIONAL GOB-SIDE BARRIER



d) BASELINE (INCLUDES HEADGATE SPLITTER BUT NO UPWARD BARRIERS)

FIGURE 10. - Passive barrier configurations.

modified and actual configurations observed underground. Figure 10(d) is the baseline system against which the others were evaluated. The barriers on the first three systems extend vertically above the top of the shearer body. The baseline headgate splitter, however, is even with the top plane of the shearer.

Testing techniques consisted of methane gas concentration mapping, smoke traces and velocity profiling. Methane gas concentration plots (showing contamination levels in the walkway) for all four of the configurations tested at full barrier height are shown in figure 11. The results show that barriers alone cannot adequately control the upwind plume at the leading drum. However, their blocking effect results in a significant reduction in walkway contamination levels from the mid-shear position through locations downstream. This dry evaluation concluded that barriers are capable of modifying the airflow over the shearer and effectively partitioning clean and dirty air without the use of sprays.

2.3.4.2 "Wet" Testing against the Airflow

The plan for passive barrier wet testing in the longwall gallery was to combine the passive barrier dry test configurations with an improved Shearer Clearer system. The objectives of the combination system testing were to reduce walkway contamination both around the shearer and downstream of the shearer while reducing the quantity of sprays and water consumption. It was believed that the barrier system could maintain or improve Shearer Clearer performance levels while reducing water usage.

The results of initial wet testing showed the traditional gob-side barrier system to be nearly as effective in controlling walkway contamination levels as the more complex barrier systems. For this reason and because of its greater practicality underground, the gob-side barrier system was combined with the improved Shearer Clearer spray system to produce the complete combination system shown in figure 12. Also for reasons of practicality, a "window" (gap) was opened in the passive barrier system to provide face visibility to the headgate operator. Introduction of the window did not significantly impair overall system effectiveness. Variations of the system shown in figure 12 were selected for the final evaluation series cutting against the airflow. Test variables were chosen to quantify the system's sensitivity to potential changing face conditions and degradation through damage in an underground environment. Test variables included:

a. Number of spray banks operating

b. Number of barrier sections installed

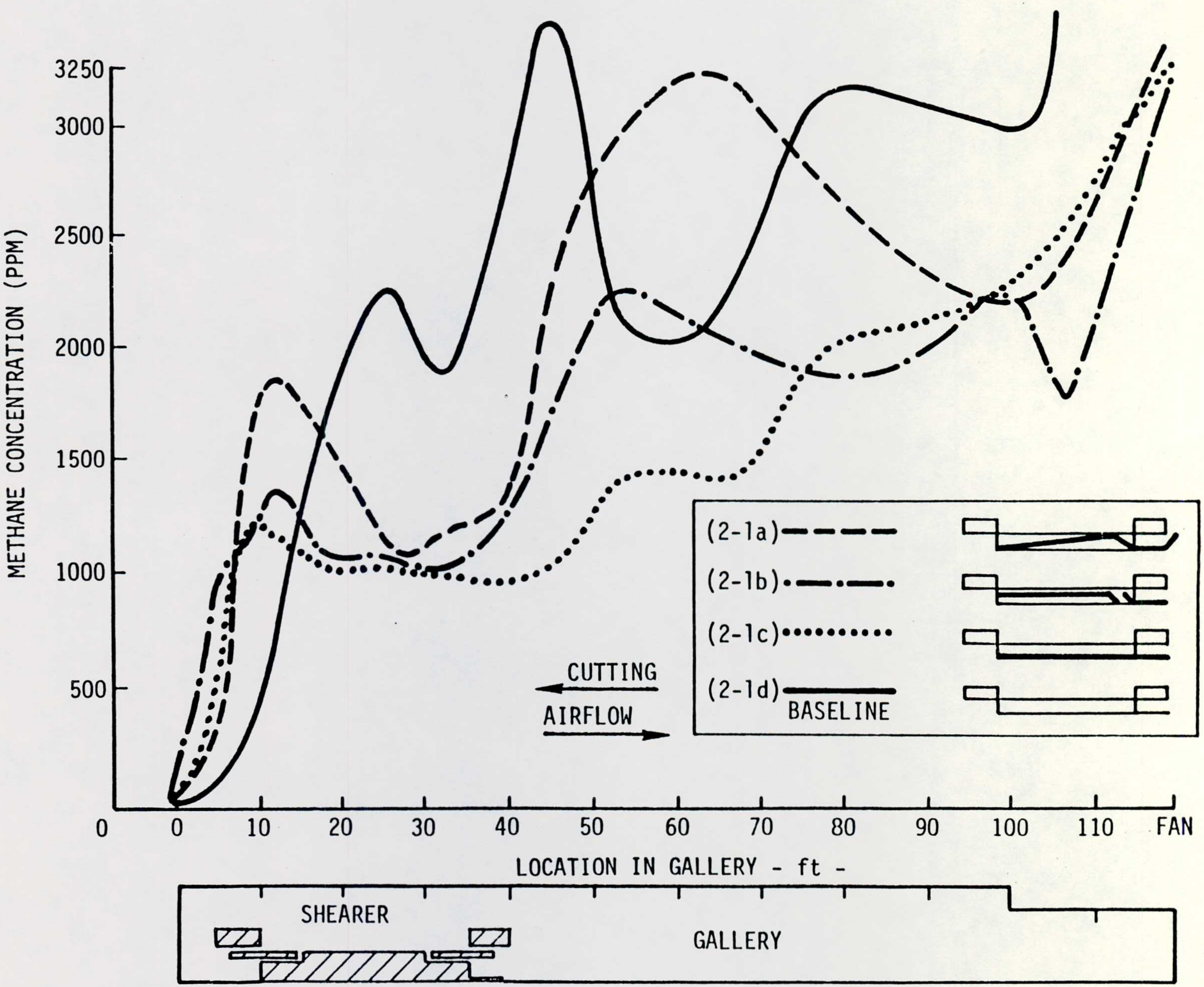


FIGURE 11. - Effectiveness of passive barriers on walkway contamination - cutting against the airflow.

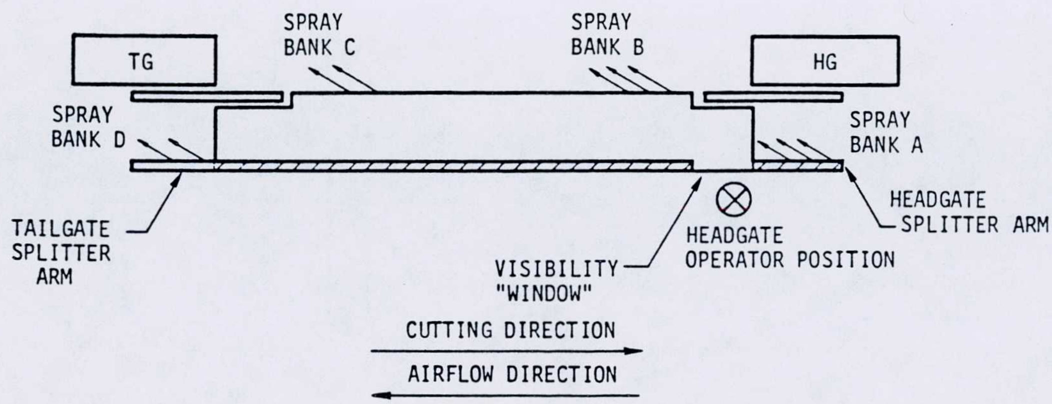


FIGURE 12. - Combination gob-side barrier and improved optimum Shearer Clearer system.

c. Barrier height

d. Spray nozzle size and capacity

e. Airflow velocity.

The most significant results of this final evaluation series are presented in figure 13. It includes comparisons of walkway contamination levels for each of the following systems:

a. 1 Baseline - headgate splitter only

b. 2 Improved Shearer Clearer <u>without</u> gob-side barrier

c. 3 Improved Shearer Clearer with gob-side barrier

d. 4 Modified Shearer Clearer (without spray bank C) with gob-side barrier.

Detailed descriptions quantifying the effectiveness of each combination system follow:

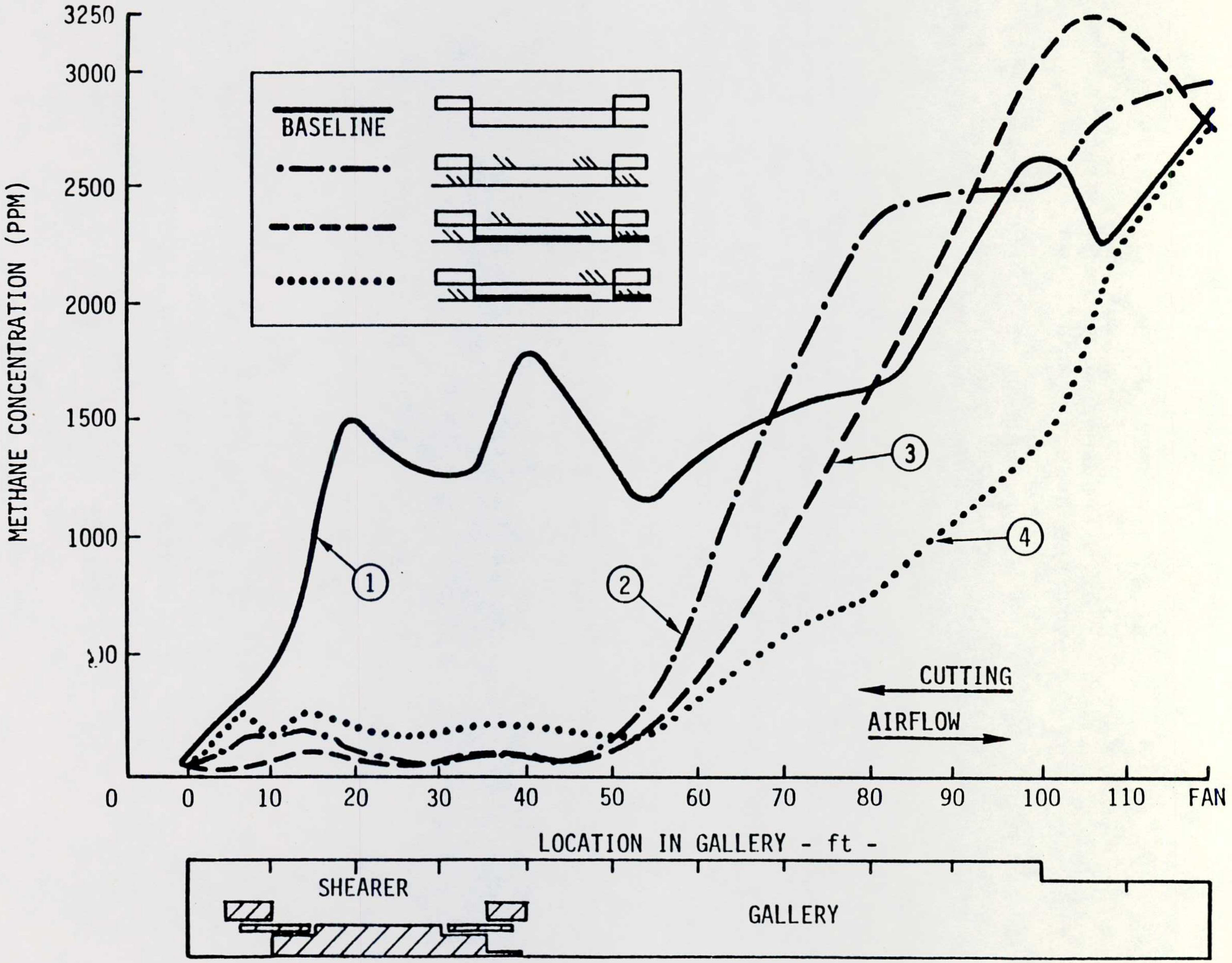


FIGURE 13. - Effectiveness of combination systems versus baseline - cutting against the airflow.

a. Curve 1 - The baseline condition shows how quickly contamination spreads into the walkway downstream of the leading drum without airsplit controls in operation.

b. Curve 2 - The Shearer Clearer system (operating at 150 psi) without barriers produced a significant improvement in contamination levels over the baseline condition:

   1. 74% reduction at the headgate operator's position

   2. 96% reduction at the tailgate operator's position

c. Curve 3 - The combination of passive barriers with the Shearer Clearer system provided further reductions in contamination levels both along the shearer and up to 50 ft downstream; reductions over the baseline condition:

   1. 86% at the headgate operator's position

   2. 96% at the tailgate operator's position

   3. 65% up to 50 ft downstream

d. Curve 4 - The elimination of spray bank C from the complete combination system produced the lowest downstream concentrations but caused an increase over the shearer; reductions over the baseline conditions:

   1. 67% at the headgate operator's position

   2. 86% at the tailgate operator's position

   3. 80% average up to the 50 ft downstream.

Additional tests (not shown in figure 13) were conducted to assess the impact of barrier height, barrier degradation, airflow velocity, and water pressure on system effectiveness. A summary follows:

a. Passive barrier effectiveness increased with increased barrier height

b. Passive barrier effectiveness decreased as portions of the barrier system were removed; elimination of the headgate splitter arm barrier caused the greatest decrease in effectiveness

c. With a full barrier spray system installed, the greater the airflow velocity, the better the overall system performance. The greater the water pressure, the better the system performance over the shearer, but the greater the reduction in downstream effectiveness.

The final series of against-the-airflow tests demonstrated the effectiveness of a combination system of spray airmovers and passive barriers. The "best" final system, providing consistent reductions in contamination levels both over the shearer and downstream of the shearer, consisted of all spray banks A through D operating at 150 psi with the full passive barrier system filling as much of the gap over the shearer as practical (considered to be a 10-3/4 in. height for longwall gallery testing).

2.3.4.3 Evaluation of Combination Systems with the Airflow

Testing with the airflow focused on the determination of key parameters affecting the final combination system. The purpose of the testing was to determine if modifications should be made in the operation of the final system when cutting with the airflow. Key differences exist between the two cutting directions which could impact system effectiveness:

a. The leading drum is upwind of the shearer operators cutting against the airflow and downwind cutting with the airflow

b. The leading drum is shielded from the airflow in the coal sump when cutting against the airflow but it is exposed when cutting with the airflow.

With the downwind drum (and cowl) raised and exposed when cutting with the airflow, it was expected that the system might perform better with certain upwind spray banks (A, B or C) turned off.

Major changes in system design for each of the two cutting directions were avoided due to the impracticality of operating two completely different systems underground. Therefore, the combination system used as the basis for the airflow test series was identical to that previously shown in figure 12.

Several complete test matrices were completed with a variety of spray banks operating, both with and without the passive barriers installed. The most significant results are presented in figure 14, which includes comparisons of walkway contamination levels for each of the following systems:

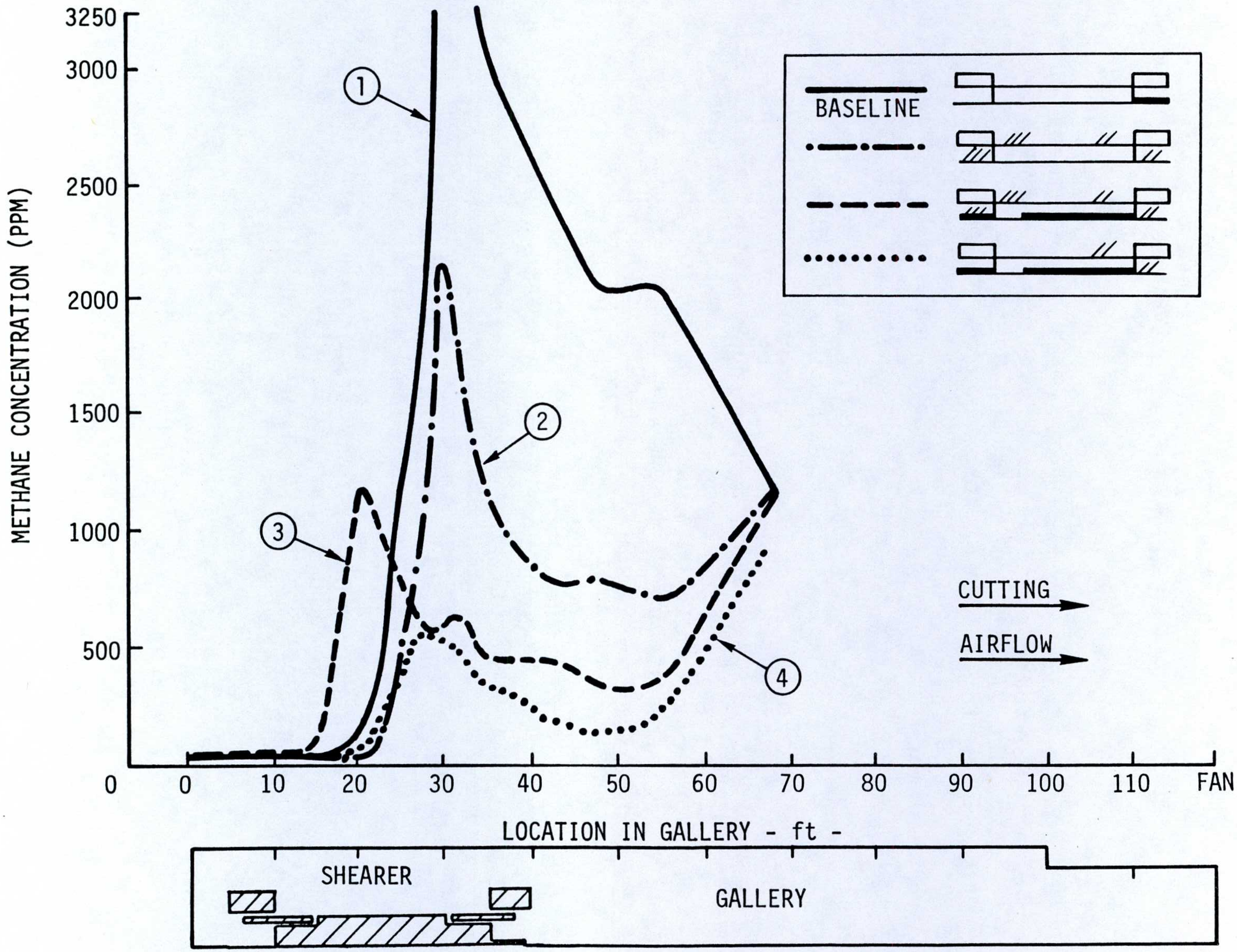


FIGURE 14. - Effectiveness of combination systems versus baseline cutting with the airflow.

a. 1 Baseline - headgate splitter only

b. 2 Improved Shearer Clearer <u>without</u> gob-side barrier

c. 3 Improved Shearer Clearer <u>with</u> gob-side barrier

d. 4 Modified Shearer Clearer (without spray banks A and B) <u>with</u> gob-side barrier.

Following are detailed discussions quantifying the effectiveness of each system:

a. Curve 1 - The baseline condition curve, although following the other curves in trend, indicates substantially higher contamination levels downstream from the mid-shearer

b. Curve 2 - The Shearer Clearer system (operating at 150 psi) <u>without</u> barriers reduced contamination levels at the leading (tailgate) end of the shearer by 64% compared to baseline

c. Curve 3 - The addition of passive barriers to the Shearer Clearer system provided a much greater reduction: 86% at the leading end of the shearer compared to baseline

d. Curve 4 - The elimination of spray banks A and B from the complete combination system produced the lowest walkway contamination levels at the leading end of the shearer, causing reductions of:

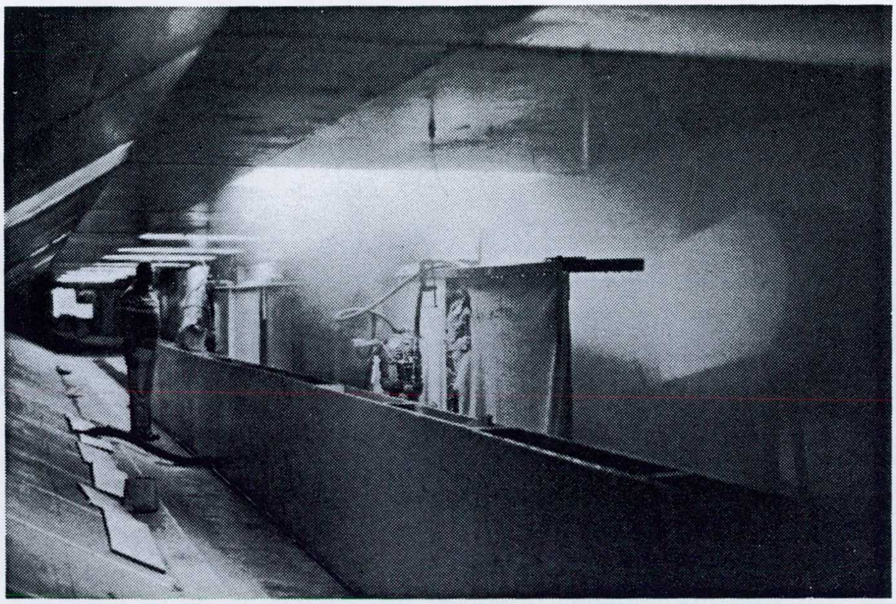
   1. 91% over the baseline condition

   2. 77% over the full Shearer Clearer <u>without</u> barriers

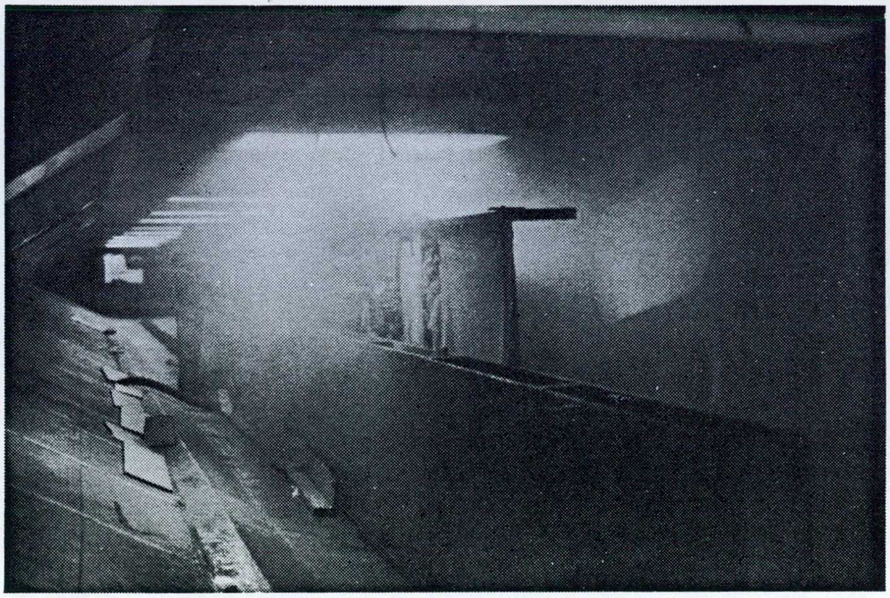
   3. 40% over the full Shearer Clearer <u>with</u> barriers.

A test was also performed using only spray banks C and D <u>without</u> the barrier system installed. The results were virtually identical to those <u>with</u> the barriers installed and indicated that overall system effectiveness is not reduced by barrier degradation.

The final test results revealed that the "best" combination spray and barrier system developed against the airflow was achieved by simply turning off spray banks A and B. Figure 15 contains photographs of smoke traces illustrating the difference in walkway contamination



a) combination spray and barrier system



b) baseline (no sprays or barriers)

FIGURE 15. - Walkway contamination patterns (cutting with the airflow).

patterns with and without the final "best" system operating (spray banks A and B turned off).

This completed the laboratory development under this subprogram. Questions unanswered in the laboratory that remained to be answered in the field evaluation included:

a. Since the laboratory development of the system took place in the longwall gallery with minimal clearance over the top of the shearer, will the effectiveness of barriers increase under high seam conditions in the field?

b. Will the airflow pattern modification by the various spray banks be the same in the field as in the laboratory (that is, will the recommendations for use of various spray banks in different cutting directions need to be changed)?

3. UNDERGROUND EVALUATIONS

3.1 FIELD SURVEYS - MINE SITE SELECTION

Six field surveys were conducted to locate suitable mine sites for the field evaluation of the combination system. Criteria for suitable sites included:

a. A high seam with a large gap between the shearer and the roof supports

b. Sufficient quantities of shearer-generated dust at the shearer operators' positions, particularly during tail-to-head passes.

The sites surveyed are listed below with a brief description of the survey results:

a. Price River Coal Company, No. 5 Mine, Helper, UT Descriptions included in Section 2

b. Kaiser Steel Corporation, York Canyon Mine, Raton, NM Descriptions included in Section 2

c. U.S. Steel Corporation (formerly Carbon Fuel Company), Morton Mine 34A, Chesapeake, WV Descriptions included in Section 2

d. Old Ben Coal Company, Nos. 25 and 27 Mines, Benton, IL The mines were visited on 10-11 May 1982, respectively. Both sites proved to be unsuitable for evaluations due to slow, hard cutting of coal (including an 18-in. rock band), hazardous roof conditions and low levels of dust at the tailgate shearer operator's position during head-to-tail cutting passes

e. Western Slope Carbon, Inc., Hawks Nest Mine, Somerset, CO Hawk's Nest was visited on 13-14 May 1982. The mine was already using a well-designed innovative combination spray and barrier system on a 10-ft coal seam. Despite the adequate headroom and positive attitude toward spray-barrier dust control techniques, the site was unsuitable for an evaluation. Extremely high shield dust levels were recorded in the walkway during the head-to-tail cutting pass and low levels of shearer-generated dust were recorded at the headgate operator's position during the tail-to-head cleanup pass

f. Kaiser Steel Corporation, Sunnyside No. 1 Mine, Sunnyside, UT The 18th Left longwall panel was visited on 17-18 May 1982. The site proved to be excellent for an evaluation for the following reasons:

1. The face height would soon extend to 10 ft with a large gap over the shearer body

2. Mining was half-face bidirectional with high shearer dust levels recorded at the shearer operator's position in both cutting directions

3. Very little dust was contributed by head-to-tail shield movement

4. The opportunity was available to perform a shop installation of the spray/barrier system

5. Management was interested in cooperating on an evaluation.

Upon completion of the six field surveys, two sites were deemed potential evaluation sites: Price River Coal Company's No. 5 Mine and Kaiser Steel Corporation's Sunnyside No. 1 Mine. It was expected that the Price River evaluation would take place first on a new panel, followed by the Kaiser evaluation. However, delays in completion of Price River's existing panel and scheduling conflicts with the evaluation of another dust control technique, resulted in the Kaiser evaluation being performed first.

3.2 FIELD EVALUATION OF COMBINATION SYSTEM

With the cooperation of Kaiser, the 18th Left longwall panel in the Sunnyside No. 1 Mine was selected as the first field evaluation site. During the field survey visit in August 1982, a 6-ft coal seam was mined with a Joy shearer. Kaiser's mine plan included moving a large Eickhoff shearer onto the panel when the coal seam opened up to 10 ft. A decision was made to perform the evaluation with the Eickhoff machine after the increase in seam height. This would allow the opportunity to install the passive barrier/spray system during the above-ground shop rebuild and to evaluate the combination system in a high coal seam.

3.2.1 System Design and Installation

As a direct result of the laboratory development and testing, a final combination system design was created for use in the underground evaluations. The design incorporated the following practical advantages:

a. "Low-profile" sprays at shearer body level, allowing for solid steel block construction

b. "Face side" spray banks of closely grouped sprays, allowing for single, multispray manifold construction

c. Low water consumption (approximately 15 gpm) through a maximum of ten BD-20-3 spray nozzles

d. A simplified, gob-side passive barrier system, allowing for ease of installation and maintenance.

Specific design features are presented below:

a. The headgate splitter arm was spring-loaded and hinged for easy removal and replacement

b. All passive barriers extending upward from the splitter and shearer body were removable for easy replacement when damaged and for purposes of A-B comparison testing during the underground evaluation

c. All sprays were mounted in specially fabricated solid steel manifolds which in turn were located beneath protective steel cover plates

d. For A-B comparison testing, the cooling water circuits were plumbed into diversion valves which routed them to <u>either</u> existing cooling spray manifolds <u>or</u> to new auxiliary cooling spray manifolds (located at the ends of the shearer directed into the panline)

e. As an alternative, some cooling circuits were plumbed to manifolds directed beneath the underframe

f. The spray system was valved to allow the use of various spray airmover and cooling water systems. This flexibility was built into the system to test the presumptions derived from the laboratory testing and to allow a comparative A-B pass-by-pass evaluation.

Figure 16 illustrates the combination system as it was installed on the Eickhoff shearer during the shop rebuild (15-18 November 1982). The general design features were identical to those discussed above.

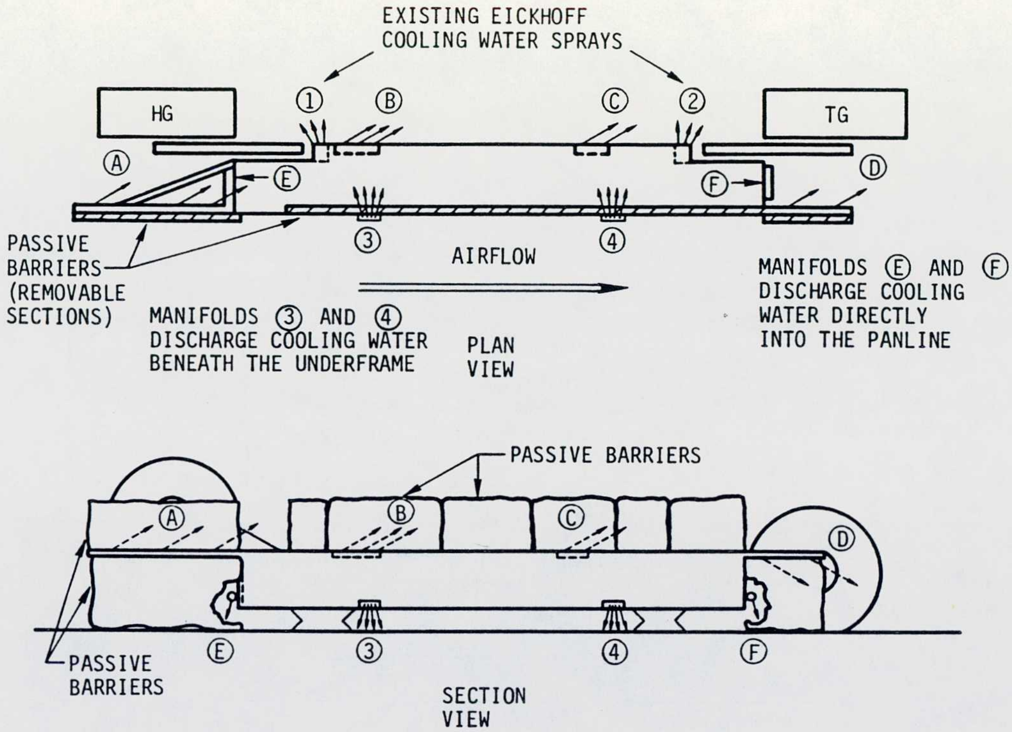


FIGURE 16. - Combination passive barrier/Shearer Clearer system with diverted cooling water.

3.2.2 <u>Water Supply System Survey</u>

While the shop installation was in progress, a water supply system survey was conducted. The purpose of the survey was to <u>predict</u> if adequate flow and pressure would be available to effectively power the water spray system installed on the Eickhoff once in place on the panel. The test apparatus used to perform the survey is shown in figure 17. The purpose of the auxiliary takeoff line was to simulate the <u>additional</u> flow of approximately 15 gpm required by the new spray system installed on the Eickhoff. The results of the test are given in table 2.

The table also includes a prediction of the flows and pressures expected on the Eickhoff. The results of the survey indicated that water flow and pressure sufficient to power the spray system should be available. However, if the pressure and flow turned out to be not sufficient, Kaiser agreed to replace the 700 ft of 1-1/4 in. diam water hose from the headgate to the shearer with 1-1/2 in. diam.

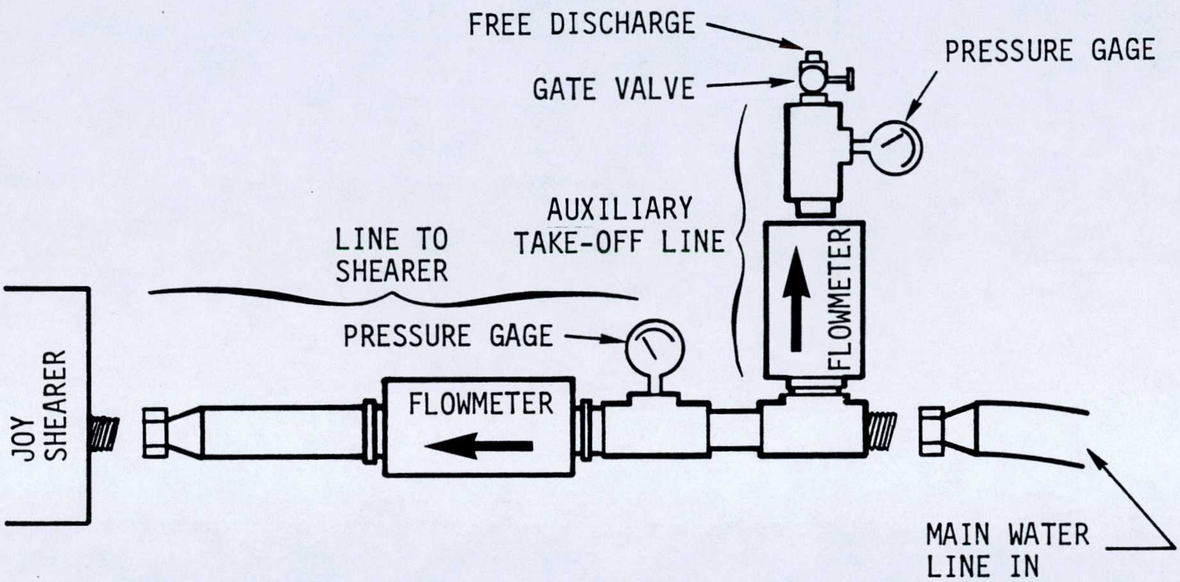


FIGURE 17. - Water supply test apparatus.

TABLE 2. - Results of pressure and flow tests (preliminary survey)

Test	Line to shearer		Auxiliary takeoff		Total flow (gpm)
	Flow (gpm)	Pressure (psi)	Flow (gpm)	Pressure (psi)	
1	45	410	N/A	Shut off	45
2	45	340	15	350	60
Eickhoff prediction	65	180	15	180	80

Due to the inadequate water filtration observed during the survey, a complete filtration system was supplied for use during the evaluation. The system consisted of two sets of hydrocyclones with upstream Y-strainers installed in parallel, capable of filtering 100 gpm.

3.2.3 Evaluation Strategy

The test strategy for the underground evaluation was designed to determine the effectiveness of the new system in controlling shearer-generated dust. This was to be accomplished through comparative A-B pass-by-pass testing with the "new" and "conventional" systems in operation. Table 3 outlines the fundamental A-B comparative tests planned for the evaluation. The comparisons were designed to determine:

a. The effectiveness of the new versus conventional systems both with and without passive barriers

b. The effectiveness of alternative spray systems for each cutting direction

c. The effectiveness of rerouted cooling water sprays.

Testing methodology consisted of:

a. Monitoring instantaneous dust concentrations in the walkway at intake, shearer and floater sampling positions

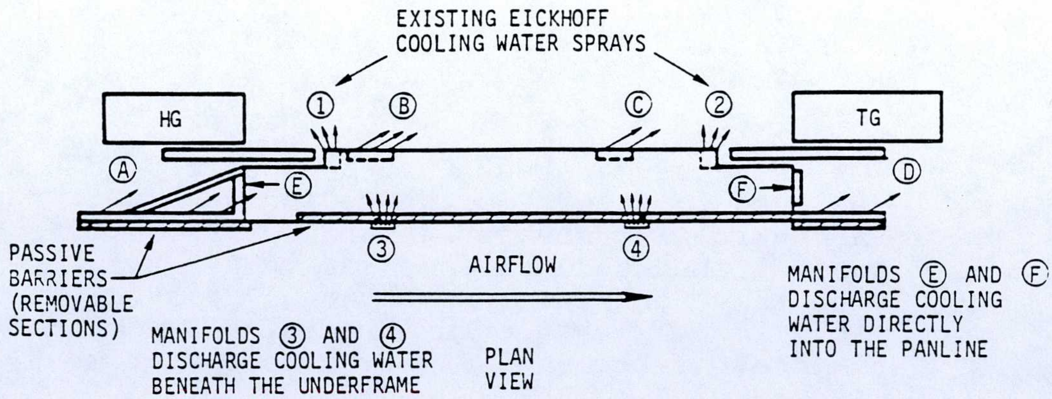
b. Conducting air velocity and air volume surveys in the headgate and at regular intervals along the face

c. Documenting airflow patterns around the shearer using smoke tube and fire extinguisher traces for each system tested

d. Performing daily headgate area surveys to document airflow, dust levels, headgate dimensions, conditions, and extent of gob fall.

All of the data collection activities were performed by two test engineers. An engineering technician provided surface support including instrument calibration and maintenance, and data transcription.

TABLE 3. - Test strategy



	Pass	System	Cutting Direction	
			Head-to-tail	Tail-to-head
Comparison 1	A	Barriers Spray system Cooling sprays	Removed C, D only E, F, 3, 4	Removed A, B, C, D E, F, 3, 4
Comparison 1	B	Barriers Spray system Cooling sprays	Removed Drums only 1, 2, 3, 4	Removed Drums only 1, 2, 3, 4
Comparison 2	A	Barriers Spray system Cooling sprays	Installed C, D, only E, F, 3, 4	Installed A, B, C, D E, F, 3, 4
Comparison 2	B	Barriers Spray system Cooling sprays	Installed Drums only 1, 2, 3, 4	Installed Drums only 1, 2, 3, 4

Note: A = "New" system;
B = Mine's "conventional" system

3.2.4 Evaluation Results

3.2.4.1 Introduction

The 18th Left longwall panel at Sunnyside No. 1 Mine was visited in May 1982 and again in August 1982.

Table 4 provides a synopsis of dust data averages collected during the two preliminary visits. During both of the preliminary visits the face was mining a relatively low seam (about 6-1/2 ft) using a Joy shearer with a fairly shallow cut and high drum rotational speed.

The dust data collected during the evaluation in February 1983 was remarkably different from that discussed above. Very high levels of intake dust due to upstream shield movement (5-10 mg/m^3) were recorded during the evaluation on head-to-tail passes. Low levels were recorded during the preliminary visits. Possible reasons for this difference include:

a. Only one shift per day was mined during the evaluation, allowing the face and roof to dry out longer between production shifts

b. Geological conditions in the roof may have changed since two coal seams merged to produce the higher coal encountered during the evaluation

c. The increased height of the roof supports during the evaluation allowed them to be set against the roof at a much higher pressure.

Very low levels of shearer-generated dust (1-4 mg/m^3) were recorded during the evaluation on tail-to-head passes. High levels were recorded during the preliminary visits. Following are potential reasons for this difference:

TABLE 4. - Results of dust monitoring - May and August, 1982 field surveys

Date	Shearer direction	Average concentrations (mg/m^3)		
		Shearer	Intake	Shearer-generated dust (shearer minus intake)
May 1982	Head-to-tail cut	4.7	1.8	2.9
	Tail-to-head cut	10.3	1.8	8.5
August 1982	Head to tail cut	3.6	0.6	3.0
	Tail-to-head cut	5.8	0.5	5.3

a. The increased seam height encountered during the evaluation caused more pronounced face sloughage on head-to-tail passes which resulted in less coal cutting during tail-to-head passes

b. The Eickhoff shearer used during the evaluation made a deep cut at low drum rotational speed. These conditions are known to reduce dust generation

c. Water flow through the Eickhoff drum sprays may have been greater than that through the Joy shearer drum sprays.

3.2.4.2 Tail-to-Head Cutting Results

During tail-to-head cutting, intake contamination levels remained reasonably constant over all passes, resulting in measurable quantities of shearer-generated dust. Table 5 contains a synopsis of the average dust concentrations for all tail-to-head cutting passes. Following are highlights of comparisons drawn from the data in table 5.

a. Shearer Clearer spray system versus conventional spray system

   1. In all cases, the Shearer Clearer reduced the levels of shearer-generated dust when compared to the conventional system

   2. The greatest reductions were realized when the passive barriers were removed (53% reduction versus an 11% reduction with the barriers installed).

b. Effects of passive barriers on each spray system

   1. Shearer-generated dust levels increased by 40% when passive barriers were added to the Shearer Clearer system

   2. Shearer-generated dust levels decreased by 27% when passive barriers were added to the conventional system.

Dust concentration plots comparing the Shearer Clearer against conventional systems are shown in figures 18 and 19. Both sets of plots are of tail-to-head passes completed on the same day during the first week of testing. Intake concentrations were similar for both passes, averaging about 0.60 mg/m^3.

TABLE 5. - Dust concentrations for conventional versus Shearer Clearer system with and without passive barriers during tail-to-head cutting passes

Average Dust Concentrations (mg/m^3)								
Sampling Period	Passive Barriers	Shearer Clearer System			Conventional System			Shearer-Generated Percent Reduction Shearer Clearer Versus Conventional
		Shearer	Intake	Shearer-Generated (Shearer Less Intake)	Shearer	Intake	Shearer-Generated (Shearer Less Intake)	
Week 1	Removed	1.19	0.84	0.35	1.82	0.90	0.92	62
Week 2	Installed	1.18	0.43	0.75	1.35	0.55	0.80	6
Week 3 (day 1)	Installed	3.06	2.37	0.69	2.40	1.47	0.93	26
Week 3 (days 2 and 3)	Removed	2.64	1.73	0.91	3.52	1.96	1.56	42
All passes	Installed	1.55	0.81	0.74	1.56	0.73	0.83	11
All passes	Removed	1.67	1.14	0.53	2.38	1.25	1.13	53

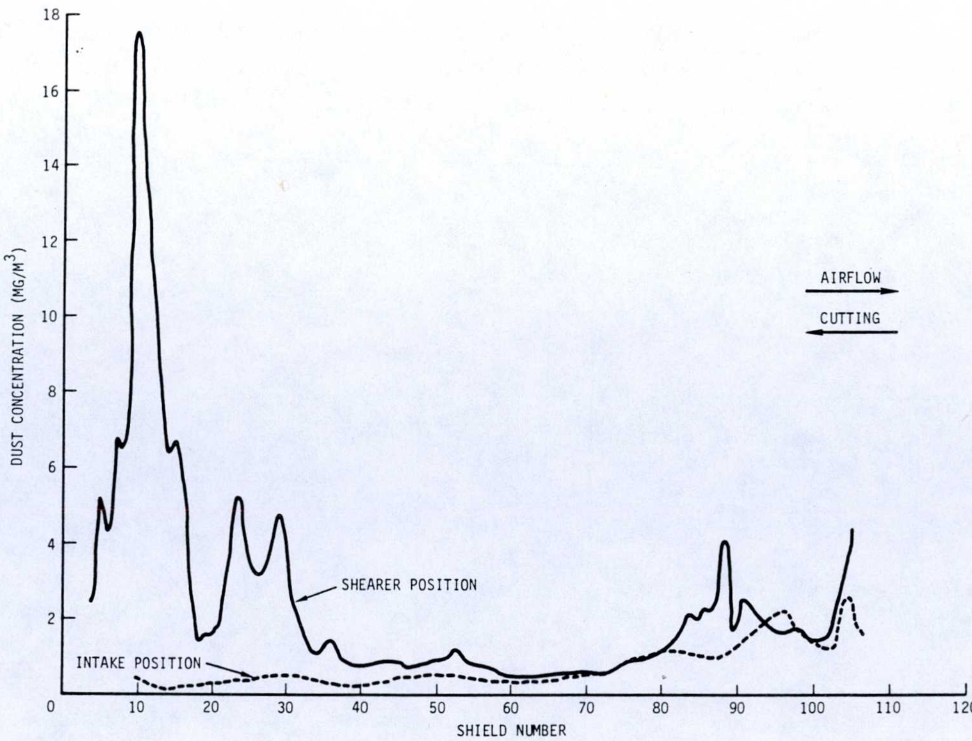


FIGURE 18. - Respirable dust concentration versus face location. Tail-to-head pass; Shearer Clearer system; without passive barriers.

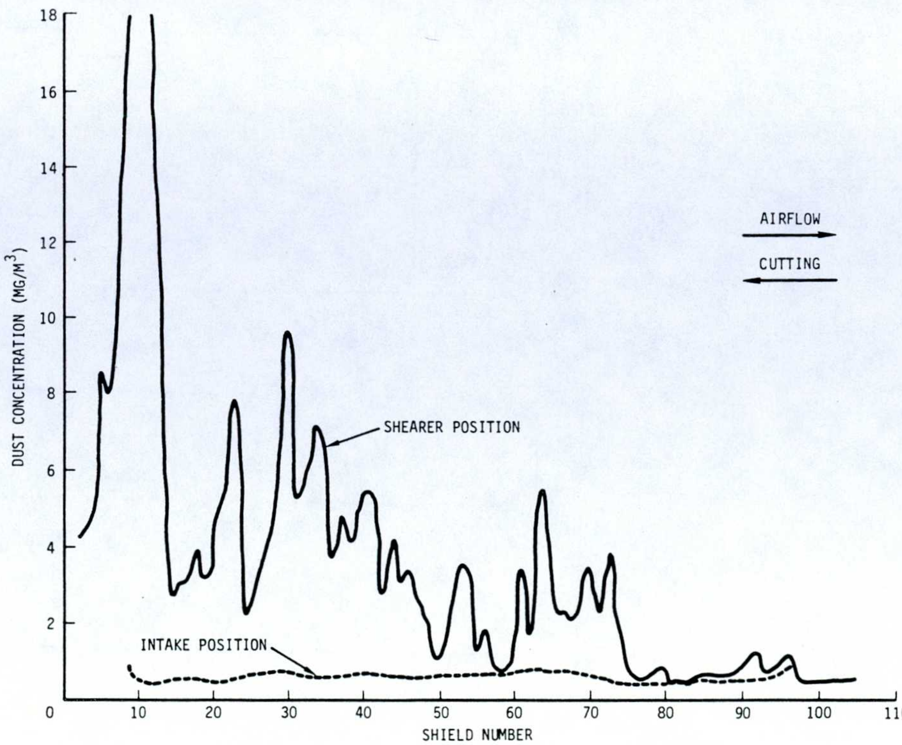


FIGURE 19. - Respirable dust concentration versus face location. Tail-to-head pass; conventional system; without passive barriers.

The shearer position concentrations were considerably higher and more erratic with the conventional system operating than with the Shearer Clearer system operating. Excluding the headgate cutout, the Shearer Clearer reduced average dust concentrations at the operator's position from about 3.0 mg/m^3 to about 1.0 mg/m^3, for a 66% reduction.

Special emphasis was placed on the results of headgate cutout data due to the high levels of shearer-generated dust recorded during the cutouts (see table 6).

Analysis of the headgate cutout data confirmed the general results of tail-to-head cutting passes described above. Highlights of the cutout analysis included:

a. In all cases, the Shearer Clearer significantly reduced the levels of shearer-generated dust as compared to the conventional system

b. The <u>greatest</u> reductions were realized when the passive barriers were removed (56% reduction versus 35%)

c. Shearer-generated dust levels <u>increased</u> by 42% when passive barriers were added to the Shearer Clearer system

d. Shearer-generated dust levels <u>decreased</u> by 4% when passive barriers were added to the conventional system.

3.2.4.3 Head-to-Tail Cutting Results

Table 7 contains a synopsis of the average dust concentrations for all head-to-tail cutting passes. Figures 20 and 21 show representative plots of dust concentration versus face location (shield number) for both the Shearer Clearer and conventional systems. Both sets of plots are of head-to-tail passes completed on the same day during the first week of testing.

The contribution of upstream shield movement to the intake dust levels shown in table 7 and figures 20 and 21 caused intake levels to be <u>greater</u> than shearer levels in every case. This made it impossible to use the analysis technique of subtracting intake levels from shearer levels to calculate "shearer-generated" dust concentrations. Nonetheless, the plots in figures 20 and 21 show the Shearer Clearer to be effective in reducing the dust exposures at the operator's position compared to the conventional system. The Shearer Clearer "shearer position" dust levels are lower despite higher "intake position" levels.

TABLE 6. - Average shearer generated dust concentrations at the headgate shearer operator's position between shields 15 and 4 during headgate cutouts

Sampling period	Passive barriers	Average Shearer-Generated Dust Concentrations (mg/m^3)		
		Shearer Clearer system	Conventional system	Percent reduction Shearer Clearer versus conventional
Week 1	Removed	4.69	7.62	38
Week 2	Installed	6.31	7.93	20
Week 3	Varied	1.93	9.20	79
All Cutouts	Installed	5.24	8.06	35
All Cutouts	Removed	3.70	8.40	56

TABLE 7. - Dust concentrations for conventional versus Shearer Clearer system with and without passive barriers during head-to-tail cutting passes

Sampling period	Passive barriers	Average Dust Concentrations (mg/m^3)			
		Shearer Clearer system		Conventional system	
		Shearer	Intake	Shearer	Intake
Week 1	Removed	3.50	6.76	3.85	7.84
Week 2	Installed	4.01	5.88	3.81	4.74
Week 3 (Day 1)	Installed	6.61	11.27	4.60	7.04
Week 3 (Day 2,3)	Removed	3.45	4.49	4.72	5.77
All Passes	Installed	4.44	6.78	3.97	4.98
All Passes	Removed	3.47	5.62	4.14	7.15

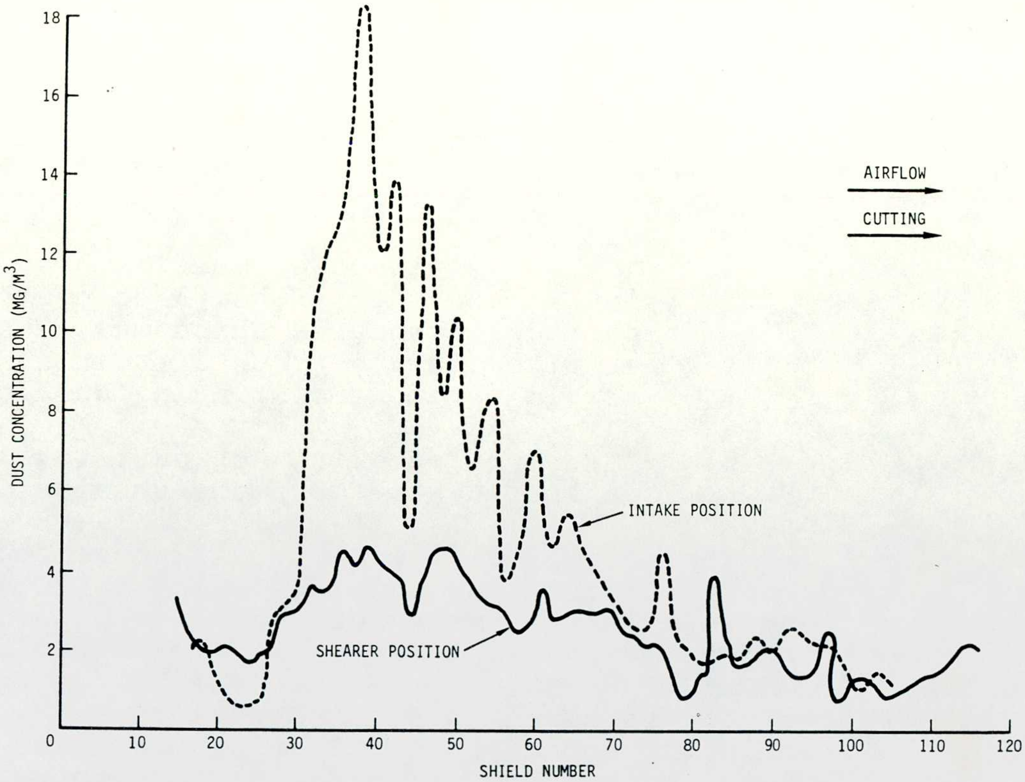


FIGURE 20. - Respirable dust concentration versus face location. Head-to-tail pass; Shearer Clearer system; without passive barriers.

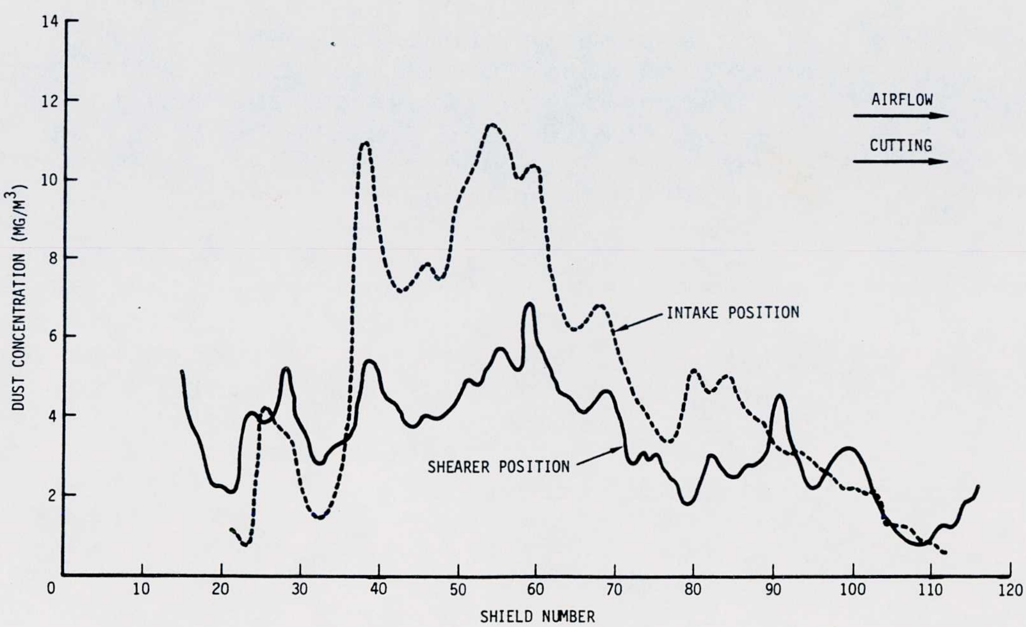


FIGURE 21. - Respirable dust concentration versus face location. Head-to-tail pass; conventional system; without passive barriers.

Because of the difficulty in differentiating between amounts of shield-generated dust and shearer-generated dust during head-to-tail passes, the following special tests were performed during the second and third weeks of the evaluation:

a. "Decay sampling" of dust levels at the normal intake and shearer sampling positions during periods of shearer shutdown. Readings were taken at fixed locations on 5 to 10 s intervals with shield movement continuing upstream

b. "Gradient sampling" of dust levels on a grid pattern upstream of the shearer during cutting.

The results of these special tests showed that shearer-generated dust levels were too low to accurately quantify Shearer Clearer system effectiveness, particularly due to the shield dust levels.

It was hoped that computer analysis would help to show the effects of Shearer Clearer operation versus conventional system operation during head-to-tail cutting passes. As a sample data run, all head-to-tail passes for the first testing week (passive barriers removed) were input into the computer. Then the data was separated according to spray system in operation and an "analysis of covariance" was run. The analysis of covariance was designed to show the degree of confidence with which the spray system in use could be assumed to affect the shearer-generated dust levels measured at the shearer position. Shearer position levels were a combination of intake dust levels (shield dust plus headgate intake sources) and shearer-generated dust levels not accounted for by variations in intake levels.

The results of the analysis showed that dust levels at the shearer position were strongly dependent on intake position levels (a fact also confirmed through manual analysis). However, shearer-generated levels were not dependent on spray system operation to a degree sufficient to quantify Shearer Clearer system effectiveness. The analysis of covariance showed a 70% degree of confidence that shearer-generated dust levels measured at the shearer position were affected by spray system changes. For this reason, further efforts at computer analysis were terminated.

Extensive laboratory testing led to the Shearer Clearer design used at Kaiser. The results of this testing indicated that the Shearer Clearer would operate most effectively with the entire system in use when cutting tail-to-head and a reduced system in use when cutting head-to-tail. The reduced system consisted of spray banks C and D shown in figure 21. Because of the unexpected contribution of shield dust to the head-to-tail results at Kaiser, it was decided to test a variety of other head-to-tail systems to determine their potential effects on shield dust control. These included:

a. All spray banks A, B, C, and D

b. Spray banks A, B, and D only

c. Spray banks C and D only

d. Spray bank D only.

The results revealed that because of the high shield dust levels, the best dust control when cutting head-to-tail is attained with all spray banks operating. Spray banks A and B appeared effective in pulling shield dust from the walkway area and confining it to the face area. These results are illustrated in figures 22 and 23, showing dust concentration versus face location for two head-to-tail passes: one with all sprays operating and one with only spray banks C and D operating. Levels at the shearer operator are approximately 20% lower with all sprays operating despite higher intake levels.

3.2.4.4 Summary

The Shearer Clearer spray system was very effective in reducing the levels of shearer-generated dust during tail-to-head cutting passes (especially during headgate cutouts). However, the combination of passive barriers with the Shearer Clearer system resulted in a decrease in its effectiveness. The use of passive barriers with the conventional system caused an increase in effectiveness of that system. It was concluded, therefore, that a passive barrier system is most effective when used with an ineffective spray system which causes dust to boil out into the walkway over the top of the shearer. An effective spray system, such as the Shearer Clearer, will provide sufficient control of the dust cloud over the shearer body and will not benefit from a passive barrier system.

The three week test period was conducted with virtually no required repairs, further demonstrating the system's mine-worthiness and ease of maintenance. Valuable practical experience was gained to support the reliability of using system components specifically designed to withstand the mining environment:

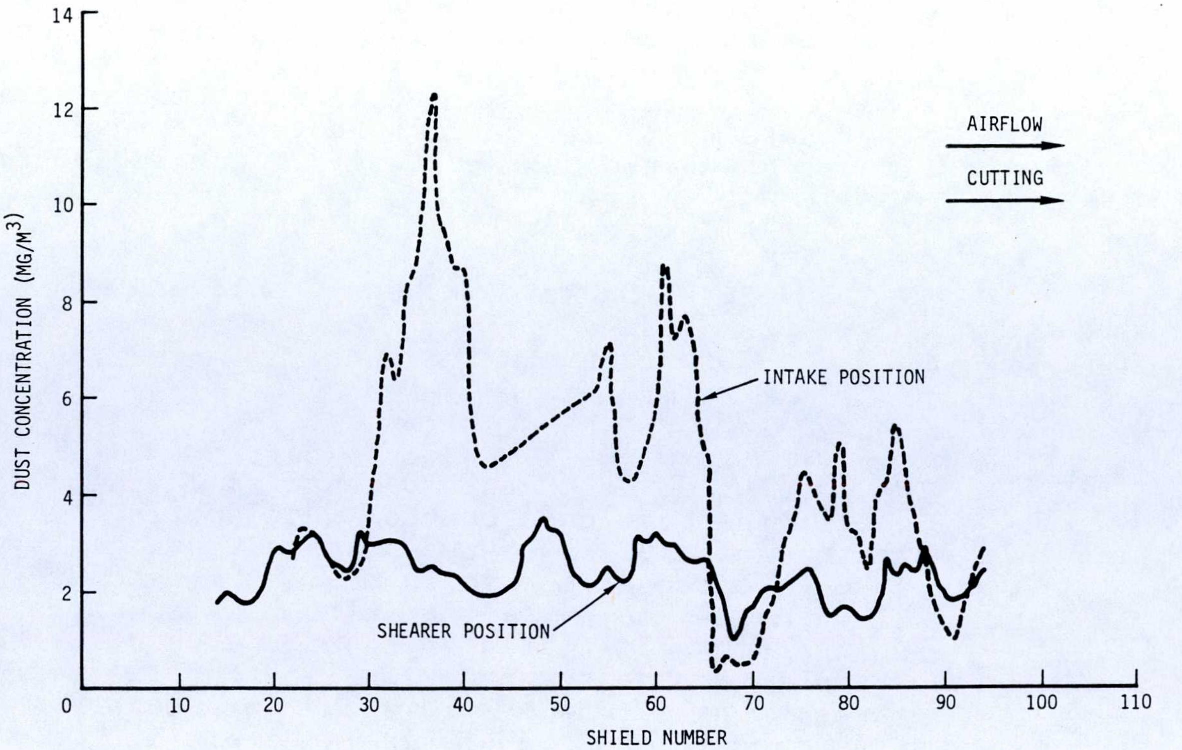


FIGURE 22. - Respirable dust concentration versus face location. Head-to-tail pass; complete Shearer Clearer system; without passive barriers.

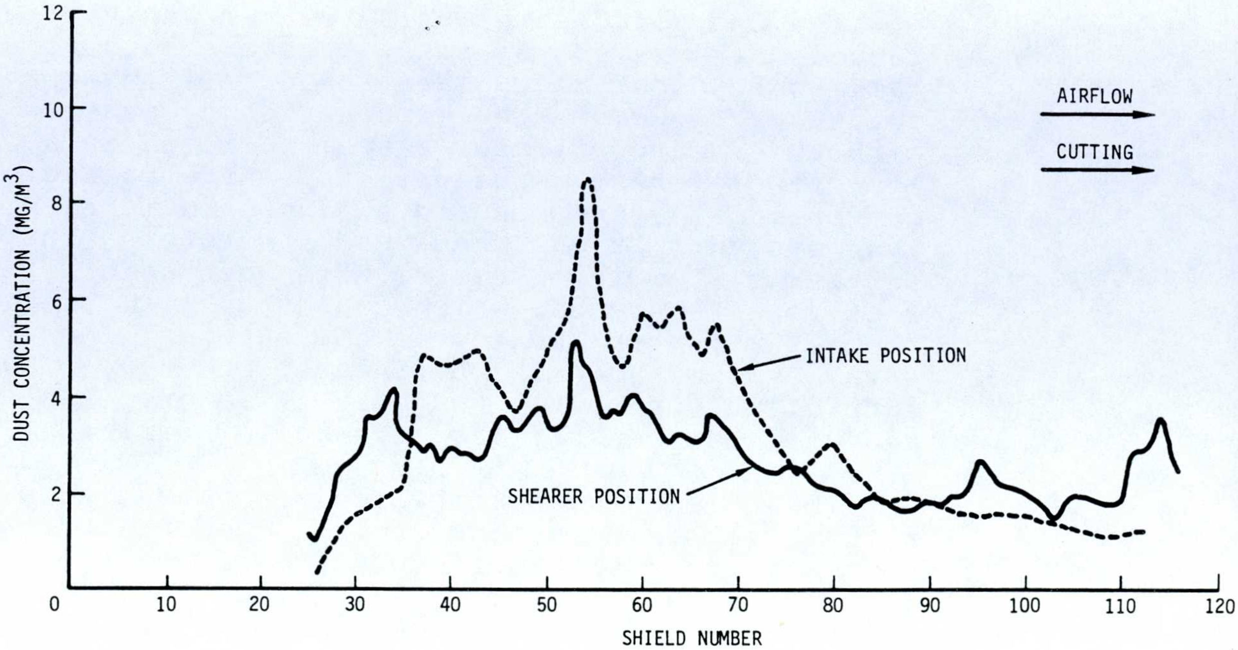


FIGURE 23. - Respirable dust concentration versus face location. Head-to-tail pass; reduced Shearer Clearer system (spray banks C & D) without passive barriers.

a. Hinged and spring-loaded splitter arms

b. "Low-profile" solid steel manifolds of closely grouped sprays, located beneath protective steel cover plates

c. A gob-side passive barrier system of easily removable, modular sections of thick conveyor belting.

In addition, the filtration system (hydrocyclones and Y-strainers) installed for the evaluation resulted in <u>no nozzle clogging</u> during the entire three week period.

3.3 SECOND FIELD EVALUATION - ARMCO STEEL, NO. 7 MINE

3.3.1 Field Surveys

At the invitation of ARMCO management, a field survey was conducted on the 1 West, 3rd Left Longwall during September 1983. The 1 West, 3rd Left panel had been out of compliance for some time with a 1.4 mg/m^3 reduced dust standard due to quartz and ARMCO was interested in upgrading and improving their dust control methods.

Conditions on the 3rd Left Longwall during the September field survey are summarized in table 8. Figure 24 illustrates the layout of the combination splitter arm, passive barrier, and shearer spray system encountered during the survey. The results of dust monitoring are presented in table 9.

The dust sampling results indicated that shearer-generated dust was the most predominant dust source on the face. Intake concentrations were very low by comparison, even during head-to-tail cutting when shield dust was a component of intake levels. From these results specific recommendations were made to ARMCO management regarding the reduction and control of shearer-generated dust. These included:

a. Increased face ventilation to increase dust dilution

b. Upgraded water supply systems to increase the quantity and pressure of supply water to the shearer

c. Reoriented cooling water discharge to eliminate dust "boil out" into the walkway

TABLE 8. - Conditions during the September 1983 survey

Longwall water supply system	-	Single Jeffrey Satellite booster pump with 20 h motor installed at end of section hard pipe 1-1/4 in. water hose from booster pump to shearer
Dynamic water pressure and flow at shearer inlet	-	Approximately 105 psi, 50 - 60 gpm
Average face air velocity	-	140 ft/min panel was new, gob had not fully fallen and consolidated
Depth of roof rock cut	-	Approximately 4 in. average

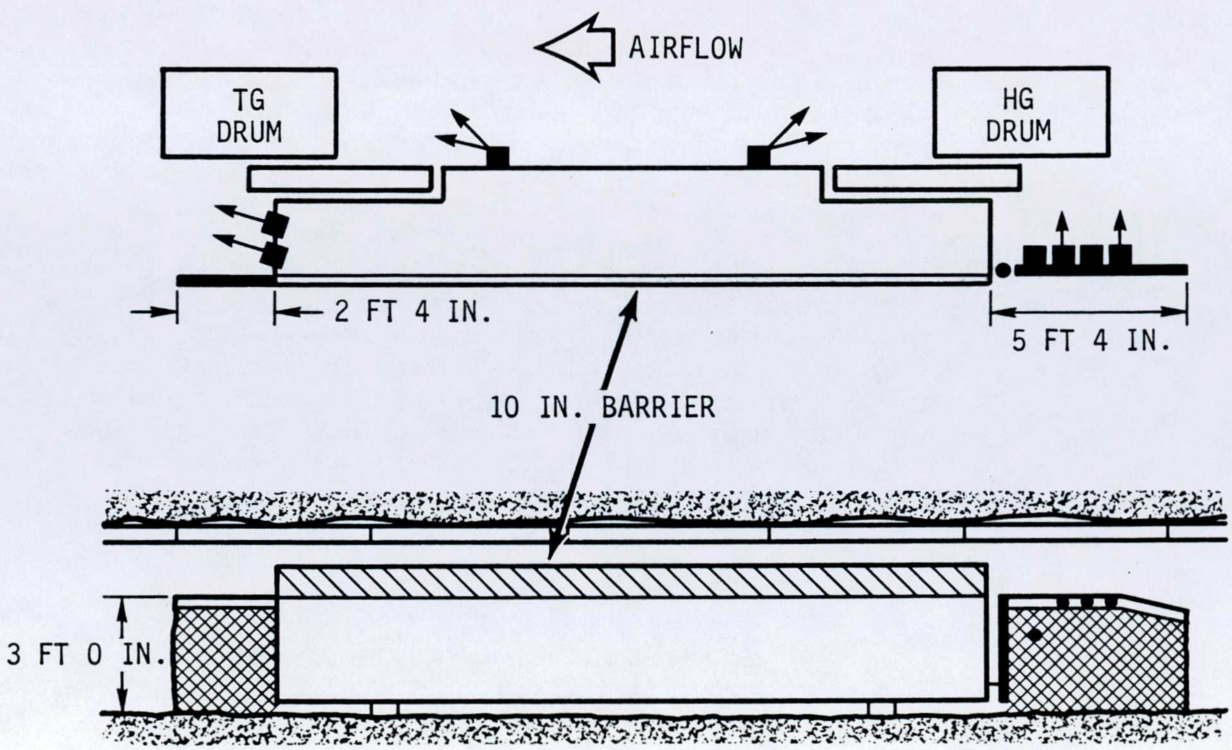


FIGURE 24. - Layout of shearer spray system - September 1983.

TABLE 9. - Average dust concentrations - September 1983 survey

Cut direction	Average concentration (mg/m^3)	
	Shearer operator	Intake
Head-to-tail	6.5	0.5
Tail-to-head	12.3	0.5

d. Redesigned and properly oriented external water sprays to keep shearer-generated dust confined to the face

e. Effective use of drum sprays to enhance dust suppression.

Modifications actually completed by ARMCO shortly after the September survey included:

a. An increase in airflow quantity along the face of nearly 100%

b. Installation of an additional booster pump in the water supply system

c. An increase in the size of water hose from the end of the hardpipe to the shearer from a 1-1/4 in. diam to a 2 in. diam (hardpipe to midface) and a 1-1/2 in. diam (midface to shearer)

d. An increase in height of the shearer-mounted, gob-side passive barrier from 10 in. to 15 in., nearly always sealing itself against the underside of the roof supports

e. Relocation of the headgate-end shearer cooling water sprays to discharge directly into the panline

f. Reorientation of all external venturi sprays to aim in the direction of the primary airflow

g. Installation of large orifice, high capacity, low pressure drum sprays.

To investigate the impact of these modifications on face dust levels, two brief additional field visits were conducted at 3rd Left. The visits were conducted by a

Bureau test engineer and an FMI test engineer on October 26 and November 16 respectively. Conditions on the longwall during the surveys are summarized in table 10. Figure 25 illustrates the layout of the shearer spray systems, reflecting the improvements made by ARMCO. Table 11 contains the results of dust monitoring performed during the surveys. For easy reference, the results of the original September survey are repeated in table 11.

The reduction in dust concentrations at the shearer operator's position between the September survey and those in October and November was dramatic (an average of 81% for head-to-tail cutting and 84% for tail-to-head cutting). Intake levels remained roughly similar at less than 1.0 mg/m^3. The significance of these reductions led to the decision to return to ARMCO for a 2-week evaluation to further investigate the major improvements which ARMCO implemented. It was clear that the improvements had produced a dramatic reduction in face dust levels, but it was not clear which factor was most important or to what extent each factor was responsible for the reductions.

TABLE 10. - Conditions during the October and November 1983 Surveys

Conditions	October	November
Longwall water supply system	Two Jeffrey Satellite booster pumps with 20 h motors installed in parallel at end of the section hardpipe 2-in. water hose from booster pumps to midface 1-1/2 in. water hose from midface to shearer	Identical to October
Dynamic water pressure at shearer inlet	Approximately 150 psi, pumps not operating properly	Approximately 250 psi; both pumps operating
Average face air velocity	270 ft/min	360 ft/min
Depth of roof rock cut	N/A	Approximately 2-3 in.

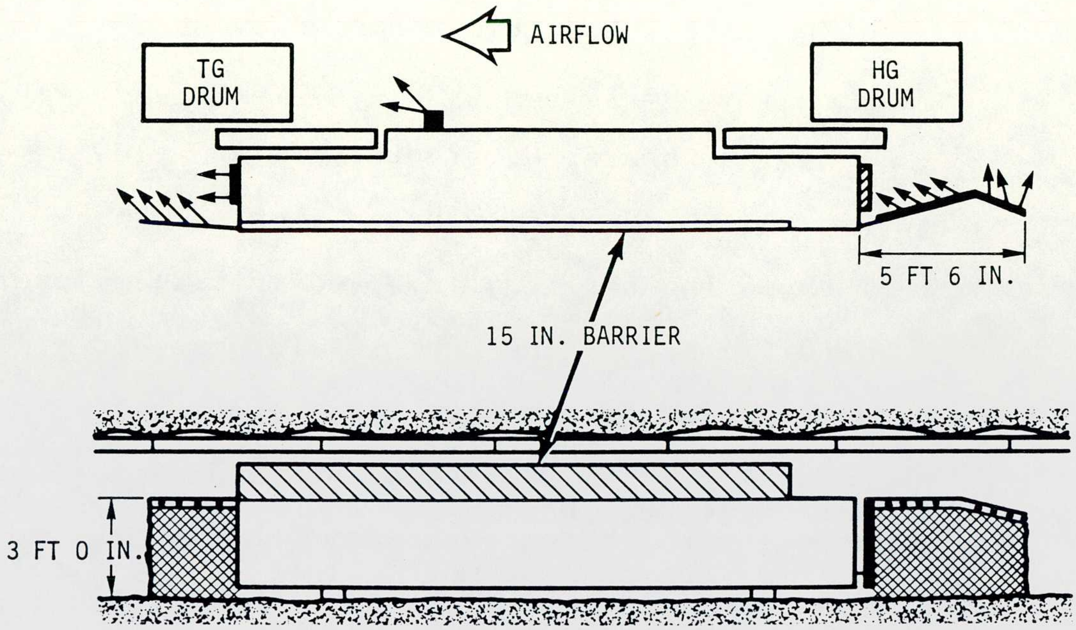


FIGURE 25. - Layout of shearer spray system after ARMCO modifications.

TABLE 11. - Average dust concentrations - September and October 1983 surveys

Survey Date	Average dust concentration (mg/m^3)			
	Head-to-tail cut		Tail-to-head cut	
	Shearer	Intake	Shearer	Intake
September	6.5	0.5	12.3	0.5
October	2.03	0.96	3.38	0.48
November	0.45	-	0.60	-

3.3.2 Evaluation Testing Strategy

The evaluation focused on "A-B-C" comparison testing to isolate and then quantify three of the most significant dust control variables changed by ARMCO:

a. Shearer-mounted passive barrier system

b. Shearer water pressure and flow levels

c. Face airflow quantities.

The testing strategy involved initially lowering water flow and airflow levels. This was done to approximate the conditions and face dust levels observed in the initial September field visit to the degree possible. Waterflow and airflow levels were then methodically changed over a variety of ranges. The intent was to measure the dust control effects by increasing each factor separately, and both together, back up to the improved levels. To document the effectiveness of the shearer-mounted passive barrier, testing at most waterflow and airflow conditions was performed both with and without the barrier installed on the shearer.

An exact duplication of the conditions and dust levels of the September field visit was impossible, since the conditions on longwall panels change continually. Factors which may well have changed between the September survey and the December evaluation include:

a. Extent of rock being cut

b. Coal characteristics (hardness, moisture content, etc.)

c. Overburden pressure, gob consolidation.

The dust sampling methodology used during the evaluation was very similar to that used during the original field survey. However, in addition to the traditional "shearer" and "intake" dust sampling positions, a "downstream" position was employed as well. The downstream position was maintained approximately 25 ft downwind of the tailgate end of the shearer, over the center of the panline and about midway between the panline and the roof support canopies. The purpose of the downstream position was to quantify the impact that passive barriers and changes of water flow and face airflow had on total respirable return air dust downwind of the shearer. The downstream position was maintained consistently throughout the evaluation; the intake position was monitored on a periodic basis only, to ensure the stability of intake dust levels. In addition to dust sampling, test engineers also monitored:

a. General face conditions and activities such as depth of roof rock being cut and activities of the shearer

b. Face air volume levels at every tenth shield along the face.

The evaluation was completed over nine production shifts between 14 and 22 December 1983. A total of 32 cutting passes were surveyed, 18 in a head-to-tail direction and 14 in a tail-to-head direction (ARMCO cuts bidirectionally).

Water pressure and flow levels to the shearer were varied over the following ranges:

a. High: 250-320 psi (70-82 gpm) - existing full water pressure

b. Medium: 180-240 psi (60-68 gpm) - approximately 26% reduction

c. Low: 100-150 psi (40-55 gpm) - approximately 56% reduction.

Two water pressure test strategies were used:

a. Maintain a constant given pressure during a full cutting pass

b. Purposely vary the pressure over the different ranges within a given cutting pass.

Face airflow velocities were also varied over three ranges:

a. High: 400-410 ft/min: maximum air velocity encountered

b. Medium: 350-370 ft/min: approximately 11% reduction

c. Low: 250-300 ft/min: approximately 32% reduction.

These variations resulted from an overall ventilation change made by ARMCO engineers midway through the evaluation. Additional efforts by FMI test engineers to lower airflows in the headgate resulted in further reduction. Face airflow evaluations spanned full shifts; ranges were not varied during any given shift. However, a full matrix of water pressure and airflow conditions were tested. Each of the three airflow velocity ranges contained testing at all three water pressure ranges.

3.3.3 Test Results

3.3.3.1 Passive Barriers

As shown in figure 25 the shearer at ARMCO was equipped with a 15-in. high passive barrier (conveyor belting) mounted along the full length of the gob-side edge of the shearer body. A series of A-B comparison tests were performed to determine the effectiveness of the barrier at reducing the dust exposures of the shearer operators. A-B testing was performed over six of the nine evaluation shifts by removing the barrier for one half of each shift.

Prior to the FMI September field survey, the shearer operators had apparently been subjected to large amounts of spray mist (and therefore dust) passing over the shearer body into the walkway. The body-mounted passive barrier was installed to alleviate this condition and was apparently very effective at doing so.

Between the September survey and the December evaluation, however, several improvements were made to the external spray system and the splitter arms. When the passive-barrier was removed during the December evaluation, no spray mist was present in the walkway even at maximum water pressures. In addition, an analysis of the dust monitoring results has shown that use of the passive barrier made no significant difference in dust concentrations either at the shearer operator or return sampling positions.

This confirmed the conclusion reached during the first evaluation at Kaiser Steel: that a passive barrier system is most effective when used with an ineffective spray system containing improperly oriented nozzles which cause dust and mist to boil out into the walkway over the top of the shearer. An effective spray system, using nozzles properly oriented in the direction of the primary airflow, will provide sufficient control of the dust/spray mist cloud over the shearer body. Such a system will not benefit from a passive barrier on the gob-side edge of the shearer. Nonetheless, the shearer operators at ARMCO preferred to operate with the barrier installed. They had adapted to its minimal visual constraints and felt it helped to protect them from falling rock and flying debris from cutting.

3.3.3.2 Tail-to-Head Cutting Results

The greatest emphasis was placed on tail-to-head cutting because its impact on the dust exposure of face personnel is considerably greater than that of head-to-tail cutting. Dust concentrations at the jacksetters and panline snaker positions are greater when cutting tail-to-head, since they are located downstream of the shearer. During head-to-tail cutting, these personnel are upstream of the shearer in fresh air.

A summary of the results of dust monitoring at the shearer operator's position during tail-to-head cutting is presented in table 12. The dust concentrations shown in the table represent the averages of dozens of dust levels recorded over a variety of locations along the face while the shearer was cutting coal during the particular water pressure and air velocity conditions given. "Low" water pressure and "low" airflow velocity was the baseline condition against which the others were compared. The percent reduction values matched with each dust concentration represent the decrease in dust level (from the baseline level of 17.54 mg/m^3) achieved when cutting coal at each set of conditions.

TABLE 12. - Average dust concentrations at the shearer operator's position for selected water pressure and air velocity conditions - tail-to-head cutting

Dust concentration (mg/m^3)/% reduction from baseline

Face airflow velocity	Shearer water pressure		
	Low 40-55 gpm 50-150 psi	Medium 60-68 gpm 180-240 psi	High 70-82 gpm 250-320 psi
Low 250-300 ft/min	17.54/ baseline	7.86/ 55.2%	6.84/ 61.0%
Medium 350-370 ft/min	8.67/ 50.6%	4.03/ 77.0%	3.53/ 79.9%
High 400-410 ft/min	4.99/ 71.6%	3.77/ 78.5%	2.97/ 83.1%

EXAMPLE: The average dust concentration at the shearer operator's position when cutting tail-to-head at a "medium" water pressure range and a "medium" air velocity range is 4.03 mg/m^3. This is a 77% reduction from the average baseline dust concentration of 17.54 mg/m^3.

The three dust concentrations associated with the condition of "low" airflow were somewhat higher than anticipated because a greater than normal amount of roof rock was being cut during a portion of the mining shifts when the airflow was lowered. Consequently, the percent reductions shown in table 12 may be slightly higher than they would have been under normal rock conditions. However, the data trends would remain the same.

An examination of the data in table 12 illustrates the relative degrees of improvement obtained by varying water pressure or air velocity levels separately or together. Many interesting comparisons can be made. The greatest improvement (an 83.1% dust reduction) was realized when both factors were increased to the "high" levels. However, an improvement nearly as great (77.0% reduction) was attained by increasing both factors to only the "medium" levels.

The same data is displayed graphically in figures 26 and 27. As shown in both figures, the largest portion of the dust reduction from increased airflow velocity versus water pressure occurred when those increases took place between the "low" and "medium" ranges. Relatively small additional dust reductions were achieved by increasing those factors from the "medium" to the "high" ranges.

The results of the dust monitoring downstream of the shearer followed trends similar to that of the shearer operator's position. Dust concentrations decreased steadily as water pressure and face air velocity levels were increased. The greatest improvements were realized when both factors together were increased through the ranges to the "high" levels.

3.3.3.3 Head-to-Tail Cutting Results

A summary of the results of dust monitoring during head-to-tail cutting is presented in table 13 and graphically in figures 28 and 29. The organization of the data and the analysis techniques are identical to those previously discussed.

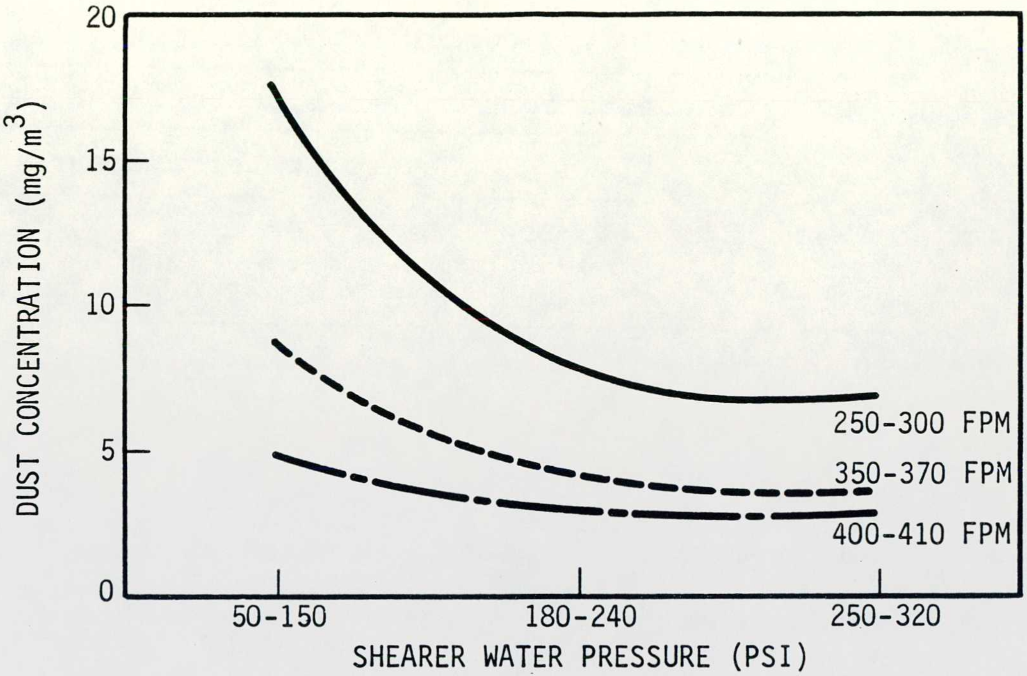


FIGURE 26. - Shearer operator dust concentration versus water pressure at three airflow velocities; tail-to-head cutting.

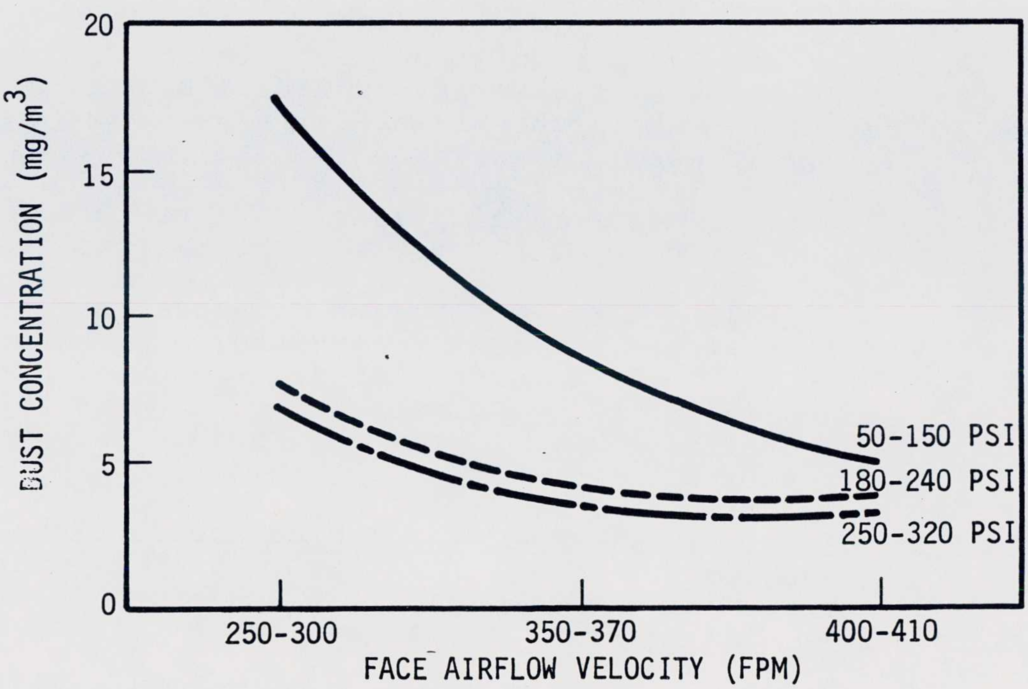


FIGURE 27. - Shearer operator dust concentration versus airflow velocity at three water pressures; tail-to-head cutting.

TABLE 13. - Average dust concentrations at the shearer operator's position for selected water pressure and air velocity conditions in head-to-tail cutting

Dust concentration (mg/m^3)/% reduction from baseline

Face Airflow Velocity	Shearer water pressure		
	Low 40-55 gpm 50-150 psi	Medium 60-68 gpm 180-240 psi	High 70-82 gpm 250-320 psi
Low 250-300 ft/min	1.84/ baseline	1.76/ 4.3%	1.41/ 23.4%
Medium 350-370 ft/min	1.37/ 25.5%	1.17/ 36.4%	1.09/ 40.8%
High 400-410 ft/min	1.11/ 39.7%	1.00/ 45.7%	0.75/ 59.2%

<u>Shearer position</u> data trends are somewhat different than those for tail-to-head cutting because:

a. The percent reduction figures are considerably smaller, indicating that the effect of increased water pressure and airflow is greater on tail-to-head cutting than on head-to-tail cutting

b. The dust reductions are more uniform with increasing levels of the two factors.

In addition, the average dust concentrations themselves were dramatically lower for head-to-tail cutting than for tail-to-head cutting. Since the primary cutting drum (tailgate) was downstream of both operators, most of the dust generated by the shearer did not pass over their positions.

The upwind drum was lowered and cutting only a very small portion of the coal face. This illustrates the dust control benefits to unidirectional longwall faces of taking the primary cut in a head-to-tail direction.

<u>Return position</u> data trends for head-to-tail cutting were similar to those for tail-to-head cutting: increases in water pressure and/or air velocity resulted in

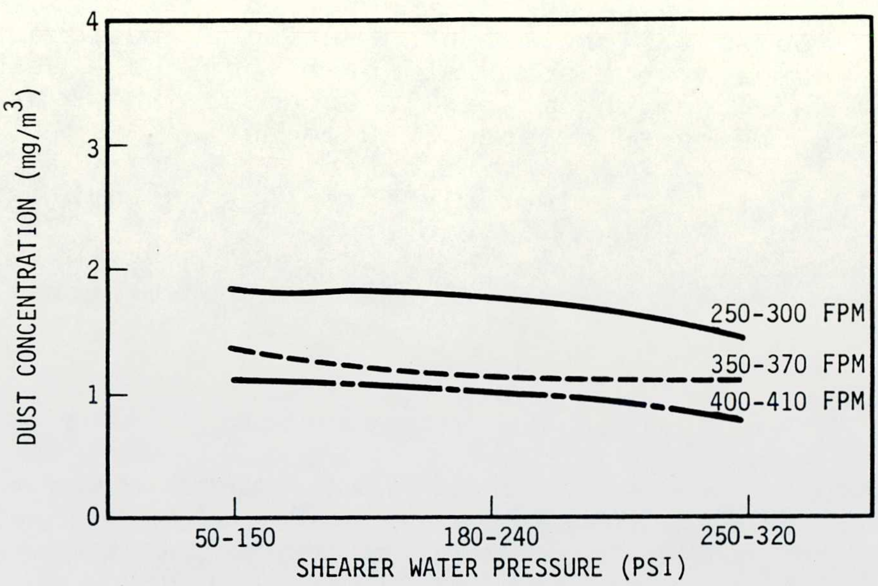


FIGURE 28. - Shearer operator dust concentration versus water at three airflow velocities; head-to-tail cutting.

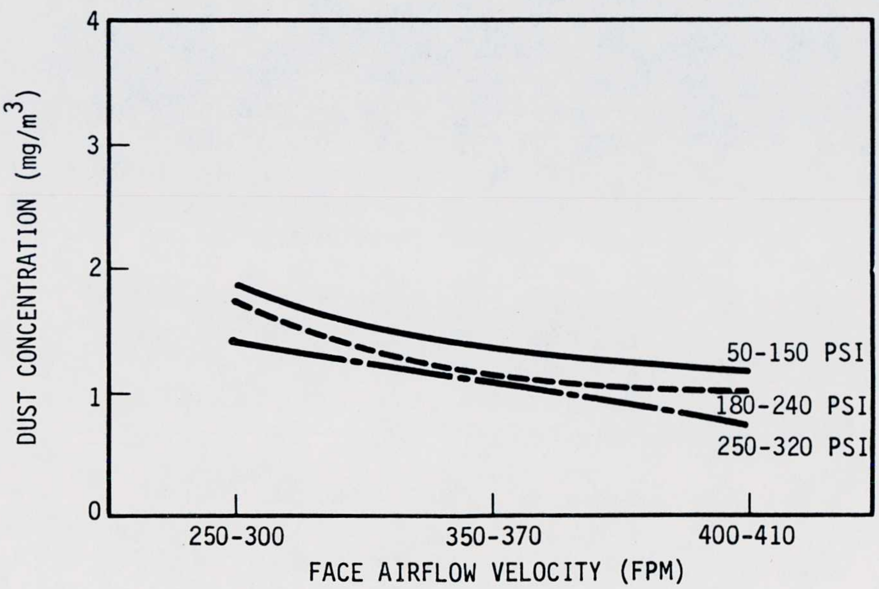


FIGURE 29. - Shearer operator dust concentration versus airflow velocity at three water pressures; head-to-tail cutting.

decreased dust concentrations in the return airstream downstream of the shearer.

As evidenced by the data previously presented, dust concentrations measured during the October and November surveys were somewhat lower than those measured under the same face conditions in December. However, two primary differences existed in December:

a. Considerably more rock was cut during most passes than in October

b. The effectiveness of the external spray system and splitter arms was diminished due to damage from roof support canopies in regions of low clearance; the spray system and splitter arms had been recently installed during the October survey.

3.3.3.4 Summary and Recommendations

It has long been known that increased shearer water pressure and face airflow can be used to reduce dust concentrations on longwall faces. However, guidelines have not been available to mine operators indicating how to most efficiently use those techniques: how to <u>maximize</u> dust reductions while <u>minimizing</u> water consumption and use of ventilating air.

The results of the ARMCO evaluation has provided valuable insight to help guide in the effective use of these methods. A summary of the conclusions drawn from the evaluation follows:

a. Increasing water pressure <u>or</u> face air velocity will result in decreased face dust concentrations; however, increasing <u>both together</u> will significantly accelerate the extent to which dust levels are reduced.

b. Eventually a "point of diminishing returns" is reached beyond which further increases in either water pressure or face air velocity will no longer produce substantial decreases in dust concentrations

c. Generally, increasing both factors together to "medium" levels will provide optimum dust reductions while maintaining reasonable degrees of water consumption and use of ventilating air.

The key to effective use of these techniques is to determine <u>where</u> the "points of diminishing return" are and which "medium" levels of water pressure and face air velocity to use. These will vary on a longwall-to-longwall basis and can be discovered through a simple program of experimentation and dust monitoring.

3.4 ADDITIONAL PASSIVE BARRIER STUDY

An additional passive barrier study was performed at Bethlehem Mines Corporation's No. 60 Mine in September and October 1983 during the evaluation of another dust control technique. At the start of that evaluation, the shearer was equipped with two diagonal passive barriers on top of the shearer as shown in figure 30. Using smoke tests to determine airflow patterns, it was shown that the barriers directed dust from the face side of the shearer into the walkway and over the operators. This detrimental effect was confirmed through dust monitoring as illustrated in table 14.

Removing the barriers resulted in a 30% reduction in dust concentrations at the operator's position for both the tail-to-head and head-to-tail passes. This directly confirmed the results of earlier laboratory testing conducted on diagonal passive barriers. In those tests the barriers blocked the airflow over the machine, directing contamination from the headgate drum into the walkway. Smoke tests revealed that eddy currents were produced behind the barriers forming contamination pockets which were also drawn into the walkway.

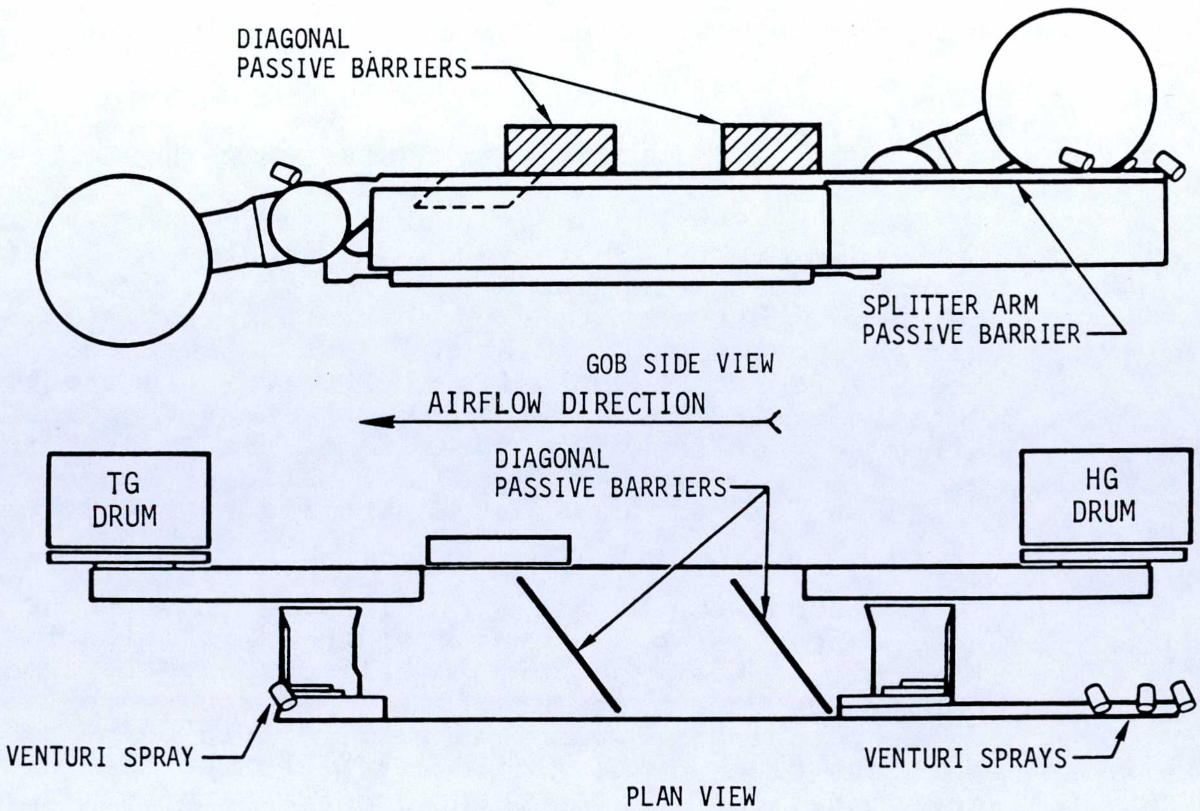


FIGURE 30. - Diagonal passive barrier system - Bethlehem No. 60 Mine.

TABLE 14. - Results of A-B comparison testing on passive barriers - Bethlehem No. 60 Mine

Cutting direction	Sampling location	Diagonal Barrier		Improvement (%)
		On (mg/m^3)	Off (mg/m^3)	
Headgate-to-tailgate pass	Shearer operator's total dust concentration	3.30	2.31	30
	Shearer-generated dust at operator	2.35	1.18	49
Tailgate-to-headgate pass	Shearer operator's total dust concentration	11.28	7.94	30
	Shearer-generated dust at operator	10.36	7.25	30

4. CONCLUSIONS

The laboratory tests and underground evaluations demonstrated that passive barriers can be very effective in reducing the respirable dust exposures of longwall face personnel by helping to confine shearer-generated dust to the face.

Of particular importance is the control of dust generated by the headgate drum during tail-to-head cutting. To achieve this, testing showed that a headgate splitter arm is a vital part of a passive barrier system, whether or not a spray airmoving system is also used on the shearer. The splitter arm begins the airsplitting process and provides a supporting framework for airmoving spray manifolds (when used).

A sturdy and practical splitter arm design which proved very successful in several underground field evaluations is given in figure 31. The arm is hinged to the shearer and spring-loaded to deflect when large pieces of coal or roof rock strike it. The orientation of the angle iron members allows spray manifolds to be mounted beneath a leg of the angle for protection.

Two points of caution should be noted. First, the arm must be mounted to a rigid portion of the shearer body that does not rotate with the ranging arm. If not, movement of the arm will cause attached spray manifolds to be improperly oriented. Typically, the splitter arm will be mounted to the upwind gearhead unit but on some shearer models, the gearhead rotates along with the ranging arm. Second, in low clearance conditions, the splitter arm may strike the underside of the roof supports, particularly if the panline "ramps up" onto the stageloader. Although the spring-loaded feature of the arm will allow for some deflection, the arm length may have to be shortened in these cases.

The complete splitter arm assembly shown in figure 31 consists of four parts:

a. The framework supports the conveyor belting barrier and spray manifolds. It is constructed of 3 x 3 x 1/2 in. angle iron and lateral steel support bars welded together. The frame also contains a portion of the hinge assembly, and one of two spring support studs

b. The hinge assembly allows the splitter arm to pivot. It is constructed in two halves of plate and pipe sections

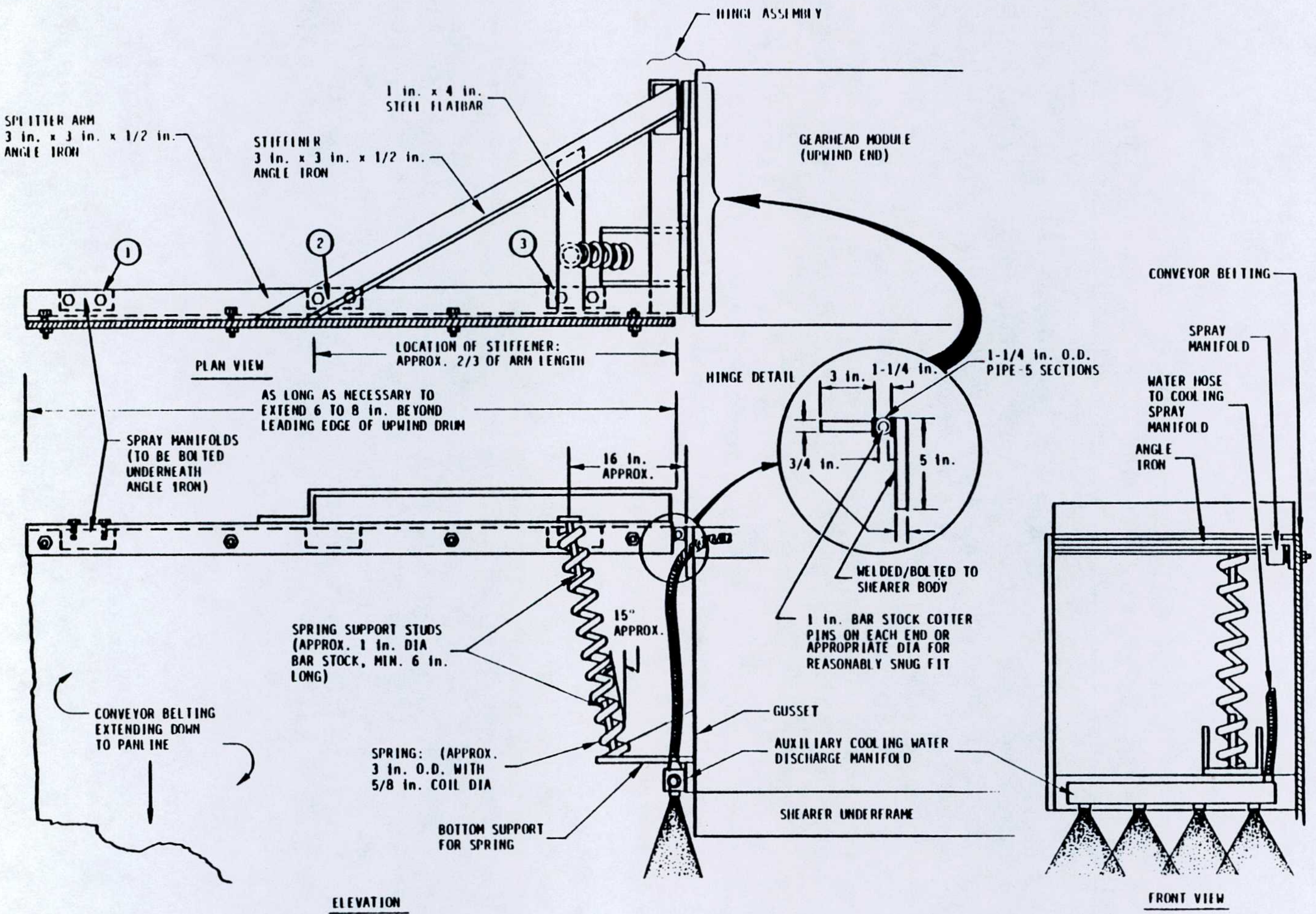


FIGURE 31. - Typical upwind splitter arm design.

c. The bottom spring support bracket guides and supports the spring. It is constructed of 1-in. steel plate, welded to the shearer underframe and strengthened with gusset plates

d. The spring supports the splitter arm and provides the capability for deflection under load.

The type and size of spring must be considered before fabricating the mounting brackets and support studs to ensure that they are properly located, sized and fitted. Tail conveyor springs from continuous miners have worked well in this application.

Once the clean/contaminated airsplit is initiated by the headgate splitter arm, a machine-mounted gob-side passive barrier can help to maintain the airsplit in certain situations. Typically, the gob-side barrier proved very effective when used on shearers with ineffective external spray systems or which were not equipped with external airmoving sprays. The gob-side barrier proved to be unnecessary on shearers equipped with effective external airmoving systems such as the Shearer Clearer.

When used, a recommended barrier design is detailed in figure 32. As shown, the barriers should be mounted along the gob-side edge of the shearer. They should extend along the full length of the upwind splitter arm and along as much of the shearer body as practical, leaving gaps where necessary for operator visibility.

The height of the barriers and of the vertical support straps will depend on the clearance available over the shearer. The barriers should extend upward as high as practical, while allowing for low clearance areas, especially in the headgate area.

The barriers are usually constructed of 3/4-in. conveyor belting bolted to a framework of angle iron and vertical steel support straps. Depending on the height of belting above the support straps, two thicknesses of belting may be necessary to prevent buckling. The barriers should be fabricated in sections, typically corresponding to cover plate or shearer component sections. They should be designed for easy removal and replacement. The "truck side-board" mounting arrangement shown in figure 32 is recommended. These mounts, extensions to the vertical support straps, slide easily in and out of support "sleeves" welded to the gob side of the shearer body.

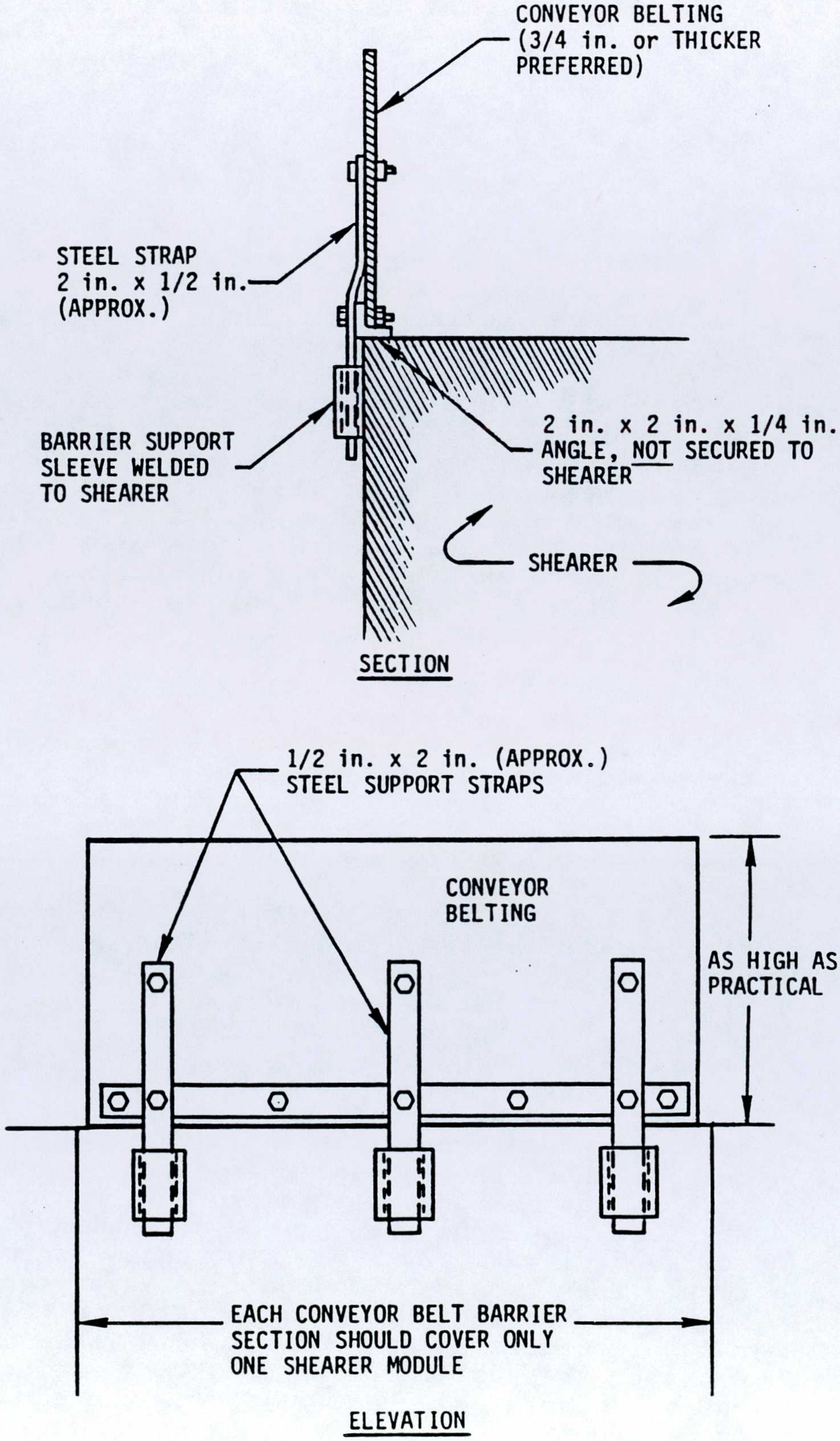


FIGURE 32. - Typical passive barrier system design.

In addition to the headgate splitter arm and gob-side barriers discussed above, passive barriers can also be installed over any open spaces between the shearer underframe and the panline to prevent conveyor dust from boiling out into the operator's walkway.