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Dust Controls To Improve Quality of Longwall Intake Air

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cfm	cubic foot per minute	mg/m^3	milligram per cubic meter
fpm	foot per minute	pct	percent
gpm	gallon per minute	psi	pound per square inch
gal/st	gallon per short ton	wt pct	weight percent

DUST CONTROLS TO IMPROVE QUALITY OF LONGWALL INTAKE AIR

By John A. Organiscak,[1] Robert A. Jankowski,[2] and Jonathan S. Kelly[3]

ABSTRACT

The Bureau of Mines has recently completed a program to identify and evaluate various methods that address control of dust generated outby the longwall mining face. Dust generated by the stageloader-crusher, the panel belt, and the intake roadway can be long-term throughout the shift, contributing significantly to the dust exposure of all face workers. Dust control techniques were identified and tested at a number of longwall mining sections located in diverse geological conditions across the United States. Dust controls investigated include (1) methods that eliminate the sources of intake dust contamination--homotropal ventilation; (2) methods to limit the amount of respirable dust released into the intake airstream--improved water application and the use of curtains and enclosures; and (3) methods to clean the contaminated air prior to delivery to the mining face--scrubber systems. Usually they can be implemented at a low cost and can be very effective. This report describes each technique and its application and presents the resulting conclusions.

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INTRODUCTION

Many longwall mine operations are still experiencing difficulty maintaining consistent compliance with mandatory Federal dust standards that limit the personal dust exposure of longwall face workers. The predominant dust source is usually the shearer; however, several dust sources outby the mining face can also contribute significantly to personal exposure levels. Past surveys by the Bureau (1)[4] have shown that on a specific operation as much as 75 pct of the shearer operators' dust exposure came from contaminated intake air, while in many instances, approximately 25 pct of face workers' respirable dust exposure was generated outby the mining face. This study showed that these sources included the stageloader-crusher, panel belt, and intake roadway, with the stageloader-crusher being the most common and significant source.

Outby dust sources can contribute significantly to worker dust exposure at a longwall face. Dust levels generated by these sources can be long-term throughout the shift and can affect all face workers. This report presents the effects of homotropal ventilation, water application, and equipment design for reducing outby generated dust. Usually, these dust controls can be implemented at a low cost and can be very effective.

HOMOTROPAL VENTILATION

The most effective method for controlling intake dust is homotropal ventilation, which routes air in the direction of coal transport along the face; i.e., tailgate-to-headgate (fig. 1). This places the outby dust sources downstream of the face workers, eliminating their dust exposure from these sources. Intake dust levels are reduced in the walkway by as much as 90 pct (fig. 2) (2). Moreover, the tailgate-to-headgate cutting cycle used in homotropal ventilation can increase productivity, since most of the coal does not have to pass through the shearer underframe.

Homotropal ventilation has the drawback that the headgate operator works downstream of the mining activities (shearer or plow), and tailgate entries must be kept in good condition. The headgate operator's dust exposure can be prevented by an auxiliary intake air split brought up the headgate entry next to the belt entry, with at least 100 fpm of airflow directed over the headgate operator (fig. 1). The gob at the headgate must remain open so that the dust-laden face air and the clean auxiliary air combine at the headgate end of the face and flow through the corner of the gob into the return or directly into the return crosscut. This may require additional cribbing in the crosscut, and between the last headgate shield and pillar. It is also recommended that the headgate operator controls be located as far outby the face

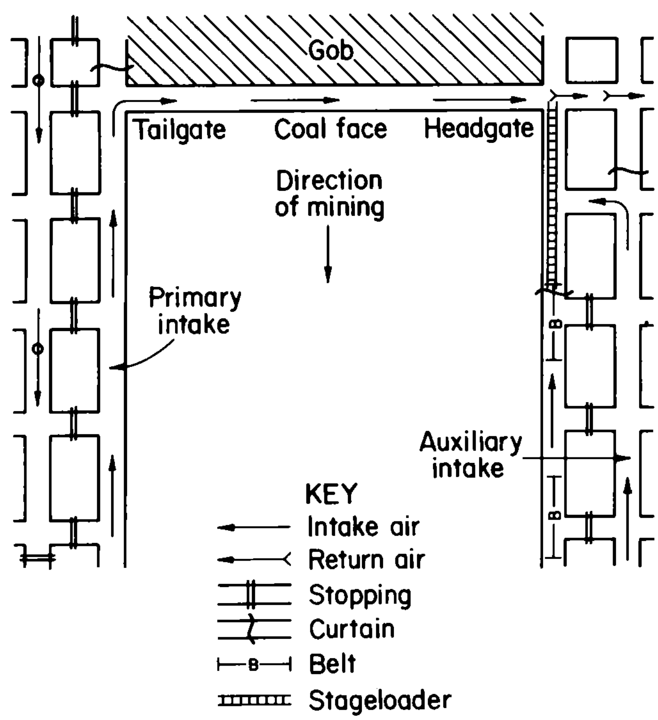

FIGURE 1.—Typical homotropal ventilation of a longwall face.

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

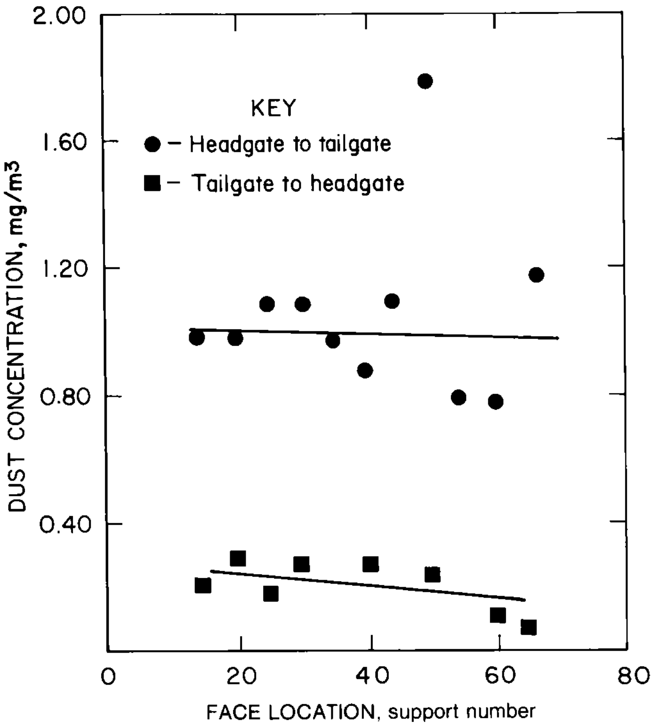

FIGURE 2.—Typical intake dust concentrations for antitropal and homotropal ventilation systems.

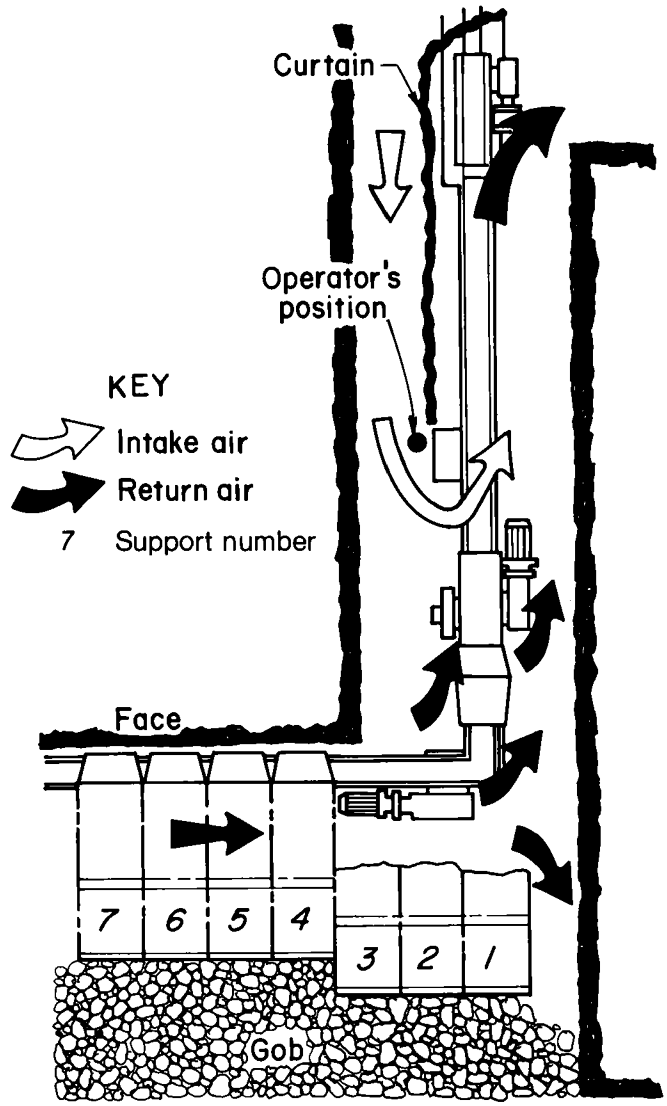

FIGURE 3.—Ventilation curtain to keep headgate operator in clean air when headgate gob is restricted.

as practical. This helps to keep the operator clear of contaminated air if the headgate gob should be closed up or seriously restricted, thus temporarily forcing the face air through the headgate to the return. A brattice curtain may have to be installed to insure clean intake air over the headgate operator when the face air is directed through the headgate to the return (fig. 3).

On homotropal ventilated faces, the tailgate entries must be kept in good condition. Intake air travels up these entries, which are under additional roof loading from the adjacent mined-out panel. Some additional cribbing may be required, but this should not be regarded as an additional task, since both headgate and tailgate entries are considered escapeways and must remain passable according to Federal regulations.

TYPES OF OUTBY DUST SOURCES AND CONTROLS

STAGELOADER-CRUSHER

Although homotropal ventilation is the most effective dust control method for all outby dust sources, it can be difficult and expensive to implement. Many other dust source controls can be implemented at a lower cost and be very effective in reducing outby generated dust.

The stageloader-crusher is usually the most significant outby dust source on most longwalls. At several longwalls surveyed by the Bureau, more than 50 pct of the shearer operators' dust exposure came from the stageloader-crusher (1). Significant dust reduction can be achieved with water sprays located strategically on an enclosed stageloader-crusher, or with a water-powered scrubber that cleans the air inside it (3).

Enclosing a stageloader-crusher and locating water sprays for optimum dust knockdown was evaluated at an underground longwall where a stageloader-crusher generated a significant amount of respirable dust. Four different dust control systems (3) were investigated as follows:

1. Baseline condition, stageloader-crusher not enclosed and four hollow cone sprays in the crusher (waterflow, 10 gpm). This is typical manufacturers' dust controls.

2. Stageloader-crusher not enclosed, four hollow cone sprays in the crusher (waterflow, 10 gpm), spray bar with two hollow cone sprays directed at the intake of the crusher (waterflow, 2 gpm), spray bar with three hollow cone sprays directed down on the chain conveyor on the discharge side of the crusher (waterflow, 5 gpm), and a spray bar with three hollow cone sprays directed on and with coal movement on the conveyor belt immediately after the stageloader dump point (waterflow, 3 gpm). Total system waterflow was 20 gpm.

3. Enclosed stageloader-crusher (brattice enclosure) with only crusher sprays operating (10 gpm total waterflow).

4. Enclosed stageloader-crusher (brattice enclosure) with all sprays operating (20 gpm total waterflow (fig. 4)).

As can be seen from table 1, the overall highest dust concentration occurred with the baseline dust control system:

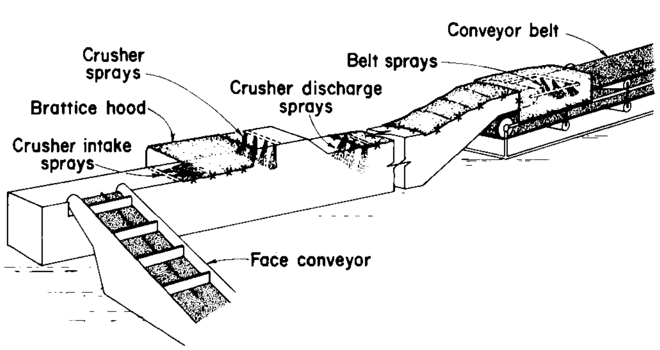

FIGURE 4.—Enclosed stageloader-crusher with strategic location of water sprays.

TABLE 1. - Dust concentrations and reductions for stageloader-crusher dust controls

Control system[1].........	1	2	3	4
Av dust conc, RAM units:				
Belt entry............	1.2	0.9	1.5	1.0
Stageloader...........	2.7	2.4	2.8	0.7
Headgate operator.....	2.4	1.0	0.9	0.5
Support 20[2]...........	1.7	1.4	1.3	1.0
Reduction in dust conc, pct:				
Belt entry............	BL	25	-25	17
Stageloader...........	BL	11	-4	74
Headgate operator.....	BL	58	63	79
Support 20[2]...........	BL	18	24	41

BL Baseline.

[1]As defined in Stageloader-Crusher section of text:

1--Stageloader-crusher open, crusher sprays only.

2--Stageloader-crusher open, all sprays.

3--Stageloader-crusher enclosed, crusher sprays only.

4--Stageloader-crusher enclosed, all sprays.

[2]This face location chosen for comparison because the airflow had ample face distance to stabilize from a directional change.

An open stageloader-crusher with crusher sprays, representing a typical manufacturers' dust control system. The overall lowest dust concentration occurred for the enclosed stageloader-crusher with all the water sprays operating. The combination of additional water sprays and enclosing the stageloader-crusher reduced dust concentrations considerably at the headgate operator (79 pct), stageloader (74 pct), and at support 20 (41 pct); modest dust reductions were observed in the belt entry (17 pct).

In further limited testing of the enclosed stageloader-crusher with additional water sprays, the waterflow was increased from 20 gpm to 30 gpm, with most of the additional water applied through the crusher-sprays. A 30-pct additional improvement in dust levels was achieved at the headgate operator's position and at support 20. No additional improvement was recorded at the belt entry, indicating that the belt spray bar was responsible for most of the panel belt dust reduction.

With all the sprays turned off, regardless of whether the stageloader-crusher was open or enclosed, conditions deteriorated, particularly in the belt entry, with a 100-pct increase in dust concentration at support 20.

An enclosed stageloader-crusher with additional water sprays placed in strategic locations is one of the most cost effective headgate dust control systems. The materials and labor-hours needed to build and maintain the system are minuscule compared with the benefits gained.

Another means of control is a water-powered scrubber (4) (Jet Spray Air Mover, JSAM) that cleans the air inside an enclosed stageloader-crusher and discharges the clean air into the mine environment (fig. 5). In this case, the stageloader-crusher is enclosed, but with an opening or ducting for the scrubber intake located as close as practical to the crusher discharge. Water sprays should again be added under the brattice hood on the intake side of the crusher, to knock down or contain the dust generated by the crusher and prevent it from boiling out of the crusher intake. The scrubber should be installed on the stageloader to draw the air from the duct or opening on the discharge side of the crusher. The scrubber exhaust should discharge air in the direction of coal movement.

This type of system was tested at an underground coal mine where the scrubber was supplied with approximately 9 gpm

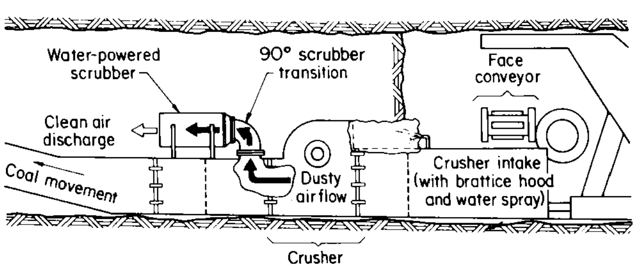

FIGURE 5.—Enclosed stageloader-crusher with a water-powered scrubber.

water at 500 psi for an airflow of approximately 2,000 cfm through the unit. With all controls operating, dust reductions of approximately 75 pct were observed at the headgate operator's position, with a 50-pct reduction in intake dust along the longwall face. The water pressure should be maintained at ~500 psi for most effective results.

PANEL BELT

For three- and four-entry longwall systems, there should be no dust contamination at the face from the longwall panel belt, unless immense quantities of ventilation air are needed for methane control. The belt entry at most of these systems should be on a neutral split of air with perceptible airflow directed away from the face, and into the air return. A properly isolated and regulated belt entry with a check curtain just outby the stageloader can provide this neutral split.

It is not unusual to find longwalls with an inadequately regulated belt entry and a poorly maintained or nonexistent check curtain where the belt entry airflow is towards the face, contaminating the intake air. On some two-entry longwalls, where a portion of the intake air is brought up the belt entry to ventilate the face (under an MSHA variance), dust contamination can be significant.

The significance of belt panel dust contamination of the intake air to the face can be shown by some data from a Bureau study of stageloader-crusher dust controls (3). The longwall was a two-entry system and brought 20 pct of its intake air up the belt entry. Figure 6 shows the longwall headgate area including measured dust concentrations and air quantities. As a result of panel belt dust contamination (2.4 mg/m^3 in 13,500 cfm air), the face intake dust concentration was 0.5 mg/m^3, based on intake air dilution [(13,500 cfm/70,000 cfm) × 2.4 mg/m^3].

Although the stageloader-crusher was the dominant dust source, the 0.5 mg/m^3 dust from the panel belt is significant because it is usually constant throughout

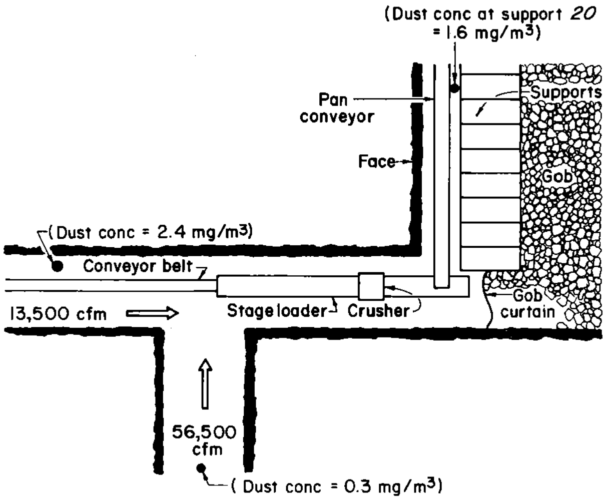

FIGURE 6.—Panel belt dust contamination at a two-entry longwall system.

the shift and represents 25 pct of the Federal compliance limit. If the belt entry could be isolated and the belt entry air could be routed into a return, the panel belt contamination of the face intake air would be eliminated. When the belt entry air is needed at the face or a neutral belt entry is hard to maintain, panel belt dust controls are required. Even if a neutral belt entry can be maintained, panel belt dust should be controlled to keep float dust to a minimum and reduce the panel belt workers' dust exposure.

To prevent the fine dust particles from becoming airborne during transport, the coal should be wetted initially at the face by drum sprays (shearer face) or by sequential face sprays (plow face). A useful guide for water application is 2 to 4 wt pct (4.5 to 9.5 gal/st) (5). Water should be sufficient to wet the coal, but should not accumulate on the floor. A Bureau study (6) of double-drum shearers showed significant reductions in shearer-generated dust, in addition to a 25-pct reduction in the face intake dust at support 8, when the total water applied to the coal, through the drums, was increased from 34 gpm to 48 gpm. The reduction in dust generated by the outby sources, stageloader-crusher and panel belt, could not clearly be established but the increase in water application was felt to have had a positive effect on both crushing and transport.

During outby transport, the water on the coal may evaporate, making rewetting necessary at intervals along the belt. This is accomplished by spraying water onto the coal, far enough inby the transfer point to allow the coal and water to mix, applying between 1 and 4 gpm water at operating pressures of 50 psi or more (7). Flat fan sprays and full-cone nozzles are typically used for coal wetting underground.

Rewetting of the coal can reduce the amount of dust generated during transport. In the above two-entry panel belt dust contamination case, belt entry dust concentration was reduced by 83 pct when the coal was rewetted at the stageloader (3). A spray bar with three hollow cone sprays installed in an enclosed stageloader downstream of the crusher, knocked down the dust in the stageloader and rewetted the coal, thus significantly reducing panel belt dust generation.

Belt maintenance and belt cleaning also control panel belt dust. Missing rollers, belt slippage, and worn belts can cause belt misalignment and create spillage that gets pulverized by the drive pulley on the nonconveying side of the returning belt. The top and bottom of the return belt should be cleaned with spring-loaded or counter-weighted scrapers, to prevent material adhering to the return belt from being pulverized by the tail-end pulley. A low-quantity water spray can also be used to moisten the belt slightly. Other means of cleaning the return belt are a motor-driven rotary wire brush that cleans the conveying side by rotating opposite belt travel (fig. 7), and a full-cone water spray, directed at the nonconveying side, followed by a piece of carpeting (belt wiper) positioned across the belt width (fig. 8). The water spray wets the fines and the carpeting removes them from the nonconveying side. This system yielded more than a 90-pct reduction of airborne respirable and float dust, compared with a dry operation (8).

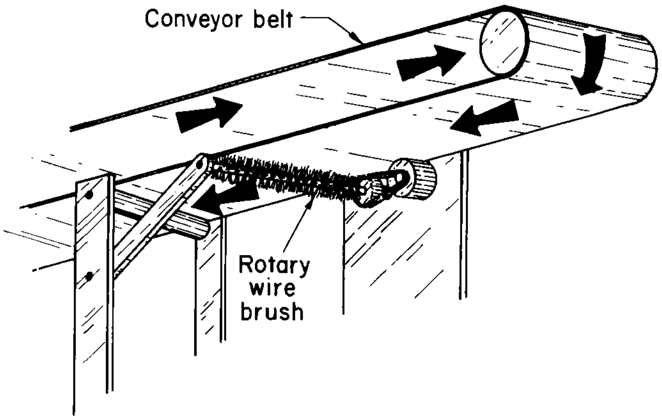

FIGURE 7.—Rotary wire brush cleans conveying side of belt.

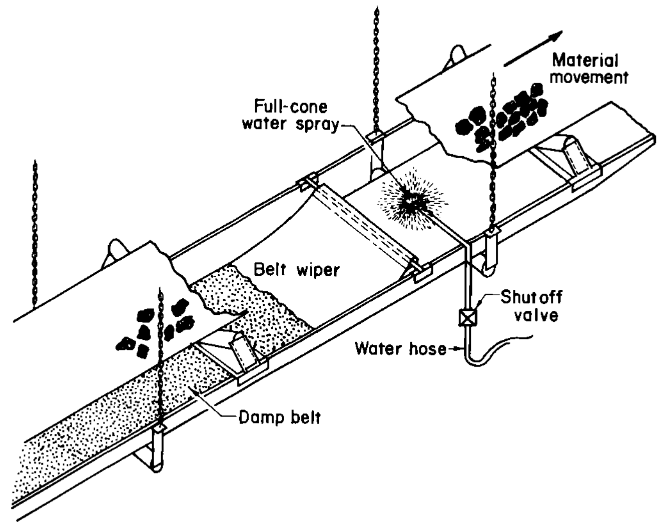

FIGURE 8.—Water spray and belt wiper clean nonconveying side of belt.

INTAKE ROADWAY

Respirable dust concentrations in the intake air at the last open crosscut are usually very low, with no significant effect on face personnel. On a typical longwall, background respirable dust concentrations in the intake air are usually less than 0.3 mg/m^3. However, if the dust concentration in the intake is higher, it will contribute significantly to the dust exposure of face personnel.

Measures to control dust sources upstream of the last open crosscut can be as simple as limiting construction, haulage of supplies, and roadway grading in the intake air during the production shift. If haulage activities must take place during a production shift, the moisture content of the dust on the haulageway floor should be about 10 pct to insure that it remains bound (7). Plain water dries out rapidly in the ventilation air, making repeated applications necessary. Addition of calcium chloride ($CaCl_2$) or another hygroscopic salt maintains the moisture content at the desired level.

SUMMARY

Outby dust sources at a longwall face can contribute significantly to face workers' dust exposure. They include the stageloader-crusher, the panel belt, and the intake roadways. By using recommended dust control practices, the dust at these sources can be adequately controlled. Sometimes several controls must be utilized as a system to control dust from many sources.

The most effective method for eliminating the exposure of face workers to all outby dust sources is homotropal ventilation (tailgate-to-headgate), which places all outby sources downwind of the face workers. However, an auxilliary air split must be maintained for the headgate operator, downwind of the mining activity, and the tailgate entries must be kept in good condition to ensure that intake air reaches the face.

If homotropal ventilation is too difficult or expensive to implement, other effective dust controls can be used on the outby sources. Stageloader-crusher dust controls include adding water sprays or utilizing a scrubber to clean the air inside an enclosed stageloader-crusher. Practices to control panel belt dust are proper belt entry ventilation, water application, belt maintenance, and belt cleaning. Control of intake roadway dust involves reducing the amount of activity in the roadway during the production shift or wetting the roadway to allay dust.

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