RI 9426

REPORT OF INVESTIGATIONS/1992

Dust Considerations When Using Belt Entry Air To Ventilate Work Areas

By J. Drew Potts and Robert A. Jankowski

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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Library of Congress Cataloging in Publication Data:

Potts, J. Drew.
Dust considerations when using belt entry air to ventilate work areas / by J.D. Potts and R.A. Jankowski.

p. cm. — (Report of investigations; 9426)

Includes bibliographical references (p. 11).

Supt. of Docs. no.: I 28.22:9426.

1. Mine dusts. 2. Mine ventilation. 3. Belt conveyors. I. Jankowski, Robert A. II. Title. III. Series: Report of investigations (United States. Bureau of Mines); 9426.

TN23.U43 [TN312] 622 s—dc20 [622'.83] 92-13942 CIP

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cfm	cubic foot per minute	mg/min	milligram per minute
fpm	foot per minute	min	minute
ft	foot	pct	percent
in	inch	st	short ton
m^3/min	cubic meter per minute	st/h	short ton per hour
mg/m^3	milligram per cubic meter		

DUST CONSIDERATIONS WHEN USING BELT ENTRY AIR TO VENTILATE WORK AREAS

By J. Drew Potts[1] and Robert A. Jankowski[2]

ABSTRACT

In this U.S. Bureau of Mines study, four underground respirable dust surveys were conducted to determine factors affecting belt entry dust levels and how using belt air to ventilate work areas affected dust exposures. Belt entry dust levels on the surveyed longwall and continuous miner sections averaged 0.59 and 0.26 mg/m^3, respectively. The stageloader-crusher contributed an additional 0.5 to 0.9 mg/m^3 of dust to belt air, while the feeder-breaker contributed 0 to 0.2 mg/m^3 of dust. A 1,000-ft increase in belt entry length or a 200- to 500-st-per-shift increase in production resulted in roughly a 0.1-mg/m^3 increase in dust. Using the belt entry as an intake entry on the continuous miner section appeared to reduce dust levels by 0.1 to 0.3 mg/m^3 during cutting. Belt air was not used to ventilate the face on the longwall section.

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INTRODUCTION

An increasing number of mines are either using or petitioning to use belt entry air to ventilate active work areas. Operators believe that using the belt entry as an intake entry will allow them to deliver more air to the face, providing better dust and methane dilution. However, this technique results in an increased number of outby dust sources. The conveyor belt itself is a source of dust generation, and the stageloader-crusher or feeder-breaker is always in intake air if belt entry air is used to ventilate the face. Application of the dilution formula shows that *if* belt entry air represents additional air brought to the face and *if* belt entry dust levels including the stageloader-crusher or feeder-breaker source can be maintained below the average dust level measured at the designated occupation, it is beneficial from a dust compliance perspective for the mine to use belt entry air to ventilate work areas. This example is demonstrated in the appendix.

Compliance data analyzed (*1*)[3] by the Mine Safety and Health Administration showed that mines using belt entry air to ventilate work areas did not have significantly different respirable dust levels at the designated occupation than mines not using belt air. For one district, mines using belt entry air had a significantly lower mean dust concentration than mines not using belt entry air. However, these findings are not based on individual case studies. The U.S. Bureau of Mines, as part of its goal to improve the health of the Nation's miners, recently conducted four underground dust surveys to further explore this topic. The objectives of this study were twofold: first, to identify the variables affecting belt entry dust levels, since the dilution formula indicates that the belt entry dust concentration is critical for successful use of belt entry air, and second, to determine how using belt entry air affected the dust exposure levels of face workers at one mine.

The Bureau conducted three underground dust surveys on a continuous miner section and one on a longwall mining section for this study. The first two surveys conducted at the continuous miner section were designed to evaluate the effects of belt entry length, production rate, and air velocity (quantity) on dust levels in the belt entry and to determine how much dust the feeder-breaker operations contributed to belt air. The third continuous miner section survey compared dust exposure levels when the belt entry was used as an intake entry with exposure levels when the belt entry was used to draw air away from the face. The longwall survey was conducted to compare longwall belt entry dust levels with belt entry dust levels collected on the miner section.

CONTINUOUS MINER SECTION BELT DUST STUDY

THE MINE

Three independent respirable dust surveys were conducted on a continuous miner section located in the Lower Kittanning Seam, West Virginia. Mining height was between 78 and 90 in, and entries were 20 ft wide. Double-split ventilation was used to ventilate the section's seven entries. Entries 1 and 7 were returns. Entries 2 through 6 were intakes. A row of permanent concrete block stoppings was constructed between entries 3 and 4 to separate intake entries 2 and 3 from the other intake entries. The panel conveyor belt was located in entry 4. This particular mine was in operation before law required mines to isolate conveyor belts; therefore, entry 4 was open to intake entries 5 and 6. In order to isolate dust generation in the belt entry, the mine constructed a row of temporary stoppings between entries 4 and 5 from the belt head to the first crosscut inby the feeder-breaker. Isolating the belt entry also allowed reversal of the airflow in the belt entry for the third survey. The stoppings were framed with lumber and sealed with brattice cloth and instant insulation. Airflow readings taken at opposite ends of the belt entry were always within 10 pct of each other, indicating that these temporary stoppings were quite tight.

SURVEY 1—EFFECT OF BELT ENTRY LENGTH, PRODUCTION RATE, AND FEEDER-BREAKER OPERATIONS ON DUST LEVELS

The first survey conducted on the continuous miner section focused on determining how belt entry length, productivity, air velocity (quantity) and dust generation at the feeder-breaker affected belt entry respirable dust levels. The belt entry was used as an intake entry throughout this 3-day survey. A series of sampling stations were placed throughout the entire length of the panel belt entry to determine if belt entry air became increasingly dusty as it moved toward the face. A production time study was conducted at the feeder-breaker to determine how production rate affected belt entry dust levels. The quantity of air in the belt entry was changed at least once during the shift to determine how air quantity affected belt entry dust levels. Airflow entering the belt entry was regulated immediately

[3]Italic numbers in parentheses refer to items in the list of references preceding the appendix at the end of this report.

inby the belt head by opening or closing gaps in the brattice cloth between entries 4 and 5. Instantaneous respirable dust samplers (RAM's) were used to isolate respirable dust levels at each sampling station during different production rates and air quantities. Sampling stations located upwind and downwind of the feeder-breaker were used to calculate the feeder-breaker's contribution to belt entry dust levels.

Sampling Equipment and Procedures

This survey was conducted with 12 gravimetric dust samplers (personal impactors), 5 RAM's, and 2 recording anemometers. Impactors collect a total dust sample and fractionate the sample by particle diameter. Average respirable dust concentrations for the sampling period were calculated (*2*) from the gravimetric impactor data. Gravimetric data were used to calibrate the RAM's. RAM's yield a respirable dust profile of the sampling period. Recording anemometers yield an air velocity profile. A ball-bearing-type vane anemometer was used (continuous traverse technique) to calibrate the recording anemometers.

Figure 1 shows sampling station locations and the equipment used at each station. Stations 1, 2, 3, and 4 were 100, 340, 580, and 820 ft inby the belt head, respectively. Station 5 was immediately downwind of shuttle car dumping operations at the feeder-breaker, and station 6 was in an adjacent intake entry. Two impactors were placed at each station. A RAM was placed at each station except station 6. A recording anemometer was placed at stations 1 and 4. Table 1 shows average gravimetric respirable dust levels collected at each station for each day of the survey as well as 3-day average concentrations.

Table 1.—Results of continuous miner section survey 1

Measurement	Day 1	Day 2	Day 3	Average
Respirable dust levels at stations,[1] mg/m^3:				
1	0.32	0.22	0.18	0.24
2	0.28	0.23	0.16	0.22
3	0.36	0.24	0.23	0.28
4	0.46	0.21	0.21	0.29
5	0.66	0.25	0.20	0.37
6	0.14	0.15	0.18	0.16
Production .... st/h ..	115	100	75	NAp
Air velocity .... fpm ..	105	125	55	NAp

NAp Not applicable.

[1]Stations 1 through 4 were located 100, 340, 580, and 820 ft inby the belt head, respectively. Station 5 was immediately downwind of shuttle car operations at the feeder-breaker, and station 6 was in the adjacent intake entry.

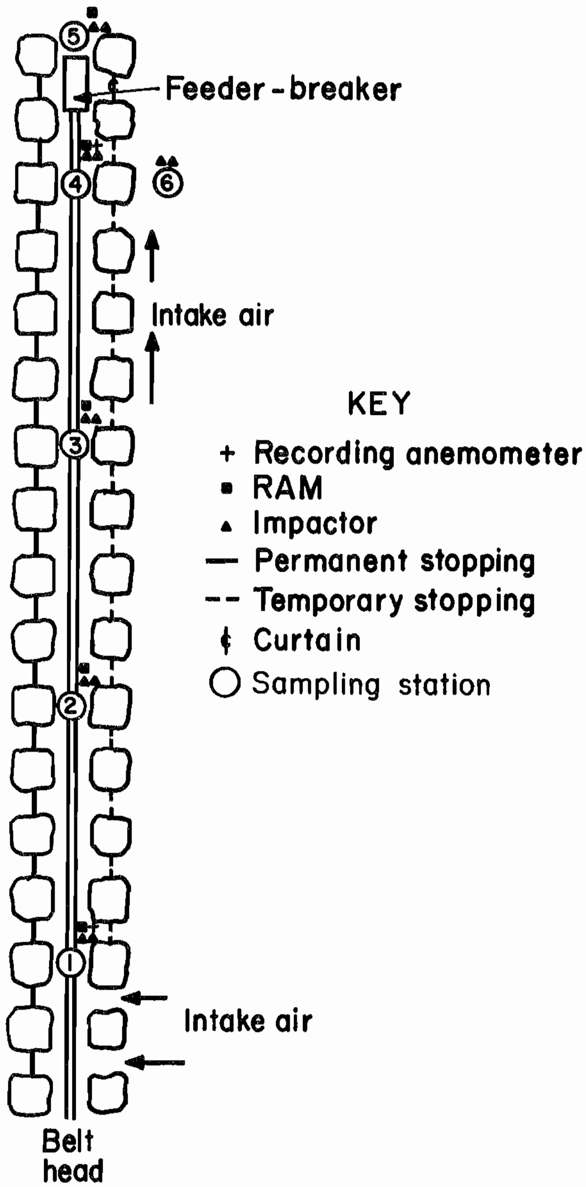

Figure 1.—Sampling station locations and equipment used for continuous miner section surveys 1 and 2. RAM = instantaneous respirable dust sampler.

Dust From Feeder-Breaker

Impactor data collected at stations 4 and 5 were used to determine how much respirable dust was being generated by feeder-breaker operations. Subtracting the dust levels measured at station 4 from the dust levels at station 5 indicated that feeder-breaker operations contributed an average 0 to 0.2 mg/m^3 of dust to the belt entry air. These fluctuations most likely resulted from changes in the production rate from day to day. Table 1 shows average production rates calculated over the entire sampling period for each day. The daily average production rate for day 3 of the study was 75 st/h, and there was no measured difference in the gravimetric data collected at stations 4 and 5. However, the average production rate on day 1 was 115 st/h, and the feeder-breaker operations appeared to generate about 0.2 mg/m³ of respirable dust.

The RAM data collected at station 5 showed how respirable dust levels downwind of the feeder-breaker fluctuated during the shuttle car dumping cycle. Figure 2 shows a profile of dust levels measured at station 5 during the sampling period from 13:30 to 13:50 on day 1. During this time, eight shuttle cars unloaded at the feeder, equating to a production rate of about 240 st/h, which was 110 pct greater than the daily average production rate of 115 st/h. Eight distinct peaks corresponding to each dumping cycle can be seen on the graph. Dust levels during this high-production-rate period averaged 0.93 mg/m³, which was 40 pct greater than the daily average dust level of 0.66 mg/m³. The peaks ranged in height from about 0.8 to 1.44 mg/m³. These data indicate that feeder-breaker operations can contribute a significant amount of dust to belt entry air, emphasizing the need for dust control at this location.

Dust Control at Feeder-Breaker

This mine used several dust control techniques at the feeder-breaker to control dust generation. Three automatic sprays were used at the mouth of the feeder-breaker to wet the coal before it was crushed. The feeder-breaker was equipped with shelved sides that acted as muck shelves. Skirt boards were used to properly load the coal onto the section belt. The mine also used a belt scraper to clean the inside surface of the belt before it entered the feeder-breaker. All of these techniques are recommended (*3-4*) to reduce dust generation, and they appeared to do a good job for the production rates and conditions encountered at this particular mine.

Effect of Production Rate on Belt Entry Dust Levels

The impactor data were also examined to determine if production rates affected belt entry respirable dust levels upwind of the feeder-breaker operations. Production rates appeared to be positively correlated with belt entry dust levels (table 1). The highest belt entry dust levels and the highest production rate occurred on day 1, while the lowest belt entry dust levels and lowest production rate occurred on day 3. The average production rate decreased 35 pct from day 1 to day 3, and the average belt entry dust level decreased 45 pct. This effect equated roughly to a 0.1-mg/m³ increase in belt entry dust levels for a 200-st-per-shift increase in production.

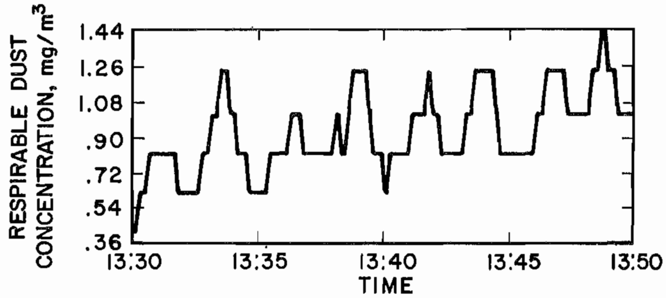

Figure 2.—Profile of dust levels in belt entry measured downwind of feeder-breaker operations.

Dust Controls at Belt Head

Dust controls used at the belt head helped to maintain low dust levels in the belt entry. Three automatic sprays were used to suppress dust at the section-to-main transfer point. The mine also used a scraper equipped with sprays to clean the outside surface of the belt after the coal had been transferred to the main belt.

Effect of Entry Length on Belt Entry Dust Levels

Impactor data collected at stations 1 through 4 (table 1) were used to determine if cumulative belt entry length affected belt entry respirable dust levels. Belt entry air did appear to get dustier as it traveled through the entry, because dust levels were slightly higher at stations 3 and 4 than dust levels at stations 1 and 2. This effect equated to roughly a 0.1-mg/m³ increase in the dust level for a 1,000-ft increase in belt entry length. Although the length effect was irrelevant on this section, it may prove to be important on longer panel development sections.

Need for Survey 2

The previous data analyses ignore airflow levels. Daily average airflows measured in survey 1 are shown in the form of air velocities in table 1. Airflow levels were ignored because no relationship between airflow and respirable dust levels in the belt entry was observed from either the gravimetric data or the RAM data collected during survey 1. A more sensitive RAM setting was used in survey 2 in an attempt to isolate the potential effect of airflow on dust levels.

SURVEY 2—EFFECT OF AIRFLOW ON DUST LEVELS

Survey 2 was conducted to isolate the possible effect of airflow on belt entry respirable dust levels. Sampling stations and procedures used in survey 1 were duplicated for survey 2; however, a more sensitive RAM setting was used for survey 2. RAM's were set on the 0-to-20-mg/m³ instrument scale during survey 1. Maximum RAM voltage output corresponds to a 20-mg/m^3 dust level using this setting. However, since dust levels never exceeded 2 mg/m^3 in the belt entry during survey 1, the more sensitive 0-to-2-mg/m^3 setting was used during survey 2 in an effort to isolate the possible effect of airflow on belt entry dust levels. The air quantity in the belt entry was changed at least once during the shift. RAM's were used to compare dust levels during different levels of airflow at each sampling station.

Figure 3 shows airflow and belt entry respirable dust levels at station 3 during the time period from 14:41 to 17:11 on day 2. Production began at 14:41 and continued through 16:06. This production period was followed by a 15-min break in production from 16:06 to 16:21 to move the continuous miner. Mining operations started again at 16:21 and continued through 16:44. The period from 16:44 to 17:11 was downtime. Data collected during this time period were similar to data collected during previous shifts. The dust levels appeared initially to rise as mining operations commenced. After a certain time period, about 45 min in this case, the dust levels appeared to stabilize and remain consistent throughout the shift, independent of airflow. Air velocity (airflow) was increased from 130 to 180 fpm during the time period from 14:41 to 16:05. Dust levels also increased from about 0.18 to 0.30 mg/m^3 during the time period from 14:41 to 15:26. However, dust levels appeared to be independent of airflow, because when air velocity was decreased to 105 fpm between 16:05 and 17:11, the dust levels remained consistent.

Dilution benefits from increased airflow may have been offset by an increase in entrainment in the belt entry, resulting from high relative air velocities. Since air velocity in the belt entry was between 105 and 180 fpm and the conveyor belt speed was maintained at 400 fpm during this survey, coal on the belt was subjected to relative velocities between 505 and 580 fpm. Past research conducted on longwall faces indicates (*5*) that entrainment effects can prevail over dilution effects at air velocities above 500 fpm.

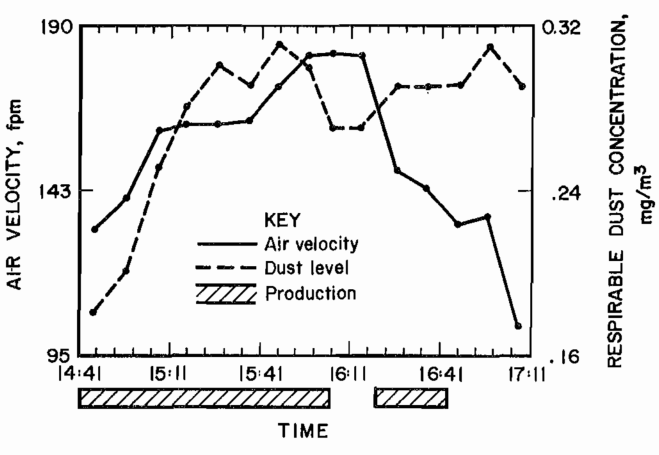

Figure 3.—Air velocity and dust level profiles collected in belt entry.

SURVEY 3—EFFECT OF USING BELT ENTRY TO VENTILATE FACE ON DUST LEVELS AT VARIOUS SECTION LOCATIONS

The third miner section survey was designed to determine how using belt entry air to ventilate work areas affected the respirable dust exposure levels of various section occupations. The belt entry was used as an intake entry on days 1 and 2 of the survey, and it was used to draw air away from the face areas on days 3 and 4. About 6,000 cfm of air was measured in the belt entry for both conditions. Gravimetric and instantaneous dust sampling techniques were used to compare respirable dust levels at various locations when the belt entry was used as an intake entry with dust levels in the same locations when the belt entry was used to draw air away from the face.

Sampling Equipment and Procedures

The survey was conducted with 10 personal impactors, 3 cyclone respirable dust samplers, and 4 RAM's. Daily average respirable dust concentrations were calculated from the cyclone and impactor data. The RAM's were used to determine dust concentrations at various positions during individual cuts. Airflow measurements were also made throughout the 4-day survey. Airflow was measured with smoke tubes in entries 2, 3, 4, 5, and 6. A ball-bearing-type vane anemometer (continuous traverse technique) was used to measure airflows in entries 1 and 7.

Figure 4 shows sampling station locations and the equipment used at each station. Sampling stations were located in the belt entry (station 1), mouth of the belt entry (station 2), right-side shuttle car cab (station 3), left-side shuttle car cab (station 4), upwind of shuttle car loading (station 5), and in the miner cab (station 6). Two impactors were placed at all stations but station 6. Miner cab dust levels were expected to be much higher than dust levels at other positions; therefore, cyclone respirable dust samplers were used at station 6 instead of impactors. Cyclones can handle greater dust loads than impactors before overloading occurs. A RAM was placed in stations 3, 4, 5, and 6.

Dust Measurement Results

Daily average respirable dust concentrations measured with the cyclones and impactors at stations 3 through 6 are shown in table 2. These values were used to calibrate the RAM's located in the shuttle car cabs, miner cab, and upwind miner positions. The RAM's allowed isolation of the average dust levels at these positions for each cut. The cut-by-cut dust levels are shown in table 3. The top portion of table 3 shows respirable dust concentrations at each RAM sampling station for each cut during days 1 and

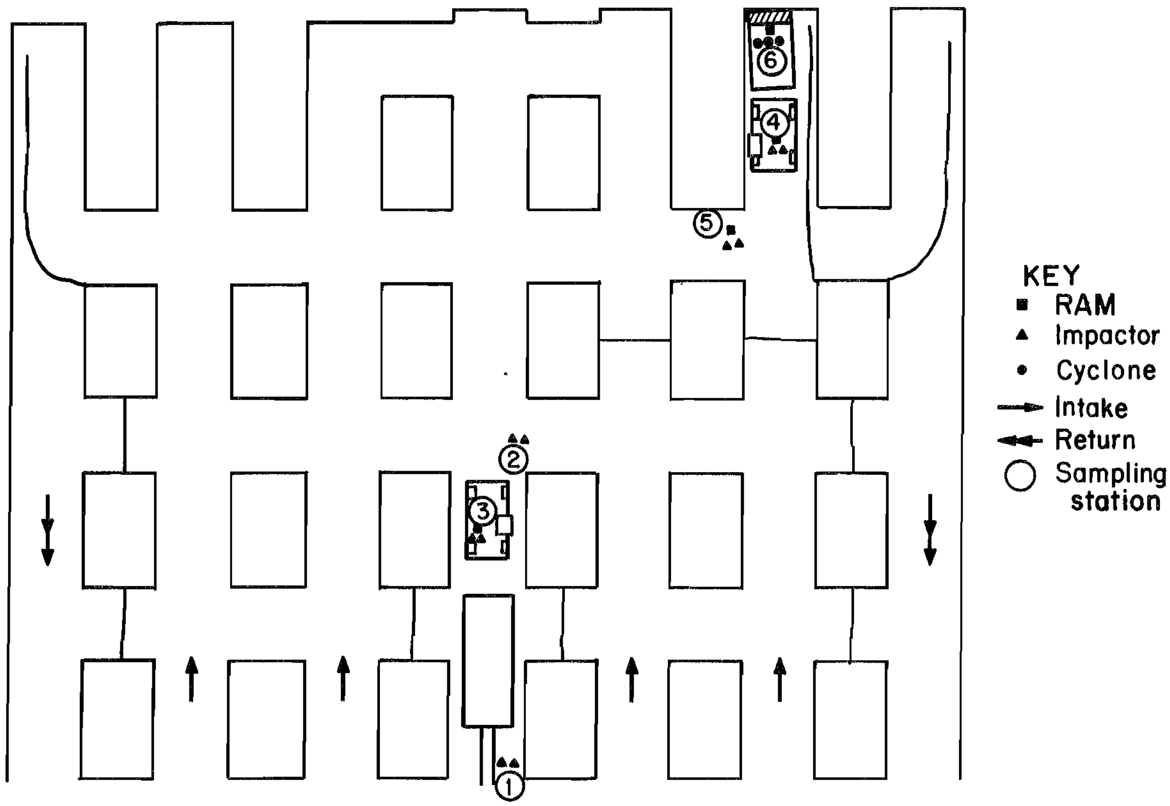

Figure 4.—Sampling station locations and equipment used for continuous miner section survey 3. RAM = Instantaneous respirable dust sampler.

2 of the study, when the belt entry was used as an intake entry. The bottom portion of table 3 shows similar data for days 3 and 4, when the belt entry was used to draw air away from the face areas. Since production rates changed between cuts, the dust levels were normalized for an average cut production rate (not daily rate) of 290 st/h. The normalized levels are shown in the last four columns of table 3. All data analyses were conducted with the normalized levels. Daily average dust levels are lower than the levels shown in table 3, because daily average levels include downtime.

Table 2.—Respirable dust levels (milligrams per cubic meter) used to calibrate RAM's

Day	Left-side car	Right-side car	Upwind miner	Miner
1	0.14	0.23	0.21	1.96
2	.12	.19	.12	2.92
3	.33	.22	.14	3.38
4	.46	([1])	0	2.92

RAM Instantaneous respirable dust sampler.

[1]All dust samples collected from right-side shuttle car on day 4 were lost when sampling equipment was pinched between car and rib.

Table 4 lists the average respirable dust concentrations calculated from RAM data in table 3. The upwind dust levels for cuts 4 and 5 on day 1 were not included in this analysis because instruments were improperly placed inby the shuttle car operators' positions during loading. This inby position exposed the upwind samplers to loading dust. The significance of each of the differences shown in table 4 was checked using the t-test statistic. Only the difference in respirable dust levels for the left-side shuttle car was significant at a 95-pct confidence level. The significance of this difference indicates that using belt entry air to ventilate the section at this particular mine reduced dust levels by 0.1 to 0.3 mg/m^3 during cutting. This analysis is based on the assumption that the RAM sampling techniques were precise enough to measure a difference this small. The RAM's were calibrated with impactor data. Two impactor samples were collected at each location. An analysis of the data collected in both shuttle cars for each day of the survey showed that the mean difference in con-centrations measured with side-by-side impactors was 0.05 mg/m^3 and the standard deviation was 0.06 mg/m^3. Therefore, it is possible that the reported reduction in dust levels measured when using the belt entry as an intake was the product of sample error; however, it is more likely the product of a real difference in dust levels.

Table 3.—Respirable dust levels (milligrams per cubic meter) measured at each RAM sampling station for each cut

Cut	Entry	Orientation	Left-side car	Right-side car	Upwind miner	Miner	Normalized for production: Left-side car	Right-side car	Upwind miner	Miner
BELT ENTRY USED AS INTAKE ENTRY										
Day 1:										
1	4	SA	0.29	0.92	0.23	9.93	0.32	1.03	0.26	11.07
2	5	RC	.22	.07	.11	1.86	.25	.08	.13	2.16
3	5	SA	.25	.36	.19	4.62	.23	.33	.17	4.19
4	6	RC	.13	.43	.34	2.31	.17	.57	.45	3.04
5	6	SA	.17	.41	.59	2.50	.15	.36	.52	2.20
6	3	LC	.12	.07	.12	1.35	.14	.08	.14	1.57
Day 2:										
1	6	SA	.09	.10	0	.83	.08	.09	0	.73
3	4	SA	.23	.51	.09	9.20	.23	.51	.09	9.20
4	3	SA	.12	.18	.22	2.89	.11	.16	.20	2.62
5	2	SA	.16	.22	0	4.43	.26	.35	0	7.14
BELT ENTRY USED TO DRAW AIR AWAY FROM FACE										
Day 3:										
1	4	RC	0.32	0.20	0.07	3.86	0.52	0.32	0.11	6.22
2	4	LC	.21	.17	.08	3.27	.23	.18	.09	3.51
3	5	SA	.64	.42	.11	5.89	.66	.44	.11	6.10
4	6	SA	.31	.28	.18	2.42	.22	.20	.13	1.75
5	7	SA	.34	.32	.17	1.40	.26	.24	.13	1.07
6	4	LC	.30	.21	.14	1.84	.24	.16	.11	1.44
7	3	LC	.45	.27	.08	17.91	.35	.21	.06	14.04
Day 4:										
1	1	SA	.56	([1])	.01	5.73	.54	([1])	.01	5.54
2	4	SA	.67	([1])	.01	5.16	.47	([1])	.01	3.65
3	4	LC	.48	([1])	.01	2.55	.48	([1])	.01	2.55
5	6	SA	.36	([1])	.01	4.27	.55	([1])	.02	6.52

LC Left crosscut.
RAM Instantaneous respirable dust sampler.
RC Right crosscut.
SA Straight ahead.

[1]All dust samples collected from right-side shuttle car on day 4 were lost when sampling equipment was pinched between car and rib.

Table 4.—Average respirable dust levels, milligrams per cubic meter[1]

Location	With belt air[2]	Without belt air[3]
Left-side car	0.19	0.41
Right-side car[4] . . .	.35	.25
Upwind miner[5] . . .	.12	.07
Miner	4.4	4.8

[1]Values calculated from data in table 3; represent production time only.

[2]Belt entry used as intake entry.

[3]Belt entry used to draw air away from face areas.

[4]All dust samples collected from right-side shuttle car on day 4 were lost when sampling equipment was pinched between car and rib.

[5]Upwind dust levels for cuts 4 and 5 on day 1 not included in data because instruments were improperly placed inby shuttle car operators' positions during loading.

Ventilation Mode Changes

An analysis of airflow levels measured during this survey may explain why respirable dust levels were lower when the belt entry was used as an intake entry. All air passing through the face areas exited through return entries 1 and 7. Airflows in entries 1 and 7 were monitored throughout the 4-day study. The average total airflow in these two entries was 58,800 cfm when the belt entry was used as an intake entry and 52,900 cfm when the belt entry was used to draw air away from the face areas. When the belt entry was used to draw air away from work areas, air drawn into the belt entry never reached the face. Therefore, about 10 pct more air was available for dust dilution when the belt entry was used as an intake entry.

Other Dust Measurements

Most of the gravimetric data were used to calibrate the RAM's. However, gravimetric data were also collected in the belt entry (station 1) and at the mouth of the belt entry (station 2). Measured and normalized respirable dust levels at these two locations are shown in table 5. A comparison of dust levels collected in the belt entry verified that feeder-breaker-generated dust was being drawn down the belt entry when the belt entry was used to draw air away from the section. The average normalized dust level in the belt entry was 0.11 mg/m^3 when the belt entry was used as an intake and 0.23 mg/m^3 when the belt entry was used to draw air away from the section. These data are consistent with those from survey 1, which showed that the feeder-breaker contributed between 0 and 0.2 mg/m^3 of respirable dust to the belt entry air. Airflow in the belt entry was about 6,000 cfm for both ventilation modes.

The mine conducted a belt move after day 2 of the study. The belt move prevented maintenance of a consistent sampling position at the mouth of the belt entry. Because of the new position of the feeder-breaker in the entry, the sampling equipment was much closer to shuttle car dumping operations on days 3 and 4 of the study. This may have exposed the samplers to dust rollback when the automatic feeder-breaker sprays were activated. It was also necessary to move the sampling equipment from the left-side rib to the right-side rib for days 3 and 4 of the study. Therefore, the reliability of the data collected at the mouth of the belt entry is questionable.

Table 5.—Respirable dust levels (milligrams per cubic meter) at belt entry and mouth of belt entry stations

Day	Belt entry ventilation mode	Belt entry	Mouth of belt entry	Normalized for production	
				Belt entry	Mouth of belt entry
1 . .	I	0.09	0.15	0.13	0.21
2 . .	I	.09	.14	.08	.12
3 . .	R	.24	.29	.18	.22
4 . .	R	.23	.22	.28	.27

I Intake.
R Return.

LONGWALL PANEL BELT DUST STUDY

THE MINE

One survey was conducted on a longwall mining section located in the Wheatcroft No. 9 Seam, KY. Mining height was about 60 in. This particular mine was using homotropal ventilation; therefore, dust generated by the conveyor belt and stageloader-crusher operations was directed into the section return. This ventilation mode prevented direct assessment of the impact of belt entry air on face dust levels but it facilitated isolation of the conveyor belt and stageloader-crusher dust sources. Crosscuts between the belt entry and the adjacent entry were open from the belt head to crosscut 7, as shown in figure 5. An airflow survey indicated that the adjacent entry was contaminated with dust generated at the belt head. Crosscuts were sealed between crosscut 8 and the longwall face with concrete block stoppings. Check curtains hung across the conveyor belt were used to control airflow in the belt entry.

THE SURVEY—EFFECT OF PRODUCTION RATE AND STAGELOADER-CRUSHER OPERATIONS ON DUST LEVELS

A 3-day respirable dust survey was conducted on a longwall mining section with a longer panel belt and higher production rates than those of the continuous miner section to determine if belt entry dust levels were different between the two sections. Belt entry length and production rates appeared to influence dust levels on the continuous miner section surveyed for this study. The sampling strategy used for the longwall survey was similar to that used for the first two continuous miner surveys. Sampling stations were placed throughout the length of the belt entry to determine how belt entry length affected belt entry dust levels. Production-time studies were used to determine how production rates affected belt entry dust levels. Stageloader-crusher-generated dust was isolated by sampling upwind and downwind of this equipment.

Sampling Equipment and Procedures

The survey was conducted with 10 gravimetric dust samplers (impactors) and 4 RAM's. Gravimetric respirable dust concentrations were calculated from the impactor data. The gravimetric dust data were used to calibrate the RAM's. RAM's were used to generate respirable dust profiles during the sampling period. A ball-bearing-type vane anemometer was used (continuous traverse technique) to measure air velocities in the belt entry.

Figure 5 shows sampling station locations and the equipment used at each station. Two impactors and a RAM were placed at station 1 in the belt entry, 800 ft inby the belt head. Station 1 was placed between crosscuts 9 and 10 because the belt entry was open to the adjacent

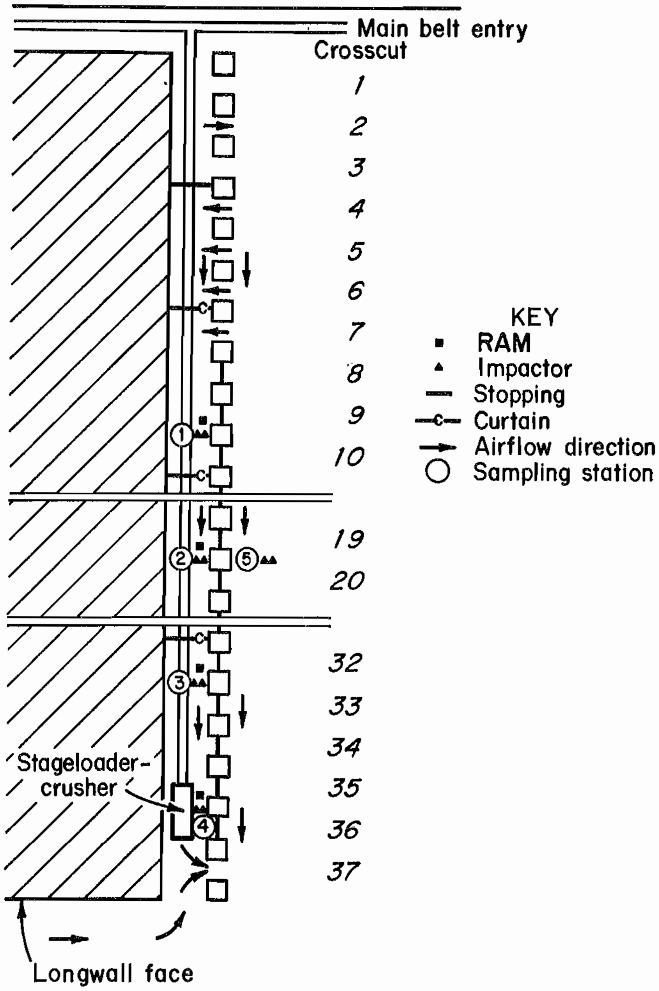

Figure 5.—Sampling station locations and equipment used for longwall mining section survey. RAM = Instantaneous respirable dust samper.

entry before crosscut 8. The same arrangement was used at stations 2 and 3, which were 1,700 and 3,000 ft inby the belt head, respectively. Two impactors and a RAM were placed downwind of the stageloader-crusher at station 4 on days 2 and 3 of the survey. Dust generated by the stageloader-crusher could not be isolated on day 1 because of its position in the entry. Face return air was sweeping over most of the stageloader-crusher during day 1. Two impactors were used to sample air in the adjacent entry at station 5 on days 2 and 3 of the study. Table 6 shows average gravimetric respirable dust levels collected in the belt entry and the adjacent entry.

Table 6.—Results of longwall section survey

Measurement	Day 1	Day 2	Day 3
Respirable dust levels at stations, [1] mg/m³:			
1	0.67	1.05	0.47
2	0.61	0.57	0.35
3	0.67	0.64	0.30
4	(2)	1.10	1.18
5	(2)	0.60	0.22
Production ... st/h	315	205	325
Air velocity at stations,[1] fpm:			
1	25	75	45
2	55	75	70
3	110	150	85

[1]Stations 1, 2, and 3 were located 800, 1,700, and 3,000 ft inby the belt head, respectively. Station 4 was downwind of the stageloader-crusher, and station 5 was in an adjacent intake entry.
[2]Station not used on day 1.

Air Leakage Into Belt Entry

The effect of belt entry length on respirable dust levels could not be measured on this section because of airflow patterns. Table 6 shows air velocities measured at the sampling stations for each day of the study and daily average production rates. Air from the adjacent entry was leaking into the belt entry throughout its length. This air may have acted to dilute the dust being generated by the conveyor belt. This certainly appears to be the case on day 3 of the study, because belt entry dust levels were lower at station 3 than levels at station 1, and dust levels in the adjacent entry were significantly lower than dust levels in the belt entry.

Effect of Production Rate on Belt Entry Dust Levels

Daily fluctuations in production rates did not produce an obvious trend in belt entry respirable dust levels upwind of the crusher at this mine. However, the difference in production rates between the longwall section and the continuous miner section did appear to affect belt dust levels. The daily average production rate on the longwall section was about 280 st/h, while the daily average production rate on the miner section was about 100 st/h. Therefore, the longwall section produced about 1,440 st per shift more than the miner section did. Using the rough estimate of a 0.1-mg/m³ increase in dust levels with a 200-st-per-shift increase in production developed from the continuous miner survey, one would expect belt entry dust levels to be about 0.7 mg/m³ higher on the longwall section. In fact, dust levels were only about 0.3 mg/m^3 higher on the longwall section. However, the positive correlation between production rates and belt entry dust levels is reinforced by these findings. For the two mines surveyed during this study, a 200- to 500-st-per-shift increase in production corresponded to a 0.1-mg/m^3 increase in belt entry dust levels.

Dust Controls in Use

Low conveyor belt dust generation on the longwall section probably resulted from the implementation of dust control techniques that were similar to those used by the continuous miner section. One spray was used at the stageloader-crusher to wet the coal before it was crushed. Two sprays were used to wet and suppress dust at the discharge to the panel belt. Two sprays were used at the belt head to reduce dust generation at the panel-to-main transfer point. Belt scrapers used at both ends of the panel belt also helped reduce dust generation.

Dust From Stageloader-Crusher

Stageloader-crusher operations generated 0.5 to 0.9 mg/m^3 of respirable dust. (These values were calculated by subtracting dust levels collected at station 3 from dust levels collected at station 4.) Different levels of generation probably resulted from different production rates. The production rate on day 2 of the study was 205 st/h, and the stageloader-crusher generated about 0.5 mg/m^3 of respirable dust. On day 3, the production rate was 325 st/h and the stageloader-crusher generated about 0.9 mg/m^3 of dust; production increased 60 pct and dust generation increased 80 pct over day 2 levels. Even so, dust levels in the headgate area averaged less than 1.2 mg/m^3 for both days.

CONCLUSIONS

On the continuous miner section, the average respirable dust level in the belt entry upwind of the feeder-breaker was 0.26 mg/m^3. Feeder-breaker operations generated an additional 0 to 0.2 mg/m^3 of dust. These low dust levels resulted from controls implemented by the mine. Three automatic sprays were used at the mouth of the feeder-breaker to wet the coal before it was crushed. The feeder-breaker was equipped with shelved sides that acted as muck shelves. Skirt boards were used to properly load the coal onto the section belt. The mine also used a belt scraper to clean the inside surface of the belt before it entered the feeder-breaker. Similar controls were used at the belt head. Three automatic sprays were used to suppress dust at the section-to-main transfer point. The mine also used a scraper equipped with sprays to clean the outside surface of the belt after the coal had been transferred to the main belt.

On the longwall mining section, the average respirable dust level in the belt entry upwind of the stageloader-crusher was 0.59 mg/m^3. Stageloader-crusher operations generated an additional 0.5 to 0.9 mg/m^3 of dust. The difference in dust levels measured between the continuous miner section and longwall mining section most likely resulted from differences in production rates. The average production rate on the longwall section was about 280 st/h, while the average production rate on the miner section was about 100 st/h. Dust control techniques used at the longwall section were similar to those used at the miner section. One spray was used at the stageloader-crusher to wet the coal before it was crushed. Two sprays were used to wet and suppress dust at the discharge to the panel belt. Two sprays were used at the belt head to reduce dust generation at the panel-to-main transfer point. Belt scrapers used at both ends of the panel belt also helped reduce dust generation. Three Bureau publications (*3-4, 6*) explain in detail how belt entry dust levels and stageloader-crusher dust generation can be minimized. The stageloader-crusher controls may also be applicable as feeder-breaker controls.

Belt entry length and production rate both appeared to affect belt entry respirable dust levels. Conversely, air quantities did not appear to affect belt entry dust levels. Greater production rates and belt entry lengths appeared to increase belt entry dust levels upwind of the stageloader-crusher and feeder-breaker operations. The entry length effect equated to roughly a 0.1-mg/m^3 increase in dust for a 1,000-ft increase in length. The production effect equated to roughly a 0.1-mg/m^3 increase in dust for a 200- to 500-st-per-shift increase in production.

Using the belt entry as an intake entry results in additional outby dust sources; however, it may also increase the amount of air available for dust dilution. On the continuous miner section surveyed for this study, the benefits of increased dust dilution appeared to outweigh the effects of additional dust sources. Data indicated that using the belt entry as an intake entry on the miner section reduced respirable dust levels by 0.1 to 0.3 mg/m^3 during cutting. However, the magnitude of outby dust sources and the dilution effect are mine specific. Therefore, any decision to use the belt entry as an intake entry for dust control should be supported with a field study similar to the ones conducted for these mines.

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APPENDIX.—IMPACT OF USING BELT AIR TO VENTILATE WORK AREAS

Case 1: No belt entry air is used to ventilate work area X. Work area X is exposed to respirable dust generated by the bolter, miner, and shuttle cars, which generate 400, 1,000, and 400 mg/min, respectively. The section is ventilated with 900 m^3/min of intake air containing no dust. The concentration in work area X (C_x) is given by the following formula, where D is the total dust generated by all sources, in mg/min, and Q is the total quantity of air, in m^3/min, available for dilution.

$$C_x = D/Q,$$

and $$C_x = (400 + 1{,}000 + 400)/900 = 2.0 \text{ mg/m}^3.$$

Case 2: Same as case 1, except belt entry air as well as intake air is used to ventilate work area X. The conveyor belt and feeder-breaker generate 600 mg/min of dust, and using belt entry air provides the mine with 330 m^3/min of additional air for dilution. C_b is the concentration of dust in the belt entry.

$$C_b = 600/330 = 1.82 \text{ mg/m}^3,$$

and $$C_x = (400 + 1{,}000 + 400 + 600)/1{,}230 = 1.95 \text{ mg/m}^3.$$

Case 3: Same as case 2, except the conveyor belt and feeder-breaker generate 720 mg/min of dust.

$$C_b = 720/330 = 2.18 \text{ mg/m}^3,$$

and $$C_x = (400 + 1{,}000 + 400 + 720)/1{,}230 = 2.05 \text{ mg/m}^3.$$

It follows that using belt entry air may reduce face dust levels if the following conditions exist:

1. Belt entry air represents additional air brought to the face; and
2. Belt entry dust levels, including the stageloader-crusher or feeder-breaker source, are lower than face dust levels.

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* USGPO: 1992—611-007/60073