CHAPTER 5.—SURFACE MINE DUST CONTROL

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In This Chapter

- ✓ *Drill dust control: wet and dry*
- ✓ *Enclosed cabs on drills and mobile equipment*
- ✓ *Haul road dust control*

Overburden drilling generates most of the respirable dust that affects workers at surface mines. Both wet and dry methods are available to reduce this drill dust. Overburden removal by mobile excavation equipment such as bulldozers, front-end loaders, and haulage trucks can be dusty, particularly under dry and windy conditions. Tightly enclosed cabs with dust filtration systems can substantially lower the dust exposure of both drill and mobile equipment operators. Haul road dust control can be achieved by water application or chemical application.

DRILL DUST CONTROL

Drill dust is controlled with wet or dry systems. Wet systems can be more efficient, but may freeze in the winter. Dry systems require careful maintenance of the drill deck shroud. An improved deck shroud is shown.

Wet Suppression. Wet drilling systems pump water into the bailing air from a water tank mounted on the drill. The water droplets in the bailing air trap dust particles as they travel up the annular space of the drilled hole, thus controlling dust as the air bails the cuttings from the hole [Page 1991].

In wet drilling systems, typical water flow rates are 0.1 to 2.0 gpm depending on the size and type of drill and the moisture level of the overburden. The drill operator controls the flow using a control valve located in the cab. Some drills are equipped with a flow meter to give the operator a visual sign of the flow rate. Raising the water flow will improve dust capture, but too much water causes operational problems. Because of this, the drill operator must exercise care in finding the best water flow rate.

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To operate the drill at the best water flow rate, the operator slowly increases the amount of water just to the point where visible dust emissions abate. The visible dust abatement point is easy to identify. Increasing water flow beyond the dust abatement point does not yield much improvement in dust control, but will most likely cause increased tricone bit degradation and possible seizing of the drill stem. If the cuttings look moist, it usually indicates that too much water is being used. This approach to adjusting the water flow can be effective; however, the time delay between adjusting the valve and expulsion of the cuttings from the hole can be several seconds. Finding the proper water flow is not as crucial with drills using drag bits, but the cuttings still should not look moist. Particular care in finding the proper flow setting must be exercised when drilling through alternating dry and wet strata.

Tests show that wet suppression systems can effectively control respirable dust. In testing, control efficiencies for 8-in holes varied widely, from a low of 9.1% at a flow of 0.2 gpm to a high of 96.3% at a flow of 1.2 gpm. The most significant increase in efficiency is usually between 0.2 and 0.6 gpm. Above this, the efficiency levels off. For those drills tested, a flow rate approaching 1.0 gpm began to cause operational problems [Zimmer et al. 1987].

The most obvious drawback to wet system drilling occurs when the outside temperatures drop below freezing. The entire system must then be heated while the drill is in operation; during downtime the system must be drained.

Dry Collection. Dry collection systems require an enclosure around the area where the drill stem enters the ground. This enclosure is constructed by hanging a rubber or cloth shroud from the underside of the drill deck. The enclosure is then ducted to a dust collector, the clean side of which has a fan. The fan creates a negative pressure inside the enclosure, capturing dust as it exits the hole during drilling. The dust is removed in the collector, and clean air is exhausted through the fan.

The dust that escapes dry collection systems has several possible sources: the shroud around the drill deck, the drill stem access hole in the drill deck, the dust collector dump, and the dust collector exhaust. Determining which is the problem is not difficult. The presence of a visible dust cloud is a good sign that respirable dust is present, even though such clouds are mostly larger-sized particles.

The integrity of the drill deck shroud, including how well it seals to the ground, is probably the single most important factor contributing to the effectiveness of a dry collection system. The shrouded volume under the drill deck should be at least 1.8 times the volume of the hole and should be at a negative pressure of at least 0.2 in w.g. The minimum ratio of dust collector air to bailing air flow recommended for most drills with a rectangular shroud is 3:1, with higher ratios desirable. Openings in the shroud lower its capture efficiency. The most common open area is the gap between the bottom of the shroud and the ground. With a ground gap of 6 to 9 inches or less, dust capture will usually be satisfactory for a 3:1 airflow ratio. However, as the ground gap increases, dust capture efficiency decreases, and a considerable amount of dust may escape [Page 1991].

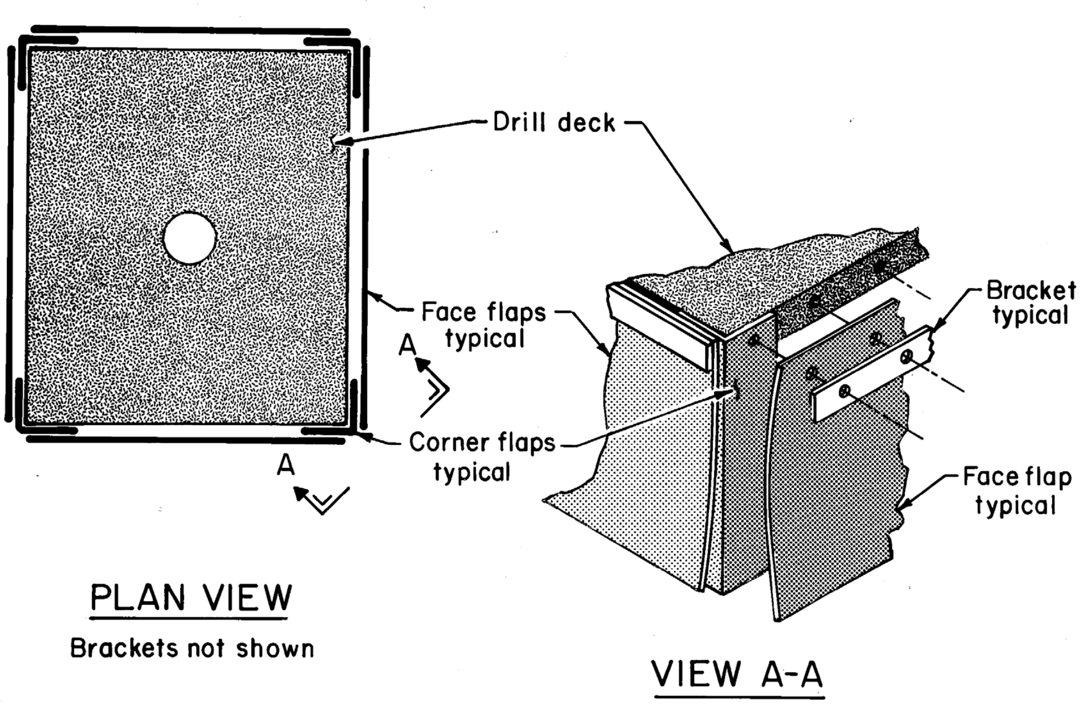

Figure 5-1.—Corner flaps added to a deck shroud to reduce leakage.

During drilling, it is sometimes necessary to raise the drill for two reasons: (1) the driller/helper needs to shovel the cuttings to prevent them from falling back into the hole, and (2) the operator must be able to observe when the coal seam has been reached and stop drilling. As a result, there are times when a ground gap cannot be avoided. However, it is important for good dust control to keep the gap to a minimum.

The effectiveness of the dust collection system also decreases if significant leaks are present from holes in the shroud. Most deck shrouds are rectangular and constructed from four separate pieces of rubber belting attached to the deck. Thus, leakage occurs at the corner seams as the individual pieces of belting separate from one another. Adding corner flaps to the shroud (figure 5-1) [Page and Organiscak 1995] can help to reduce this corner leakage.

Improved shroud design for dry collection systems. A new type of circular rubber shroud is much superior to the traditional rectangular design because it has no corner seams and it can be easily raised and lowered to make a better seal at the ground [NIOSH 1998] (figure 5-2). The circular shroud is attached to the drill deck with steel banding. A second much thicker steel band is attached to the bottom of the shroud to maintain shape and provide weight. The shroud is raised and lowered through activation of a hydraulic cylinder and lift wires attached to the bottom steel band. The bottom can be raised almost to the drill deck and lowered to make contact with the ground after raising and leveling the drill. Raising and lowering of the shroud is helped by using thin sheet rubber and cutting the rubber so the shroud has a slight conical shape. The shroud also has a small trap door that can be manually opened to shovel the cuttings out of

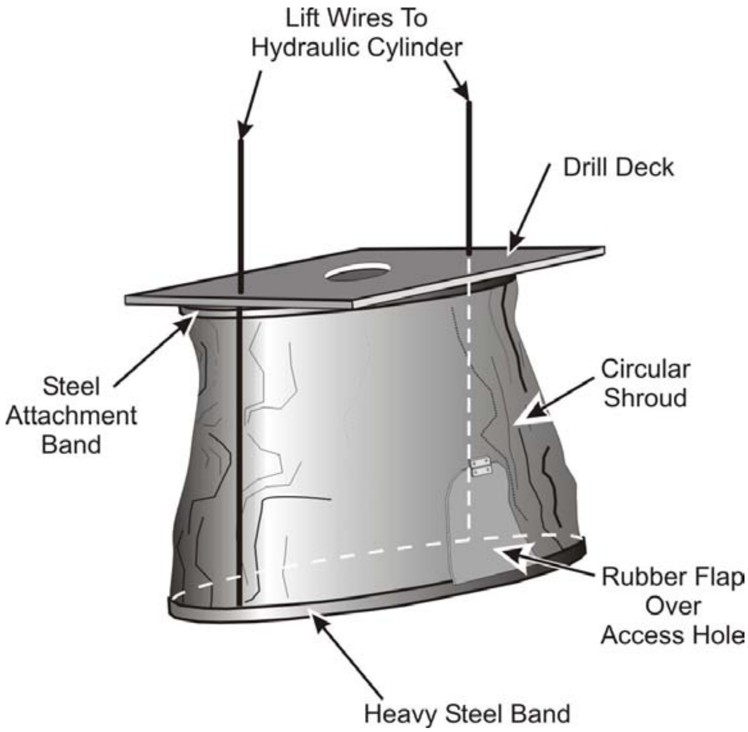

Figure 5-2.—A circular shroud that can be raised and lowered improves dust collection efficiency.

an access hole without having to raise the shroud above the ground and lose dust capture efficiency.

During testing, the circular shroud had a dust reduction efficiency of 99% or better. Comparable tests on the common square shrouds typically achieve 95%, so the amount of dust escaping from the circular shroud is lower by a factor of five.

Maintenance of dry collection systems. A recent field survey of six highwall drills [Organiscak and Page 1999] has shown that proper maintenance is crucial to the performance of dry collection systems. During the survey, the dry dust collection systems on four of the six drills were malfunctioning, and dust levels were very high. The collector fan on one drill was not operating because the drive belts were broken. Another drill had one-quarter of the shroud material missing. The two remaining drills had dust escaping from underneath the shroud due to sloped and uneven ground conditions. When these problems were corrected, dust was reduced by 51% to 88%.

Other maintenance-related dust sources were also identified during this survey. Dust was escaping from torn drill stem seals at the top of the drilling tables. Dust was discharged from a collector's exhaust because the collector filter was torn, and dust was entrained by the wind when the gathered fines in the collector were dumped 4 ft onto the ground. The problems with the drill stem seal and collector discharge were easily fixed by replacing the worn items. Wind entrainment of dust from dumping of the collector was reduced by attaching a cloth shroud to the dust discharge port [Page and Organiscak 1995] and extending it down to within a few inches of ground level.

ENCLOSED CABS ON DRILLS AND MOBILE EQUIPMENT

Enclosed cabs can work well to reduce dust, but high efficiencies require a lot of maintenance. Cab sealing is important.

Dust surveys on drills and bulldozers have shown that enclosed cabs can effectively control the operator's dust exposure. In practice, many enclosed cabs do not provide adequate dust protection [Organiscak and Page 1999]. The cab protection factors (outside versus inside dust level) measured on rotary drills ranged from 2.5 to 84; those measured on bulldozers ranged from 1 to 45. Newer cabs were usually better sealed and cleaner; older cabs tended to be more poorly sealed and dirtier.

Older cabs can be improved by being retrofitted with systems that heat, cool, and filter the air and by being tightly sealed. Both steps are necessary to ensure good dust control. First, the cab needs to have a high quality of recirculated and incoming filtered airflow. Second, the cab structure must be adequately sealed so that clean make-up air pressurizes the cab, keeping out dust that would otherwise be blown in by the wind.

A recent cab retrofit study by Cecala et al. [2002a,b] showed the importance of cab sealing and pressurization. A poorly sealed cab with no pressurization showed no improvement in dust levels even when retrofitted with a new filtration/air-conditioning system. However, a cab retrofitted with a new filtration/air-conditioning system and pressurized to 0.2-0.4 in w.g. gave a protection factor of 52. Another cab pressurized to 0.01-0.15 in w.g. gave a protection factor of 10. An earlier study by Organiscak et al. [2000] also concluded that cabs must be pressurized to offer adequate protection. Very small one-person cabs need at least 25 cfm of make-up air for adequate pressurization, and larger cabs proportionally more. Also, it was found that pressurization must be continuous and the operator must always keep the doors and windows closed. During the study, the operator of one drill opened the cab door to collar the next hole, letting notable amounts of dust enter the cab. Although the operator then shut the cab door during the drilling operation, the air filtration system took about 7 min to remove the dust cloud.

Since positive pressurization cannot be achieved unless cabs are leak-tight, cabs should be checked regularly for leaks. Doors should be on a single hinge, with intact tight gaskets. Bifold and slider doors leak too much. Flexible boots must be on all control linkages entering the cab and the boot seams sealed with silicone caulking. All other seams and gaps should also be sealed with silicone. A flashlight can be used to check for gaps, and a smoke bomb released inside the cab will reveal even the smallest leaks. Older cabs are often hard to seal properly.

Cecala et al. [2002a,b] also make recommendations on the design and installation of filtration/air-conditioning systems. For effective filtration, the system should have two fans, one to recirculate inside air through a filter and a second to pressurize the cab with outside make-up air passed through a second filter. The filters must be designed to trap small-sized respirable dust. About 75% of the air passing through the cab should be recirculated, thus keeping the air-conditioning unit to a reasonable size. The inlet for the make-up air should be located high on the cab and away from outside dust sources [NIOSH 2001a] to extend filter life and reduce air-conditioner maintenance.

Inside the cab, several actions can be taken to reduce dust. Air outlets should be at the top and inlets at the bottom. This top-to-bottom airflow keeps down the dust originating from dirty work clothes, boots, and a dirty floor. Potential dust sources on the cab floor also need to be relocated or removed. The fans on floor heaters will stir up dust, so these heaters should be moved higher up in the cab [NIOSH 2001b; Cecala et al. 2001]. Cab interiors should also be vacuumed and cleaned regularly to remove the dust that drifts in through open windows or is carried in on the operator’s shoes and clothing. In many instances, a thick layer of sweeping compound on the cab floor will reduce dust [NIOSH 2001c].

HAUL ROAD DUST CONTROL

The best dust control method depends on the type of road aggregate. Spillage is a consideration in selecting the dust control.

Many methods are available for haul road dust control. Water application to the road surface is the most obvious, but there are many others. These include:

- *Salts*—hygroscopic compounds such as calcium chloride, magnesium chloride, hydrated lime, sodium silicates, etc. Salts increase roadway surface moisture by extracting moisture from the atmosphere.

- *Surfactants*—such as soaps and detergents. Surfactants decrease the surface tension of water, which allows the available moisture to wet more particles per unit volume.

- *Soil cements*—compounds that are mixed with the native soils to form a new surface. Examples are calcium or ammonium lignon sulphonate, portland cement, etc.

- *Bitumens*—compounds derived from coal or petroleum such as coherex peneprime, asphalt, oils, etc.

- *Films*—polymers that form discrete tissues, layers, or membranes such as latexes, acrylics, vinyls, fabrics, etc.

- *Soil cements, bitumens, and films*—These form coherent surface layers that seal the road surface, thereby reducing the quantity of dust generated.

Chlorides. Chlorides are the most commonly used products for haul road dust control. A study by Rosbury and Zimmer [1983a,b] showed that the highest control efficiency measured for a chemical dust suppressant, 82%, was for calcium chloride 2 weeks after application. Average efficiencies hovered in the 40% to 60% range over the first 2 weeks after application, then decreased with time. After the fifth week beyond application, the limited data show a control efficiency of less than 20%. The effectiveness of chlorides is enhanced by good roadway preparation, that is, a good crown and good drainage at the shoulder. Also, it is helpful to loosen at least 1-2 inches of the existing roadway surface. This allows the chloride to penetrate evenly into the gravel. To enhance dust control efficiency, the roadway surface should not be compacted before applying chlorides.

It is important that the gravel be kept close to the optimum moisture just before applying chlorides. The product will thus be absorbed much more quickly and evenly into the gravel. Chloride should never be applied to dry gravel in that it will not be evenly absorbed and may show failure in spots. Also, rain on a freshly treated surface will leach out and dilute the chloride, causing it to run off the road. Therefore, application should be postponed if rain is forecast for that day.

Water and chemical suppressants. Untreated plain water is commonly used for roadway dust control. The study by Rosbury and Zimmer [1983a,b] showed that watering once per hour resulted in a control efficiency of about 40%. Doubling the application rate increased the control effectiveness by about 15% to 55%. Chemical dust suppressants (primarily salts and lignons) can be more cost-effective than watering under some conditions. However, all chemical dust suppressants (with infrequent watering) share one common failing compared to frequent watering. Material spillage on roadways is very common, and the material spilled is subject to reentrainment. With frequent watering, newly spilled material is moistened at close intervals. When chemicals are applied with infrequent watering, newly spilled material could go for long periods before being moistened. Therefore, in mines where spillage cannot be controlled, watering alone is better for dust control.

In many instances, chemical suppressants have an advantage over plain water. In locations where trackout from an unpaved road to a paved road creates a dust problem, chemical suppressants are a good choice. Watering actually aggravates the trackout problem with moisture and mud; chemical suppressants, particularly bitumens and adhesives, leave the road dry. Finally, some mines have a dust problem in winter when temperatures are subfreezing but little moisture is present. The case for chemical suppressants over water in such instances is clear.

Road aggregate and dust control. Different types of road aggregate dictate different approaches to dust control. Recommendations based on specific road aggregate are:

1. *Gravel with few fines.* In gravel road surfaces with not enough fines, only watering will be effective. Chemical dust suppressants can neither compact the surface (because of the poor size gradation) nor form a new surface, and water-soluble suppressants will thus leach.

2. *Sand.* In compact sandy soils, bitumens, which are not water-soluble, are the most effective dust suppressant. Water-soluble suppressants such as salts, lignons, and acrylics will leach

from the upper road surface. However, in loose, medium, and fine sands, bearing capacity will not be adequate for the bitumen to maintain a new surface.

3. *Good gradation.* In road surfaces with a good surface gradation, all chemical suppressant types offer potential for equally effective control.

4. *Silt.* In road surfaces with too much silt (greater than about 20% to 25% as determined from a scoop sample, not a vacuum or swept sample), no dust suppression program is effective, and the road should be rebuilt. In high-silt locations, the chemical suppressants can make the road slippery and are not able to compact the surface or maintain a new road surface because of poor bearing capacity. Further, rutting under wet conditions requires that the road be graded, which destroys chemical dust suppressant effectiveness. If the road cannot be rebuilt, watering is the best program.

If there is uncertainty about the gradation of the gravel or if there is doubt about the equipment and products to be applied, the process can be tried on a 500- to 1,000-ft test section of the road. If the process fails at the test section level, then only a small investment and time are lost.

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