

# Control Of Dust In Hard Rock Tunnels

by Fred N. Kissell

This article explains how to reduce respirable dust in hard rock tunnels during excavation by tunnel boring machines (TBMs). When dust levels are too high, the dust source must be pinpointed and the ventilation and dust collection systems must be checked. If the ventilation and dust collection systems are working properly, then the water sprays or conveyor dust controls must be upgraded. The management of other air contaminants has been covered elsewhere (Kissell, 1996).

## Finding The Dust Source and Looking for Ventilation Malfunctions

### Taking samples to pinpoint the dust source:

In tunnels with high levels of dust, the first task is pinpointing where the dust enters the airstream. Most dust originates from rock breakage at the tunnel face, but the location where this dust enters the airstream can vary. Dust can leak out from behind the TBM face shield, it can leak from gaps in the ventilation duct, and it can leak from a malfunctioning dust collector. It can be shaken loose from the underside of the belt as it passes over the idlers. Without knowing the exact source, efforts to reduce dust are hit-and-miss.

To locate the dust source, dust samples and air quantity measurements should be taken at the following locations:

- at the portal or at the base of the entrance shaft,
- at a location 1/3 of the way from the portal to the TBM,
- at a location 2/3 of the way from the portal to the TBM,
- at the rear of the TBM trailing gear, about 50 ft towards the portal,
- at the middle of the TBM trailing gear,
- at the front of the TBM trailing gear,
- at the front of the TBM where ground support is installed, and
- at the outlet of any ventilation duct if the outlet is inside the tunnel.

The dust samples can be eight-hour gravimetric filter samples or measurements taken with a light-scattering dust monitor. If a light-scattering monitor is used, repetitive readings must be made to ensure that observed changes in the dust level are not the result of changes in the TBM cutting rate.

Figure 1 gives the results from a dust concentration survey in a tunnel with an exhaust ventilation system. Both gravimetric filter and light-scattering measurements were made at regular

intervals between the portal and the front of the TBM. This figure shows that, for this tunnel, most of the dust breathed by workers entered the airstream between the TBM and the portal, either from the conveyor belt or from a leaking ventilation duct.

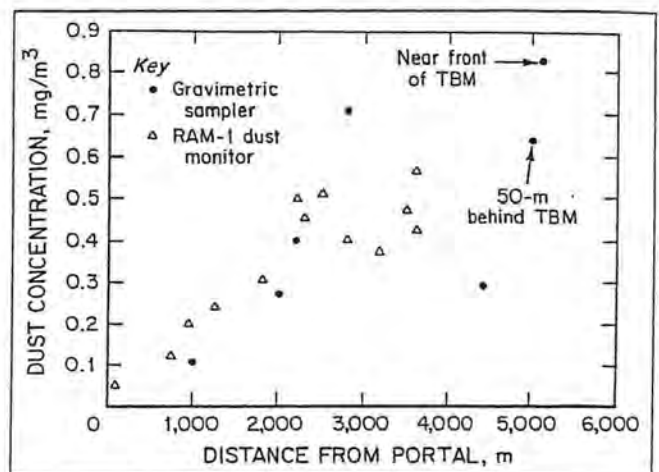


Figure 1: Results from a dust concentration survey.

After the initial sampling, additional measurements in and around the TBM and trailing gear with a light-scattering dust monitor can provide useful information. Possible dust sources at the TBM include leakage from the head or from ventilation duct, emissions from rock drilling and conveyor transfer points, and the stirring of settled dust by work activities and cooling fans. To assess which of these are relevant, a light-scattering dust monitor can be used to measure the dust level close to each suspected source.

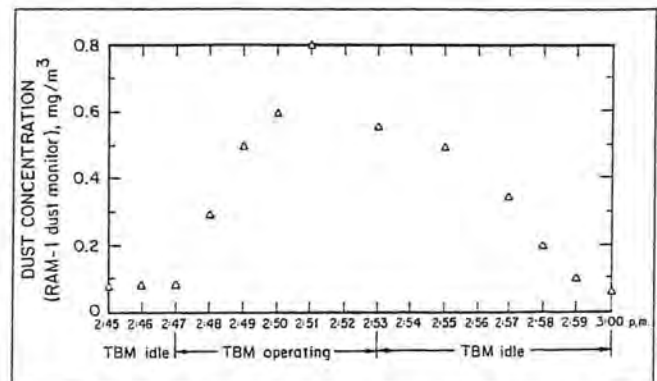


Figure 2: Dust concentration measured near cutter head with TBM idle and operating.

Figure 2 demonstrates the value of additional sampling around the TBM. In this tunnel, the only dust level of any consequence was measured at the front of the TBM near the cutterhead as the cutterhead operated. As the figure shows, the dust concentration rose (with little delay) after the cutterhead began to rotate and immediately dropped when the cutterhead stopped. Rising and falling concentration profiles of this sort were only measured close to the cutterhead, indicating that the dust was leaking out somewhere close to the cutterhead.

#### Checking the ventilation system:

The air quantity measurements, taken at the same locations as the dust samples, are to ensure that the ventilation system is operating properly. Hidden leaks in ventilation ductwork are common, and may cause abnormally low air velocities in a portion of the tunnel. Thus, high dust levels may result from the simple failure to deliver enough air.

Ventilation systems with multiple fans will inevitably leak and recirculate some air. If recirculation is a concern, small holes should be drilled in the ventilation duct and the air pressure checked with the static pressure port of a Pitot tube. Exhaust systems should be under negative pressure, and blowing systems under positive pressure. In multiple fan systems, short regions of ductwork next to the fans may have the pressure reversed, but reversed pressure regions should be a very minor portion of the ductwork.

If the dust concentration at the front of the TBM is much higher than measured elsewhere, check to ensure that the ventilation duct is extended far enough forward. Exhaust ducts must extend as far as the forward-most worker, and ideally an additional 10 ft or more. Blowing ducts must extend to within 20 feet of the forward-most worker, assuming the jet of air emerging from the duct is unobstructed.

Unusually warm air from the TBM electrical equipment may also be an indicator of a malfunctioning ventilation system.

Occasionally, the ventilation system design includes some faults, and faulty designs inevitably result in higher dust levels. A common fault is the failure to provide overlap in auxiliary, or scavenger, systems. Figure 3 shows a properly operating scavenger system. The main fan acts to bring in clean air, and the scavenger fan inlet is located in the clean air stream.

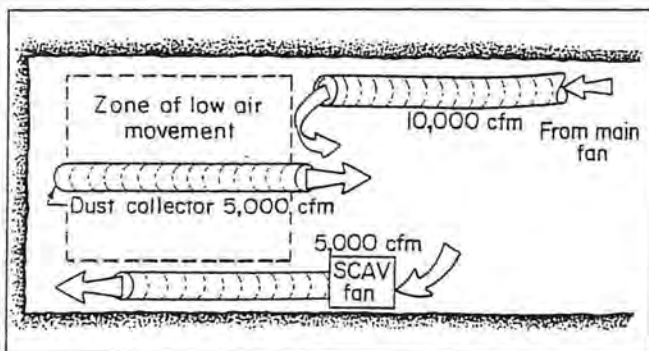


Figure 4: Low velocity zone because ducts have similar air quantities moving in opposite directions.

If the proper overlap between the main duct inlet and the scavenger inlet is not maintained, the scavenger fan picks up contaminated air returning from the face.

Another common problem found in tunnel ventilation systems is the low velocity zone created by moving similar quan-

ties of air through ductwork in opposite directions. For example, Figure 4 shows a tunnel with 5,000 cfm in a scavenger fan fresh air duct and 5,000 cfm in a dust collector duct. Because these two ducts have similar air quantities moving in opposite directions, there is a zone of low air movement between them. Therefore, dust sources in this zone can produce high dust concentrations.

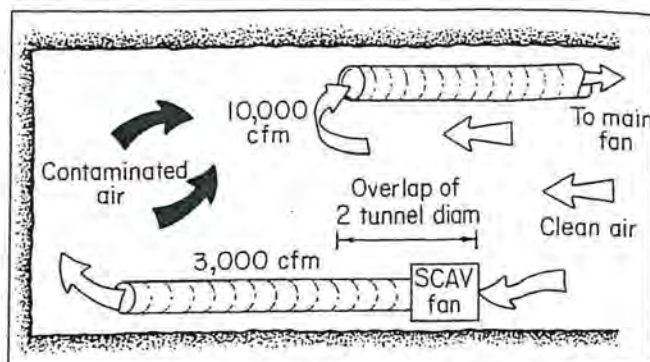


Figure 3: Auxiliary, or scavenger, system with adequate overlap.

If the scavenger fan duct depicted in Figure 4 moved air in the opposite direction, the air quantity delivered to the immediate face area would be increased from 5,000 to 10,000 cfm and the amount of air moving through the zone between the ducts would be 10,000 cfm.

#### Checking the dust collector:

Most dust is removed via the dust collector system, and so it is important that the system works properly. Dust collectors in mines and tunnels can be high-maintenance equipment. Screens and filters clog frequently. Gaskets disappear and access doors leak. Ductwork leading to the collector fills with coarse particulate that cuts off the airflow. Fans located on the inlet side of the collector suffer rapid erosion of their blades. Filters can be improperly seated with air leaking around them. Filters also develop holes from abrasion by larger sized particulate. A dust sample and an air quantity measurement taken in the collector outlet will reveal if the filters are working properly and whether the air quantity is adequate.

### Upgrading The Dust Controls

If no obvious and correctable problem emerges from the dust survey and from the checks of the ventilation and dust collector, it may be necessary to upgrade the water spray system and the conveyor dust controls, as follows:

#### Water sprays:

The role of water sprays is a double one; the first being airborne capture and the second being surface wetting of the broken rock. Of the two, airborne capture is less effective. The typical water spray gives no more than 30 percent capture of respirable dust (Courtney and Cheng, 1977). Because of this, adequate surface wetting of the broken rock is most important. The vast majority of dust particles created during breakage are not released into the air but stay attached to the surface of the rock (Cheng and Zukovich, 1973). Wetting the broken rock ensures that the dust particles stay attached. A key factor is the uniformity with which the rock is wet (Hamilton and Knight,

1957). For example, in coal mining, releasing water near the cutting picks of rotating shearer drums is far more effective at suppressing longwall dust than are external sprays on the shearer body, because the rotating drums act to mix the coal and the water. Increasing the number of sprays can be another way to promote uniformity of wetting. At a longwall shearer (Bazzanella et al, 1986), lowered dust by 60 percent by increasing the number of drum nozzles from 17 to 46, even with the same total water flow rate.

The lessons from this knowledge are two-fold. First, it is best to fully wet the material during the breakage process. This is when most mechanical mixing is likely to take place, and it ensures that the benefits will carry over to any downstream secondary handling operation. Because of this improved mixing, it is better to have an additional 30 gpm at the cutterhead than it is to have 10 gpm at each of three conveyor transfer points downstream. Also, it gives more time for the water to soak in and the excess to drain away. Second, uniformity of wetting is helped by using more nozzles with smaller orifices and by ensuring that the nozzles are aimed at the broken

material rather than just wetting an adjacent metal or rock surface.

As little as 1 pct of moisture on dry rock significantly reduces dust. However, since it is difficult to achieve a uniform application of such a low moisture level underground, the best moisture content might be as high as 5 pct. Whether this much water is always practical is another matter, so one should ensure that the water is being uniformly applied before automatically raising the flow rate. For instance, on a TBM, sprays located on the rotating head will be more effective than fixed sprays at the crown, and sprays aimed to intercept the falling muck will be more effective than sprays aimed at the uncut face.

Aside from efforts to improve spray effectiveness, one of the most helpful actions a contractor can take is to provide some automatic feature that turns sprays on and off as needed. This allows sufficient wetting while helping to avoid the problems associated with overuse of water.

#### Use of Foam:

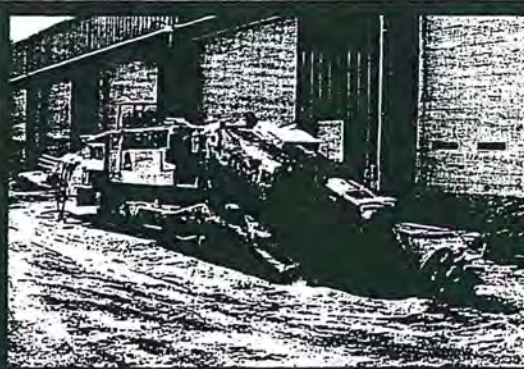
The use of foams for dust control has been extensively studied in coal mines. Here, foam works better than water,

providing dust reductions in the 20 to 60 percent range when compared to water. Foam also can produce similar results at lower water use. Seibel (1976) compared 15 to 20 gpm of high expansion foam to 19 gpm of water at a belt transfer point. Compared to water, the foam averaged 30 percent additional dust reduction. Mukherjee and Singh (1984) found that foam released from a longwall shearer drum cut the dust 50 percent when compared to conventional sprays on the drum. Also, the system used half the water.

The benefits of improved mixing and uniformity of wetting have also been obtained with foam, its effectiveness far greater when the foam was mechanically mixed in with the coal (Mukerjee and Singh, 1984) or silica sand (Volkwein et al., 1983). Page and Volkwein (1986) have published a comprehensive review of foam for dust control in mining and minerals processing. The drawback of foam is high cost.

#### Control of conveyor dust:

Conveyor belts can generate large amounts of dust, and methods to deal with belt dust are well known (Goldbeck and Marti, 1996; Swinderman et al.,



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1997). The following questions must be addressed if belt dust is high:

1. Are transfer points enclosed? A simple enclosure with a spray or two inside of it may be adequate. If this is not enough, the air inside must be exhausted to a dust collector or ventilation duct, with all of the leakage points on the enclosure sealed properly (Swinderman et al., 1997).
2. Is the material being conveyed adequately wet, but not so much that it leaves a sticky mud residue on the belt? When this residue dries, dust is released, and so an end result of excessive wetting can be an increase in belt dust.
3. Are the undersides of both the top and the bottom belts being wet (Ford, 1973) so dust sticking to the belt is not shaken loose by the idlers? Does the belt stay wet or is it drying out and releasing dust?
4. Are the belt scrapers working properly? Is a second set of scrapers being used? Has a belt washing system been installed (Bennett and Roberts, 1988; Stahura, 1987)?
5. Is the belt running true, and not spilling its contents (Swinderman et al., 1997)?

*Fred Kissell is an engineer with the NIOSH Pittsburgh Laboratory, formerly part of the U.S. Bureau of Mines. He specializes in gas and dust control.*

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