EFFECT OF BELT AIR ON DUST LEVELS IN UNDERGROUND COAL MINES

by

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ABSTRACT

On January 27, 1988, the Mine Safety and Health Administration published proposed ventilation standards for underground coal mines. Included in this standard was a proposal that would permit, under certain conditions, the use of belt air to ventilate working faces. Because of concerns regarding the impact that belt air use could have on miner health and safety, the Secretary of Labor appointed an Advisory Committee to assess the belt air issue. This committee began its evaluation in June, 1991.

One of the issues evaluated by that committee was the impact of belt air use on dust levels in the face area. The committee concluded that the use of belt air could increase or decrease dust levels; however, the change would not have a significant impact on face worker dust exposures. The committee further recommended that a designated area with a 1.0 mg/m^3 standard be established when belt air is used to ventilate the face. This designated area would be in the belt entry just outby the section tailpiece.

Several specific concerns were addressed during the Advisory Committee meetings. These specific concerns included:

1. the effect on intake dust levels when belt air is used at the face;
2. the effect on worker exposure when belt air is used at the face; and,
3. the potential entrainment of dust in the belt entry.

The purpose of this paper is to review the specific issues related to respirable dust when belt air is used to ventilate the working face, and provide the data used to evaluate the impact of belt air.

INTRODUCTION

On January 27, 1988, the Mine Safety and Health Administration (MSHA) published a proposed ventilation standard for underground coal mines. This standard would permit the use of belt air to ventilate working faces provided that among other things, an Atmospheric Monitoring System (AMS) is installed in the belt entry. Other proposed safeguards include a minimum 50 fpm belt entry air velocity, the use of nonflammable conveyor belt and maintenance of dust levels below a 1.0 mg/m^3 standard.

MSHA also conducted a study to obtain information relative to existing belt ventilation practices (U.S. Department of Labor, 1989). In this report, MSHA identified three general methods used to ventilate belt entries of underground coal mines. These methods are depicted as Case 1, 2, and 3 in Figure 1. Case 1 depicts when all the belt air is being directed into the return through a regulator. This includes the case where belt air is being coursed outby from the face. Case 2 shows the situation where a portion of the belt air is directed to the return and a portion of the air leaks to the face. Case 3 shows the situation where all of the belt air is directed to the face.

Current regulations require Case 1 type ventilation, unless a petition for modification has been approved. However, due to inaccuracies in airflow measurement techniques, and the low pressure differentials between belt and return entries, Case 2 belt ventilation systems can occur without detection. Both Case 2 and Case 3 belt ventilation systems course air over the section loading point and to the active face. When this occurs, dust from both the belt entry and the section loading point are directed into the face area.

This use of Case 2 or Case 3 belt entry ventilation has led to concerns relative to effects on respirable dust levels. These concerns include:

1. The effect on intake dust levels when belt air is used at the face;
2. The effect on worker exposure when belt air is used at the face; and,
3. The entrainment of dust in the belt entry.

From August thru September, 1991 MSHA conducted a short term Spot Inspection Program (SIP) (U.S. Department of Labor, 1993) to assess the actual dust levels and the extent of dust controls used in the coal mining industry. Results of analysis of the SIP data showed that for sections that used belt air to ventilate the face, the intake dust concentration was higher by 0.18 and 0.12 mg/m^3 for continuous miner and longwall sections, respectively. However, for sections that used belt air to ventilate the face, the designated occupation dust concentration was lower by 0.64 and 0.33 mg/m^3 for continuous miner and longwall sections, respectively.

In addition to the studies conducted during the Belt Entry Ventilation Review, and the SIP, MSHA has conducted a number of studies on individual longwall sections which utilize belt entry airflow to ventilate the working face. The purpose of this paper is to review and summarize these studies and to determine the impact on respirable dust levels when belt air is used to ventilate the working face.

EFFECT ON INTAKE AIR DUST LEVELS WHEN BELT AIR IS USED TO VENTILATE A FACE

Figure 2 shows a schematic of a longwall section with the belt entry located adjacent to the solid block of coal. Ventilation direction is indicated by the arrows. Typical dust sources in belt entries can include transfer points, overcasts, box checks, crushers/feeders, and belt rollers.

Control technologies have been developed and demonstrated to be effective in controlling the amount of airborne dust in a belt entry. These technologies include dilution by airflow, water sprays, belt scrappers, enclosures and dust collectors. The Bureau of Mines (Organiscak, 1986 and Potts, 1992) has evaluated the effectiveness of these controls.

U.S. regulations require that the respirable dust level within 200 feet of a working face be maintained at or below 1.0 mg/m^3. On a longwall section where belt air is not used, this measurement would be typically taken in the intake crosscut. On a longwall section where belt air is used to ventilate the face, a 1.0 mg/m^3 designated area (DA) would typically be established (via a 103c Petition for Modification) in the belt entry outby the stageloader. The actual intake respirable dust concentration is a combination of these two measurements.

This combined intake respirable dust concentration can be calculated by weighting the dust concentrations with the respective airflows using the following formula:

$$C_c = \frac{(C_i \times Q_i) + (C_b \times Q_b)}{Q_i + Q_b} \qquad \text{(Equation 1)}$$

where:
- C_c = Combined Intake Dust Concentration, mg/m^3,
- C_i = Intake Entry Concentration, mg/m^3
- C_b = Belt Entry Concentration, mg/m^3
- Q_i = Intake Air Quantity, cfm
- Q_b = Belt Air Quantity, cfm.

Individual contributions of intake and belt to the combined intake respirable dust concentration were calculated using the following formula:

$$C_{ci} = \frac{(C_i \times Q_i)}{Q_i + Q_b} \quad \text{and} \quad C_{cb} = \frac{(C_b \times Q_b)}{Q_i + Q_b} \qquad \text{(Equation 2)}$$

where: C_{ci} = Individual Contribution of Intake Dust Concentration, mg/m^3,

C_{cb} = Individual Contribution of Belt Dust Concentration, mg/m^3.

MSHA has conducted studies to assess the impact of belt air use on longwall intake dust levels and occupational exposures. Fixed-point samples were collected in the intake and belt entries; and at the headgate and tailgate along the longwall face. Dust pumps for fixed-point samples collected at the intake, belt, headgate and tailgate, were operated only while on the section. The fixed-point samples were used to identify dust sources. Typical fixed-point dust sampling locations are shown in Figure 2.

Table 1 shows the combined intake and contribution of belt and intake dust levels to the combined intake for six longwall sections. The combined intake dust concentration ranged from 0.1 to 0.5 mg/m^3. The contribution of intake entry dust to face dust levels ranged from 0.1 to 0.4 mg/m^3. The contribution of belt entry dust to face dust levels ranged from 0.1 to 0.3 mg/m^3.

In four out of five mines surveyed, the use of belt air caused the combined intake air dust concentration to increase. In the case where the combined intake did not increase, the belt dust concentration was approximately equal to the intake dust level and the belt airflow was low. Even though the dust concentration in the belt entry was generally higher than the concentration in the intake entry, the contribution to the combined intake was not always reflected when there was low airflow in the belt entry.

Figure 3 shows a graph of the combined intake dust concentration versus percent of belt air in the total intake airflow for a 0.5 mg/m^3 intake respirable dust concentration and various belt dust concentrations. This graph can be used to determine the combined intake concentration for any of the mixture situations. For example, for a 50 % belt airflow and a 1.5 mg/m^3 belt concentration would give a 1.0 mg/m^3 mixture concentration.

EFFECT ON WORKER DUST EXPOSURE WHEN BELT AIR IS USED TO VENTILATE THE FACE

The impact of belt air on occupational exposure was determined from the impact of belt air on the headgate (shield 10) dust concentration. This location was chosen because face workers would be exposed to this concentration for most of the working shift.

Table 1 gives the average mine data, the calculated combined intake, individual contributions of the intake and belt to the combined intake, and the contribution of the crusher/stageloader. The effect of the stageloader/crusher was calculated by taking the difference between the combined intake and the measured concentration at the headgate (shield 10).

The contribution of crusher/stageloader dust to face dust levels ranged from 0.5 to 1.3 mg/m^3. Even though the concentration of dust in the belt entry approached or exceeded 1.0 mg/m^3, the actual contribution to face exposure was relatively low due to the belt airflow being a small percentage of total intake going to the face.

More significant than the belt contribution was the contribution from the stageloader/crusher which contributed between 0.5 and 1.3 mg/m^3 to exposures of workers along the face. The dust concentration attributed to the crusher/stageloader proportionately changes with changes in airflow. As a result, a reduction in face airflow resulting from a reduction in belt airflow could result in an increase in face dust levels. This is because the airflow from the belt entry also dilutes the dust generated at the stageloader/crusher.

The use of belt air will generally increase the combined intake dust level, however, depending on the specific section dust control and ventilation configuration the dust exposure of face occupations could either go up, down or remain unchanged. When the belt airflow times the belt dust concentration is less than the dust generation rate at the crusher/stageloader, the dust exposure will go down. When the belt airflow times the belt dust concentration is greater than the dust generation rate at the crusher/stageloader, the dust exposure will go up. When the belt airflow times the belt dust concentration is equal to the dust generation rate at the crusher/stageloader the dust exposure will remain the same.

The average fixed-point sampling results along the longwall faces are also shown in Table 1. Average results of the fixed-point samples collected at the headgate (shield 10), ranged from 0.6 to 1.7 mg/m^3. Average increases in dust concentration along the longwall face ranged from 1.8 to 11.3 mg/m^3. These values measured along the face indicate that position of workers, relative to dust being generated, would be critical to controlling worker exposure.

ENTRAINMENT AND REENTRAINMENT OF DUST IN BELT ENTRIES

Entrainment of dust occurs during the cutting, crushing and breaking of material. On a longwall section these operations primarily occur at the shearer, from shield movement, at the crusher and from mechanical vibration. Reentrainment occurs when dust, that has initially been suspended, settles and then becomes resuspended. Because of the low settling velocity (2 cm/min) and the relatively short length of a longwall face, little dust would settle to be reentrained.

A longwall section belt was chosen to evaluate entrainment/ reentrainment in a belt entry because it represents the worst case for dust. Leakage would be from intake to belt entry and its effect can be determined by application of a dilution formula. On a continuous miner section belt entry, there would also be leakage from belt entry to return which makes the entrainment calculation more difficult.

Typically the only belt entry dust measurement that would be taken by a mining company is the designated area (DA) sample outby the crusher/stageloader. This measurement tells only what the dust level was, not where the dust was introduced into the mine environment. In order to establish where the dust came from a special study where samples are collected along the belt line is required.

Figure 4 shows the results of studies conducted on two longwall belts. In each case, belt air was used to ventilate the longwall face. With relative velocities of 750 to 940 fpm, the increase in dust concentration along a 2000-foot belt ranged from 0.1 to 0.2 mg/m^3. More significant than the dust increase from the belt entry was the outby dust sources which resulted in dust levels just inby the belt overcast ranging from 0.8 to 1.0 mg/m^3. These studies indicate that the dust concentration measured outby the crusher was primarily due to dust generated at outby transfer points not from entrainment along the belt.

The exception to this occurs when a box check is used to restrict the airflow in the belt entry. Because of the reduced area, the airflow through the box check can be at velocities greater than 2000 fpm. In these cases entrainment can occur. However, a box check is used to restrict the airflow in a belt entry and would not typically be used when belt air is being used to ventilate the working face.

As a result the use of belt air does not appear to create any additional problems relative to dust entrainment along the belt entry. The use of belt air will eliminate some of the present entrainment sources by the removal of box checks in the belt entry.

SUMMARY

1. The use of belt air will generally cause the combined intake dust level to increase. If the belt air concentration is greater than the intake air concentration, the combined intake dust concentration will increase. This increase, however, should not have a significant impact on a mine's ability to meet the 1.0 mg/m^3 intake dust

standard.

2. The use of belt air could increase or decrease the exposure at the face depending on the specific section dust control and ventilation configuration. Any increase would not exceed the increase in the combined intake dust concentration.

3. The air velocities that will result when belt air is used to ventilate the face typically will not be high enough to cause entrainment of dust in the belt entry. Additionally the removal of box checks would remove restrictions that cause localized high velocities. This should reduce the amount of dust entrainment taking place in the belt entry.

4. If increased entry velocity is caused by a restriction, dust levels as a result of entrainment can increase. If increased entry velocity results from an increase in air quantity, dilution compensates for entrainment and dust levels will not significantly change. The added airflow could then provide additional dilution of dust generated in the face area.

REFERENCES

Organiscak, J. A., et. al., "Dust Controls to Improve Quality of Longwall Intake Air," U.S. Bureau of Mines I. C. 9114, 1986.

Potts, J.D., and Jankowski, R.A., "Dust Considerations When Using Belt Entry Air to Ventilate Work Areas," U.S. Bureau of Mines R. I. 9426, 1992.

U.S. Department of Labor, Advisory Committee, "Use of Air in the Belt Entry to Ventilate the Production (Face) Areas of Underground Coal Mines and Related Provisions," 1992.

U.S. Department of Labor, "Belt Entry Ventilate Review: Report of Findings and Recommendations," 1989.

U.S. Department of Labor, "Report of the Statistical Task Team of the Coal Mine Respirable Dust Task Group," September, 1993.

TABLE 1. - CALCULATION OF CONTRIBUTION OF INTAKE, BELT, AND STAGELOADER DUST GENERATION TO FACE EXPOSURES.

MEASUREMENT	Mine A	Mine B	Mine C	Mine D	Mine E	Mine F
RESPIRABLE DUST - mg/m^3						
INTAKE	0.3	0.1	0.2	0.4	0.4	0.2
BELT	0.6	NA	0.8	1.2	0.5	0.4
SHIELD #10	1.0	0.6	1.4	1.0	1.7	1.0
SHIELD #158	3.1	11.9	3.6	4.4	3.5	2.9
VENTILATION - cfm						
INTAKE	19300	37100	28500	38800	31600	44400
BELT	15500	NA	13000	3000	4300	53600
HEADGATE	31500	30900	41500	32300	34800	83800
HEADGATE DUST SOURCE CONTRIBUTIONS - mg/m^3						
INTAKE CONTRIBUTION	0.2	0.1	0.1	0.4	0.4	0.1
BELT CONTRIBUTION	0.2	NA	0.3	0.1	0.1	0.2
COMBINED INTAKE	0.4	0.1	0.4	0.5	0.4	0.3
CR/STLD* CONTRIBUTION	0.6	0.5	1.0	0.5	1.3	0.7
FACE DUST CONTRIBUTION	2.1	11.3	2.2	3.4	1.8	1.9

*CRUSHER/STAGELOADER

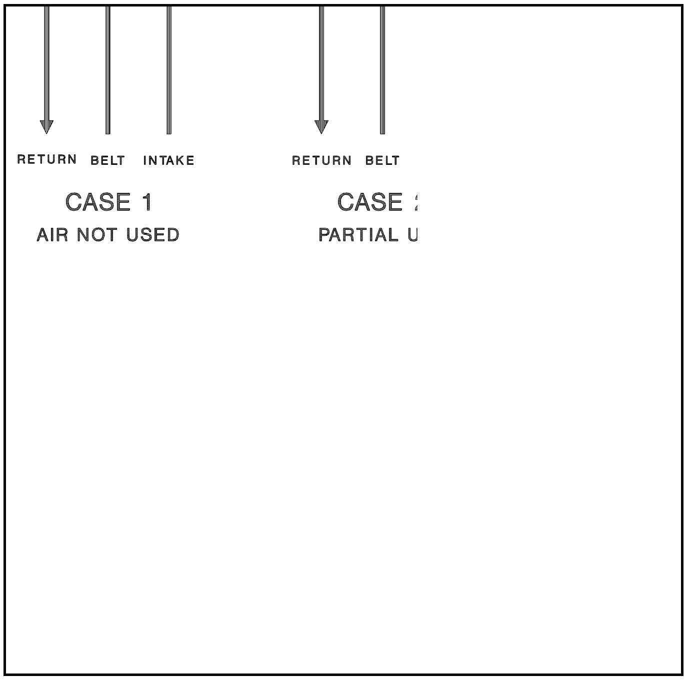

Figure 1. - Schematic of Belt Ventilation Systems.

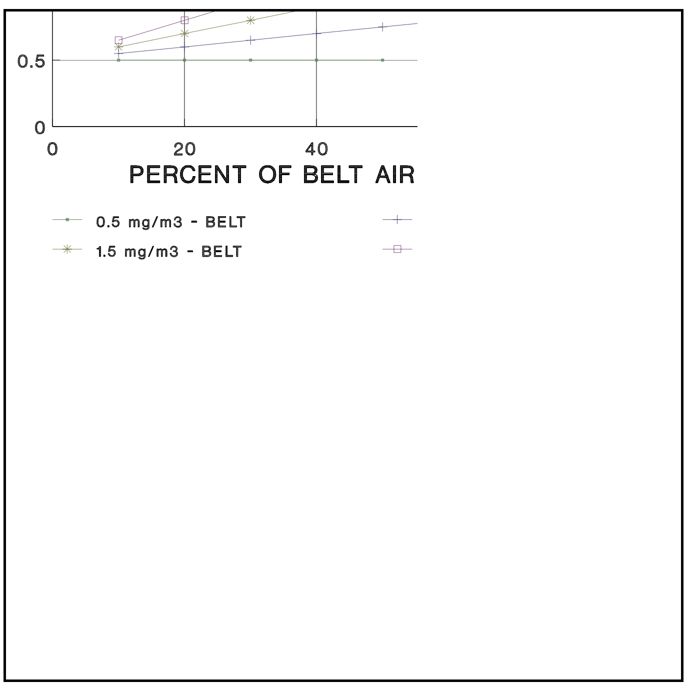

Figure 2. - Combined Intake Dust Levels for Belt Airflows and Dust Levels.

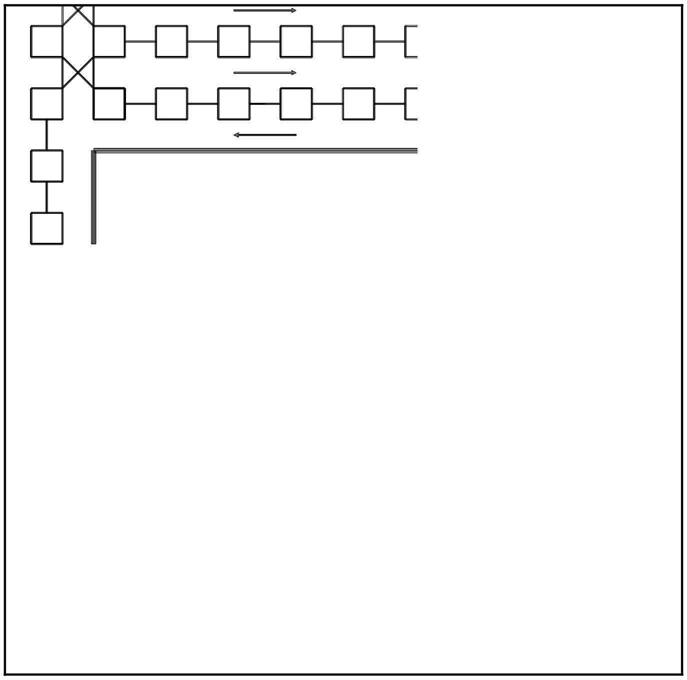

Figure 3. - Longwall Section Dust Sampling Locations.

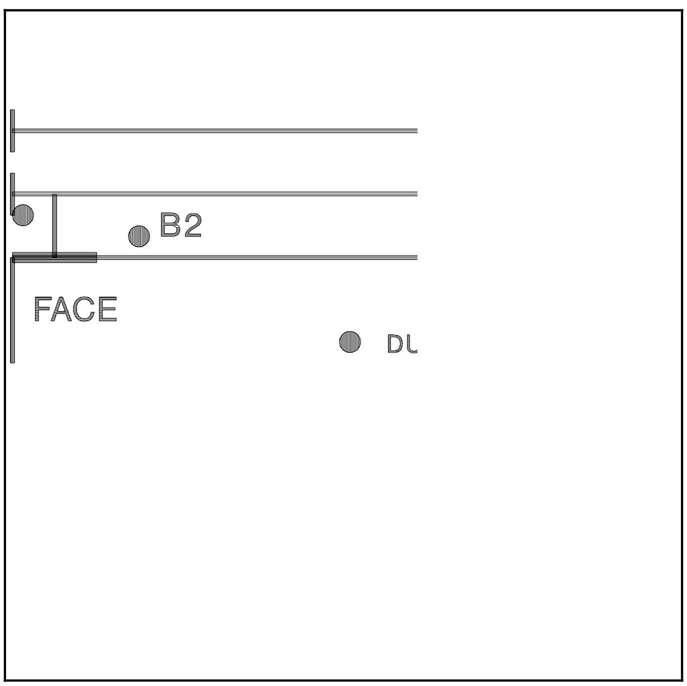

Figure 4. - Belt Entry Dust Levels and Sampling Locations.