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Comparison of Respirable-Dust Concentrations Measured With Personal Gravimetric Sampling Instruments Operated On-Section and Portal-to-Portal

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COMPARISON OF RESPIRABLE DUST CONCENTRATIONS MEASURED WITH PERSONAL GRAVIMETRIC SAMPLING INSTRUMENTS OPERATED ON-SECTION AND PORTAL-TO-PORTAL

by

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ABSTRACT

Proposed changes in Part 70 of Title 30, Code of Federal Regulations (CFR), will require respirable dust sampling of all active working areas of a mine outby the working face. Respirable dust samples are required to be collected portal-to-portal. This report describes a study conducted to determine if area samples collected only during on-section time could be used to assess average full-shift respirable dust concentrations in outby areas of a mine where men work and travel.

The results of the study showed that on-section measurements were linearly related to portal-to-portal measurements. A relationship established between portal-to-portal and calculated time-weighted average measurements showed that for respirable dust concentrations of 2.0 milligrams per cubic meter of air, portal-to-portal exposures could be estimated to within 15 percent. The results also showed that measurements representative of the intake airways may not be representative of an individual's exposure while traveling to and from the working place.

INTRODUCTION

Proposed changes in Part 70 of Title 30, CFR, will require respirable dust sampling of all active working areas of a coal mine outby the working face. Proposed Part 70.211 requires:

> A respirable dust sample shall be taken and transmitted during the first month of each bimonthly period, beginning with the bimonthly period of _____, 19 ___, with respect to the designated sampling points in areas of a mine in which miners work or travel. The Coal Mine Health and Safety District Manager may allow these samples to be taken during the second month of the bimonthly period if the mine operator provides an acceptable reason that these samples could not be submitted during the first month of the bimonthly

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period. The samples shall be taken on production shifts at locations of the mine designated by the operator in the approved respirable dust control plans required by §70.300. The plans shall include designated sampling points for areas of active workings such as along haulageways and travelways; transfer, loading and dumping points; central shops; and in such other areas as may be required by the District Manager.

With respect to this Part, respirable dust sample means a sample collected portal-to-portal with an MRE instrument or any other sampling device approved by the Secretary of the Interior and the Secretary of Health, Education and Welfare.

Because it is recognized that transporting and operating area sampling equipment portal-to-portal may entail some logistics problems when large mining operations require extensive area sampling, a program was conducted to determine if on-section time dust measurements could be used to assess the average full-shift respirable dust concentrations in outby areas of a mine where men work and travel. This report describes a study conducted to compare respirable dust concentrations determined from area samples collected portal-to-portal with those collected only during on-section time.

PROCEDURES

The study was conducted in a large 10-section mine utilizing mining methods, equipment and haulage systems typical of those used throughout the coal mining industry. Nine sections were being mined with continuous mining machines and one section with a longwall plow. Shuttle car, belt and rail haulage systems were employed, resulting in a variety of different types of loading and transfer points.

Five sampling packages, each containing two personal respirable dust sampling instruments, were located near areas of dust generation in the mine. One package was located at the dump point on each of three continuous mining sections and two packages were located on a longwall section; one approximately 15 feet in front of the longwall face within 20 feet of the main return airway (stall area) and the other at a belt-to-belt transfer point (cross belt). One personal sampling instrument from each package, designated the portal-to-portal sampler, was started at the portal a few minutes before entering the mine and worn during travel in the man-trip car to the mining section. Upon arrival at the section, the portal-to-portal sampler was placed in the appropriate package, and the remaining sampler, designated the on-section sampling instrument, was turned on. At the end of the shift, the on-section sampling instrument was turned off, and the operating time for the instrument recorded. The portal-to-portal sampling instrument was removed from the package and worn while traveling from the section to the surface, where it was turned off and the sampling time recorded.

MRE[4] sampling instruments were located in the main intake airways (haulage roads), positioned approximately 4 feet from the rib with inlets perpendicular to the airflow. The MRE sampling instruments were used to measure the average intake air concentrations, which were assumed to be the exposure of the mining personnel while traveling to and from the working section.

All sampling equipment was calibrated prior to beginning the study. Personal respirable dust samplers were calibrated to respire 2.0 ± 0.1 liters of air per minute; MRE samplers were calibrated to respire 2.5 ± 0.1 liters of air per minute.

Respirable dust concentrations obtained with personal sampling instruments were converted to equivalent MRE concentrations by multiplying by the factor 1.38.[5]

ANALYSIS OF DATA

The comparative portal-to-portal and on-section concentration measurements are depicted in columns 1 and 2 of table 1. Relationships were derived between the portal-to-portal and on-section concentration measurements, portal-to-portal and on-section concentration measurements normalized to the portal-to-portal sampling time (column 3), and portal-to-portal and calculated time-weighted average concentration measurements (column 4).

TABLE 1. - Respirable dust concentrations, mg/m^3, MRE equivalent

1 Portal-to-portal	2 On-section	3 Normalized on-section	4 Time-weighted average	5 Measured intake air	6 Traveltime, min	7 Calculated intake air
2.3	3.0	1.8	2.1	0.8	190	1.2
0.8	1.7	0.7	1.2	.8	275	.1
4.4	5.1	2.9	3.2	.8	210	3.5
2.0	3.4	2.2	2.4	.8	183	.0
3.6	4.4	3.2	3.4	.8	132	1.5
1.0	2.0	1.2	1.5	.8	210	.0
3.6	4.1	2.7	3.1	.8	158	2.4
3.6	4.3	2.9	3.2	.8	153	2.1
1.7	2.8	1.9	2.1	.8	167	.0
2.2	2.7	1.9	2.1	.8	149	1.1
1.4	1.6	.9	1.2	.8	221	1.2
3.4	4.7	2.9	3.1	.8	200	1.6
2.2	2.8	1.7	2.0	.8	182	1.2
2.4	4.4	1.1	2.9	.8	196	.0
2.4	3.8	2.3	2.5	.8	202	.5
.8	.8	.6	.8	.8	139	.8
.7	.7	.4	.7	.8	124	.7
.8	.9	.6	.7	.3	175	.6
1.4	1.9	1.4	1.5	.3	114	.0
1.6	1.6	1.3	1.3	.3	100	1.6

[4]Isleworth Model 113A four-channel, horizontal elutriator, gravimetric respirable dust sampling instrument developed at the Mining Research Establishment of the National Coal Board, Isleworth, England.

[5]Tomb, T. F., and others. Comparison of Respirable Dust Concentrations Measured With MRE and Modified Personal Gravimetric Sampling Equipment. U.S. Bureau of Mines RI 7772, 29 pp.

The normalized on-section measurements were calculated using the equation:

$$C_{osn} = C_{os} \ (t_{os}/t_{p-p}),$$

where C_{osn} = normalized on-section concentration, mg/m^3,

C_{os} = on-section concentration, mg/m^3,

t_{os} = on-section sampling time, minutes,

and t_{p-p} = portal-to-portal sampling time, minutes.

Calculations using this equation are based on the assumption that the intake air concentration (exposure during traveltime) is zero.

The time-weighted average concentrations were calculated using the respective traveltimes (column 6) and intake air concentrations (column 5) for the shifts sampled. The concentrations were calculated using the equation:

$$C_{TWA} = \frac{(C_{os} \ t_{os}) + (C_{ia} \ t_t)}{t_{p-p}},$$

where C_{TWA} = time-weighted average concentration, mg/m^3,

C_{ia} = intake air concentration, mg/m^3,

and t_t = traveltime, minutes.

The method of least squares was used to derive regression lines relating portal-to-portal, on-section, and adjusted on-section measurements. The standard errors of estimate, $S_{y/x}$, and correlation coefficients, r, were also calculated for the regression lines determined. The standard errors of estimate were used to evaluate the relative degree of spread about the three regression lines and the correlation coefficients used as a measure of the degree of linearity between the respective variables.

Because a one-to-one relationship was not obtained when the difference in sampling time and respirable dust exposure during traveltime were taken into account, the intake air concentrations necessary to obtain the time-weighted on-section concentrations equal to the measured portal-to-portal concentrations were calculated using the following equation:

$$C_{iac} = \frac{(C_{p-p} \ t_{p-p}) - (C_{os} \ t_{os})}{t_t},$$

where C_{iac} = calculated intake air concentration, mg/m^3,

and C_{p-p} = portal-to-portal concentration, mg/m^3.

The values determined for the calculated intake air concentrations are listed in column 7.

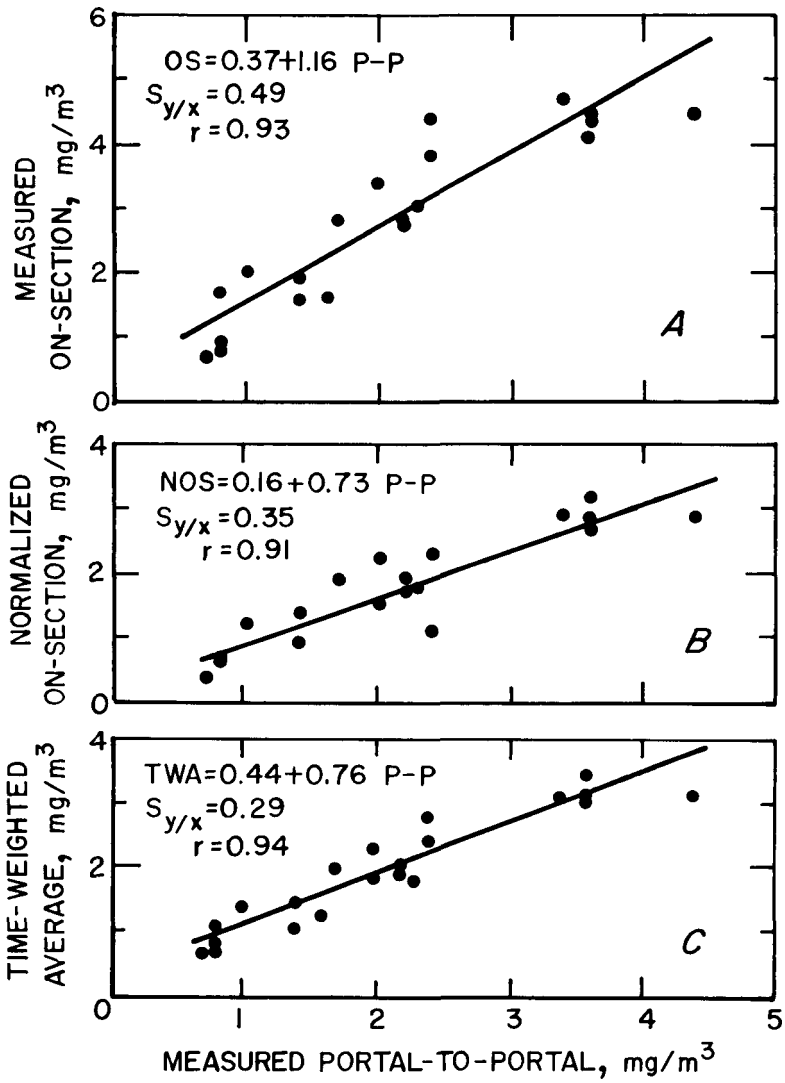

FIGURE 1. - Comparison of on-section and portal-to-portal respirable dust measurements.

DISCUSSION OF RESULTS

The least squares regression lines, defining the relationships derived between portal-to-portal and on-section and adjusted on-section measurements, are shown on figure 1. The correlation coefficients calculated for the respective relationships show that the on-section and adjusted on-section measurements are linearly related to the portal-to-portal measurements.

The relationship derived between portal-to-portal and on-section measurements, figure 1A, shows that on-section concentration measurements are significantly greater than those determined portal-to portal. The reason for this is the extensive time required to travel to and from the working sections.

The relationship derived using the normalized on-section measurements, figure 1B, shows that during this study approximately 25 percent of a miner's full-shift exposure occurred during travel to and from the working place. When the intake air and on-section measurements are used to calculate a time-weighted average concentration for the shift, the relationship between the C_{TWA} and portal-to-portal measurements, figure 1C, indicate that exposure during traveltime is greater than the measurements obtained in the intake airways. By forcing the intercept of the regression line, shown in figure 1C, to be 0.1 mg/m³ (by adding a sufficient number of zero pairs to the data), the parameters defining the adjusted relationship becomes:

$$C_{TWA} = 0.1 + 0.85\ C_{p-p}.$$

This adjusted regression equation indicates that exposure during travel is approximately 15 percent greater than measurements obtained in the intake airways. The difference between measured and calculated intake air

concentrations is also depicted in table 1. The measured intake air concentrations are the average concentrations along the motor road during the entire shift and, as evidenced by the data, do not necessarily represent the exposure encountered during travel to and from the working section. It is hypothesized that the higher calculated values were due to resuspension of settled dust that occurred from movement of the transportation vehicles.

It should be emphasized that in this particular study, the traveltime was disproportionally high. For most operations, total traveltime will not exceed 2 hours or one-fourth of the full shift. Therefore, it would be expected that on-section and portal-to-portal measurements should not differ by more than 25 percent, and that calculated C_{TWA} concentrations should be within 10 percent of portal-to-portal concentrations.

The relationship established between the calculated C_{TWA} and portal-to-portal measurements had the highest correlation coefficient ($r = 0.94$) and the lowest standard error of estimate ($S_{y/x} = 0.29$ mg/m^3). These data indicate that for a respirable dust concentration of 2.0 milligrams per cubic meter of air, portal-to-portal concentrations could be estimated to within 15 percent using a calculated C_{TWA}.

SUMMARY AND CONCLUSIONS

Current regulations promulgated to enforce the Federal Coal Mine Health and Safety Act of 1969 and proposed revisions to those regulations require mine operators to collect accurate samples of the quantity of respirable dust in the mine atmosphere to which each miner is exposed.

The procedures used to collect accurate samples of the quantity of respirable dust requires full-shift (portal-to-portal) measurements to be obtained. A study[6] conducted to evaluate the feasibility of employing area sampling to enforce the respirable dust standard in underground coal mines demonstrates that there may be some logistics problems encountered in transporting and operating area sampling equipment portal-to-portal. Consequently, a program was conducted concurrently to determine the feasibility of using on-section time dust measurements to assess the average respirable dust concentration in outby areas of a mine where men work or travel.

In this study, respirable dust measurements obtained portal-to-portal were compared to measurements obtained only during the time personnel were working on the section. The portal-to-portal measurements were also compared to the on-section measurements after they had been normalized for traveltime, and after they had been used to calculate a full-shift, time-weighted average concentration.

The results from this study showed that on-section and adjusted on-section measurements were linearly related to portal-to-portal measurements. A

[6]Tomb, T. F., and R. S. Ondrey. Determining the Feasibility of Area Sampling To Enforce the Respirable Dust Standard in Underground Coal Mines. MESA IR 1037, 9 pp.

relationship established between the portal-to-portal and calculated C_{TWA} measurements showed that for a respirable dust concentration of 2.0 milligrams per cubic meter of air (the respirable dust standard) the portal-to-portal concentration could be estimated to within ±15 percent. The results also showed that respirable dust concentrations measured in the intake airways may not be representative of an individual's exposure while traveling to and from the working place. It was estimated that individual exposure levels during traveltime were approximately 15 percent greater than concentrations measured in the intake airways.

These results demonstrate that it may be feasible to assess the average full-shift respirable dust concentration in outby areas of a mine using on-section time dust measurements if dust levels to and from the workplace are used to adjust the on-section measurements.

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