Assessment of Respirable Dust Control for Rotary Blasthole Drills at Surface Coal Mines

RAYMOND GADOMSKI and DEBORA L. CHIZ
Mine Safety and Health Administration,
Pittsburgh Health Technology Center

Several studies were conducted to assess respirable coal mine dust levels and evaluate the environmental dust controls used in conjunction with rotary blasthole drills at surface coal mines. Because the quartz content of the material being drilled is often greater than five percent, operators must maintain respirable dust concentrations below a dust standard based on the quartz content of the dust. As a result specialized dust collection equipment is often required to maintain compliance with the applicable standard.

Dust was controlled on each of the drill units evaluated by use of two independent dust control systems. One system used a dust collector to capture and remove dust generated from the drill hole, while the other system, an environmentally controlled cab enclosure, was used to control the amount of respirable dust to which the drill operator was exposed. Dust samples were collected inside the cab enclosure and near the air inlet on the outside of the cab enclosure. While the efficiency of the drill steel dust collection system was not evaluated, the systems were being properly maintained and outside dust concentrations were below 2.0 mg/m^3. Study results indicate that with the additional control obtained from a properly maintained cab enclosure, respirable dust levels at the drill operator position inside the cab could be maintained at or below 0.4 mg/m^3.

Introduction

Among the health hazards associated with the mining industry is the occurrence of several lung diseases known as pneumoconiosis. The two most prominent forms of the disease include coal workers pneumoconiosis (CWP) caused by the inhalation and deposition of coal dust in the lungs, and silicosis, caused by inhalation and deposition of crystalline silica (quartz) in the lungs. Once the dust is deposited within the lungs a process occurs which inhibits the exchange of oxygen and carbon dioxide in the lungs. As this process progresses, disability or even death to the individual can occur.

Since there is no cure for pneumoconiosis the primary focus has been to control the exposure to which an individual is subjected.

Part 71 of Title 30, Code of Federal Regulations sets forth Mandatory Health Standards for Surface Coal Mines and Surface Work Areas of Underground Coal Mines. Part 71.100 sets a respirable dust standard of 2.0 mg/m^3 and Part 71.101 reduces that standard when quartz is present. When the respirable dust in the mine atmosphere of the active workings contains more than 5 percent quartz, the respirable dust standard is computed by dividing the percent quartz into the number 10. This procedure essentially provides for a 100 ug/m^3 standard for exposure to quartz.

As part of routine mine inspection procedures, respirable dust samples are collected on various surface mine occupations. After determining the respirable dust concentration of the sample at the local Mine Safety and Health Administration (MSHA) office, the samples are forwarded to a central laboratory for quartz analysis.

Figure 1 shows information for occupations on which data was obtained for surface mine operations. The number of samples analyzed on each occupation ranged from a low of 14 on the road grade operator occupations to a high of 222 on the bulldozer operator occupation. The solid bar depicts the percent of samples that contained greater than 50 ug/m^3 of quartz and the hatched bar depicts the percent that exceeded 100 ug/m3 of quartz. Thirty-one percent of all the samples (719) analyzed in this program contained more than 50 ug/m^3 of quartz (National Institute for Occupational Safety and Health [NIOSH's] recommended standard for quartz exposure), and approximately 18 percent contained more than 100 ug/m^3 (MSHA's current standard for quartz exposure). The data also shows that the occupations of bulldozer operator, highwall drill operator and highwall drill helper had the highest quartz exposure. Approximately 40 percent of the samples analyzed on these occupations had a quartz content that exceeded 100 ug/m^3

This information indicates the potential for excessive dust exposures containing high levels of quartz for selective surface mining occupations. As a result, the Dust Division

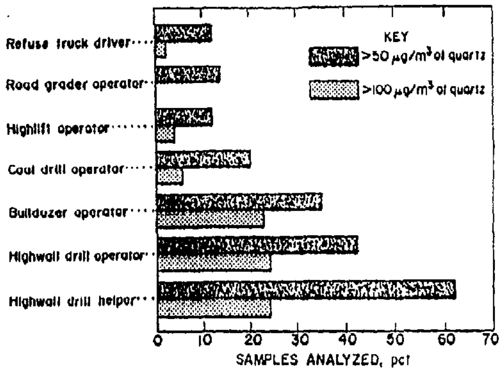

FIGURE 1. Information for surface mine occupations.

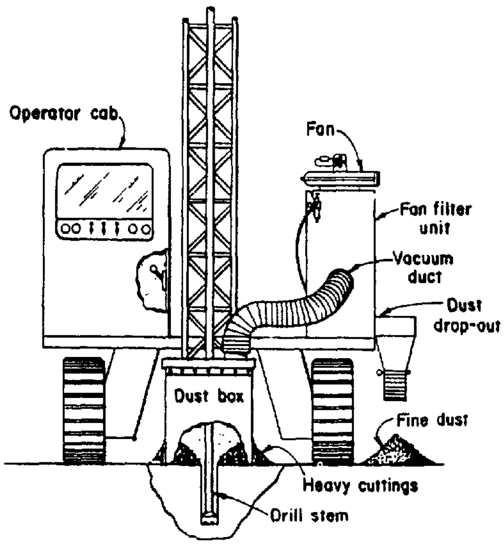

FIGURE 2. Typical dust collector system.

began a program to evaluate the technology that was currently available to control respirable dust exposures for these occupations.

Dust control measures for bulldozers generally are limited to cab enclosures. Dust Control measures for highwall drill operations include both cab enclosures and drill steel enclosures with collectors. Shown in Figure 2 is a typical dust collector system with basic components. Since highwall drills incorporate two dust collection systems, they were selected for evaluation. Through input from various MSHA District Offices, operations were selected for evaluation which used various state-of-the-art dust collection systems. The operations selected were on reduced respirable dust standards. Based on the quartz content of the dust, the standards ranged from 0.5 mg/m3 to 0.8 mg/m^3. The purpose of these studies was to evaluate the efficiency of the environmental dust controls used in conjunction with rotary blasthole drills at surface coal mines.

Description of Operations

The Highwall Drill Systems evaluated included a Driltech, Reedrill and a Bucyrus Eric Drill. (Reference to specific makes of equipment for identification purposes only and does not constitute endorsement by the Mine Safety and Health Administration.) Each of the three drills had an enclosed cab, equipped with an air conditioning/filtration unit and additionally, a dust collection system which surrounded the drill steel and exhausted the dust from around the blasthole. The cab enclosure and air conditioning/filtration systems along with the drill steel and blasthole dust collection systems were optional equipment designed for compatibility with the drills.

The dust collection systems for the drill steel and drillhole of the Driltech and Reedrill were a Kentucky Road Equipments' Electronic Dust Collector and a Metroplex "L" Series Dust Collector, respectively. These collectors draw dust through ducting from a bonnet-hood type apparatus centered around the hole, to an automatic self-cleaning dust collector. The dust collector contains filter elements which are cleaned by an electronically controlled backflushing operation. Dust from the backflushing operation is deposited into a dropout hopper. The dust in the dropout hopper is manually dumped from a remote location after each hole is drilled. Airflow through the collection system is maintained by a fan powered by a hydraulic motor.

The Bucyrus Erie Drill was equipped with an Amerpulse dust control system. The Amerpulse is a continuous cleaning pulse jet dust collector. A duct leads from the dust enclosure over the drillhole to the dust control unit. Dust ladden air is drawn from the blasthole enclosure into the dust collection unit. Air is cleaned in two stages. The first stage is a skimmer which removes the larger particles, the second stage is a diffuser where the smaller particles are filtered. Particles removed in both the skimmer and diffuser area drop into the skimmer hopper. The dump gates on the hopper are air operated and the air cylinders are connected to the same air line as the hoist clutch for the drill steel. When the hoist clutch is activated to remove the drill from the hole, the cuttings are automatically dumped beside the machine.

The cab enclosure on the Driltech and Reedrill had combined air conditioning/filtration units. The cab enclosure on the Bucyrus Eric Drill had separate air conditioning and filtration systems. These systems were designed to condition and filter air entering the cab and at the same time maintain

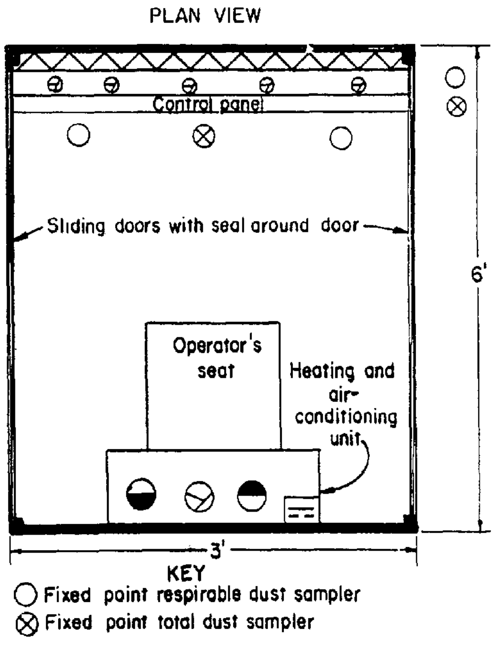

FIGURE 3. Relative locations of the respirable and total dust samplers.

TABLE I

Results of Gravimetric Sampling of Operators Cab of Various Drills Studies

Make/Model of Drill	Condition Sampled	Respirable Dust Concentration, mg/m³ (MRE Equivalent)	
		Inside Cab[a]	Outside Cab
Driltech Model D40-K	Baseline	1.32	1.06
	Operator did not smoke	0.56	1.94
	Installation of new filters	0.20	1.69
Reedrill Model SK-35	Baseline	0.30[b]	1.79
	Installation of new filters	0.29	0.79
Bucyrus Erie Model 45R	Baseline	0.322[b]	0.67
	Installation of new filters	0.31	0.57

[a] Average of two respirable dust measurements.

[b] Average of concentration obtained on two sampling shifts.

the cab under a positive pressure to prevent dust entering the cab through openings in the cab.

Sampling Procedures

Respirable dust samples were collected with approved Mine Safety Applicances (MSA) coal mine dust personal sampler units. The dust samplers were calibrated and operated at a flowrate of 2.0 lpm. The MSA equipment with the 10 mm nylon cyclone removed, was used to take total airborne dust samples. Samples were pre- and post-weighed to 0.01 mg on an electronic analytical balance. Concentrations for the respirable samples were converted to Mining Research Establishment Instrument (MRE) equivalent concentrations by multiplying by the factor 1.38.(1) Respirable dust samples were analyzed for quartz content by infrared spectroscopy. Total dust samples were particle sized with a Model TA II Coulter Counter(2) using a 50 um aperture tube to classify particles, ranging in size from 0.79 to 25.41 um, into 16 size intervals.

To evaluate the performance of the dust collection systems on the various highwall drills, respirable dust samples were collected inside and outside the operators' cab. Samples collected inside the cab included two respirable dust samples and a total dust sample. One respirable sample and a total sample were collected at a fixed point approximately two feet from the operators controls. This location was typical of the position used when collecting samples for compliance purposes. The other respirable sample collected inside the cab was collected at a fixed point near the discharge of the air conditioning/filtration unit. Respirable and total dust samples were also collected at two locations outside the cab. One set of samples was collected near the drill steel. The other set of samples was collected near the inlet of the cab air conditioning unit. The relative locations of the samples are shown in Figure 3. All respirable dust samples were collected for eight hours of the ten-hour work shift.

A differential pressure measurement was taken using a Dwyer Magnehelic gauge to determine if a positive pressure existed inside the cab. Chemical smoke tubes were also utilized to determine if any air leaks were present in and around

TABLE II

Respirable Dust Concentration at Various Times After Cleaning of Dust Filtration Systems on Rotary Blasthole Drills

	Respirable Dust Concentration, mg/m³	
	Inside Cab	Outside Cab
Driltech Model D40-K		
Basline	1.32	1.94
After Installation of New Filters	0.20	1.69
After 30 working shifts	1.15	1.82
Reedrill Model SK-35		
Basline	0.30	1.79
After Installation of New Filters	0.29	0.79
After 5 working shifts	0.36	1.55
After 10 working shifts	0.35	0.50
After 25 working shifts	0.25	2.41

TABLE III

omparison of Fixed Point Samples Collected Inside ne Cab and Personal Samples Collected on the Drill Operator

	Respirable Dust Concentration, mg/m^3	
	Fixed Point	Operator Sample
Reedrill Model SK-35	0.24	0.27
	0.37	0.36
	0.29	0.30
	0.36	0.37
	0.35	0.46
	0.23	0.34

door seals of the cab and the ducting running to the dust lector unit.

After each survey was completed, the dust samples were ghed and the respirable dust concentrations computed he near 0.01 mg/m^3. These samples were then analyzed quartz.

sults and Discussion

Table I shows the gravimetric sampling results of rators cabs of various drill studies. Samples were taken de and outside the cab to establish a baseline so a comison of the dust levels could be made before and after the allation of new filter. Initial dust levels inside the cab ged from 0.30 mg/m^3 to 1.32 mg/m^3. Dust levels, after nging the filters, decreased in all the cabs, ranging from mg/m^3 to 0.31 mg/m^3. The Reedrill and the Bucyrus- dust concentrations inside the cab decreased by three cent. The Driltech concentration decreased by 84 per- t.

n addition to filter maintenance, various work practices contributed to maintaining the dust levels. Good sekeeping which includes keeping the cab free of debris periodic wet mopping of the cab can also contribute to er dust levels inside the cab.

or these three drills, keeping doors and windows of the closed tightly did not significantly effect the dust levels de the cab. This, however, was due to the fact that the air ation systems did maintain a slight positive pressure in- the cab. Prior to changing filters the positive pressure de each cab was approximately 0.01 inches of water. r changing the filters the positive pressure inside the s ranged from 0.03 to 0.04 inches of water. This increased itive pressure also indicates that after cleaning the cab iltration system more airflow is induced into the cab.

n two of the drills, efforts were made to determine the expectancy of the filters. Sampling was conducted at ous intervals following filter replacement. Results of e samples for the Driltech and Reedrill are given in le II. In this case of the Driltech, samples were collected ediately before and after the installation of a new filter then after 30 working shifts. Immediately after the filter change, there was an 85 percent decrease in concentration. However after 30 shifts, the concentration was seen to increase indicating a deterioration of the filter. In an attempt to determine more precisely when the system begins to deteriorate additional incremental sampling was conducted during the study of the Reedrill. As seen in Table II the deterioration of the filter was not as clearly defined as the study of the Driltech indicated.

In addition to evaluating dust levels inside and outside the cab, a comparison was made between the fixed point sample collected inside the cab and the personal sample worn by the operator. The fixed point sample location was typical of the location monitored for enforcement sampling and evaluation of the dust collection system. Table III shows the results of fixed point samples collected inside the cab and personal samples collected on the drill operator. A comparison of the fixed point samples and the personal samples collected on the operator shows that the samples collected on the operator were slightly higher than the fixed point sample. This difference can possibly be attributed to the fact that the operators' duties require work outside the cab approximately 15 percent of the time.

While a fixed point sample inside the cab approximates the operators' dust exposure, it may not be representative of a helpers' exposure if a helper is required to perform work outside the cab. As evident from sample results, dust levels outside the cab are significantly higher than dust levels inside the cab.

Table IV summarizes the quartz determinations made on respirable dust samples collected during these evaluations. The quartz values for the samples collected inside and outside the cab are shown. Although, the quantity of dust collected for some samples was less than normally utilized for quartz analysis, the data indicates that the quartz content of samples collected inside the cab were consistently less than those collected outside the cab. The data also indicate that the filtration systems were selectively removing quartz from the filtered air.

TABLE IV

Comparison of Quartz Levels Inside and Outside of Cabs of Rotary Blasthole Drills

	Percent Quartz	
	Inside Cab	Outside Cab
Reedrill Model SK-35		
Baseline	3	7
Baseline	6	11
After Installation of New Filters	7	13
After Installation of New Filters	13	15
After Installation of New Filters	3	6
After Installation of New Filters	9	16
Bucyrus Erie Model		
Baseline	13	29
Baseline	12	6
After Installation of New Filters	11	26

TABLE V

Particle Size Distribution

Particle Size (um)	Inside Cab		Outside Cab	
	% Mass	Cumulative %	% Mass	Cumulative %
1.00	5.01	5.01	1.01	1.01
1.26	5.91	10.93	1.30	2.31
1.59	7.11	18.05	1.78	4.10
2.00	9.12	27.17	2.57	6.67
2.52	9.36	36.54	3.22	9.90
3.18	9.73	46.27	3.84	13.74
4.01	10.84	57.12	5.19	18.94
5.05	8.05	65.17	6.01	24.96
6.36	10.19	75.37	7.46	32.42
8.01	11.78	87.15	8.27	40.70
10.09	8.56	95.72	8.36	49.06
12.71	4.27	100.00	11.01	60.08
16.01	0.	100.00	7.33	67.41
20.17	0.	100.00	9.77	93.48
25.41	0.	100.00	6.51	100.00

Particle size distribution of the samples inside and outside the cab, were analyzed on a Model TA II Coulter Counter and the results are shown on Table V. The data gives a fraction of the total number of particles in any size range. The mass median diameter of the dust inside and outside the cab is 3.5 um and 10.0 um with standard deviations of 2.1 and 2.9, respectively. This information indicates that in addition to selectively removing quartz, the filtration systems were also removing the larger particles from the air.

Conclusions and Recommendations

Based on the sampling results obtained from each study, and observations made throughout the studies, several conclusions and recommendations can be made.

1. For each study, compliance with a reduced dust standard was achieved.
2. The dust collection systems, air filtering systems and seals on the door enclosures of the drill cab combined with the operators' work practices can maintain dust levels in the cab below the reduced standards.
3. Air filtering systems should be checked and cleaned and/or filters replaced on a regular basis.
4. Fixed point dust concentrations inside the cab may not be indicative of the drill operator's helper exposure since his duties require him to perform work outside the cab.
5. The cab or work enclosure should be maintained under a positive pressure to prevent dust from entering from the outside environment. Periodic replacement of air filters will increase the positive pressure in the cab and permit maximum air delivery of the filtration system

In addition to these conclusions and recommendations, the following work practices observed should be followed to minimize environmental contamination.

1. Excessive quantities of dust should not be allowed to build up in an enclosed cab. The interior of the cab should be vacuumed or wet mopped on a regular basis.
2. Seals on the doors and windows of the cab should be

maintained. In addition to helping to maintain a positive pressure in the cab, good seals may result in lower noise levels within the cab.

moking can contribute significantly to the respirable dust determination of a confined area such as an enclosed cab. This practice should be discouraged to he extent possible.

Minimize, to the extent practicable, the opening of he doors of the cab.

Maintain a program that encompasses a check for eaks of the hose and duct system of the dust collector on the drill. Leaks in the ducting results in a lowering of the air flow design factor of the collector resulting in the unit operating at less than its maximum capability.

Acknowledgment

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