ANALYSIS AND PREDICTION OF LONGWALL METHANE EMISSIONS: A CASE STUDY IN THE POCAHONTAS NO. 3 COALBED, VA

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ABSTRACT

Increasing longwall panel dimensions, particularly face width in gassy coalbeds, may result in unexpected increases in methane emissions. To investigate this problem, continuous longwall face emission monitoring studies were conducted at two adjacent mines operating in the Pocahontas No. 3 Coalbed, where longwall faces were to be extended from 229 to 305 m (750 to 1,000 ft). It was predicted by regression analysis of methane emissions data from 229 m (750 ft) wide longwall faces that extending faces to 305 m (1,000 ft) would increase methane emission rates by only 7 percent (0.6 m^3/min (20 cfm)), to 8.6 m^3/min (304 cfm) at the VP-1 Mine. In contrast, it was predicted that extending faces at the VP-3 Mine could increase methane emissions by as much as 13 percent (1.8 m^3/min (65 cfm)) to 16.1 m^3/min (567 cfm). The geologic and mine design factors influencing the variation in face emissions between the two mines will be discussed.

INTRODUCTION

As part of its Coal Mine Health and Safety research program, National Institute of Occupational Safety and Health (formerly U.S. Bureau of Mines) Pittsburgh Research Center, has been investigating methane emissions associated with longwall mining (Diamond, et al., 1992, McCall, et al., 1993, and Schatzel, et al., 1992). The general goals of this research program include the development of a fundamental understanding of the factors influencing gas migration so that techniques can be developed to predict underground methane emission levels. An understanding of the interrelationship of geology, mining methods, gas storage, and migration is also required to develop methane control strategies to cope with the increased levels of methane emissions sometimes resulting from the use of high productivity, advanced mining technology (Diamond, et al, 1994).

The primary purpose of this study was to predict the methane gas emission consequences of mining longwall panels of greater face width in the Pocahontas No. 3 Coalbed. The mine operators were considering increasing longwall panel face width from 229 to 305 m (750 to 1,000 ft). However, since historically high methane emissions from the longwall face and gobs were already being experienced, there was a concern for further increases in methane emission rates. If higher emission rates were encountered on wider faces, it was preferable from a safety perspective to be prepared in advance, either with increased ventilation airflow, or additional methane drainage. As part of this work, the emission characteristics and factors influencing emission rates on the two study panels were also investigated.

STUDY AREA

The longwall methane emission studies were conducted in the VP-1 Mine, and adjoining VP-3 Mine, located in Buchanan Co. VA (Fig. 1). Additional mines in this complex, both active and inactive, are located to the east and south. The two study panels are approximately 1,600 m (1 mile) apart. The depth of cover ranged from 485 m (1,590 ft) at the VP-1 site to 668 m (2,190 ft) at the VP-3 site.

INSTRUMENTATION AND MONITORING STRATEGY

The gas emission monitoring instrumentation consisted of a methane sensor to measure gas concentration and a data logger to continuously collect and store information. Airflow was periodically measured at the monitoring locations by standard mine ventilation survey methods using a hand held anemometer. Methane gas emissions were monitored at four locations at each mine site. Two instruments were attached to shields over the pan line, the first close to the headgate and the second close to the tailgate. Two additional locations were monitored in the bleeders to determine the total volume of methane gas liberated from each panel, as well as the adjacent mined areas. Gas production data from vertical gob gas ventholes and underground horizontal boreholes were also obtained for evaluation. A production time study was conducted to relate the methane gas emission data to mining activity on the face.

METHANE EMISSION DATA

To predict the methane gas emission consequences of mining longwall panels of greater face width, it was first necessary to determine if a general increase in methane emission levels occurs with time (staircase effect), both during a longwall pass, and from day to day. To characterize any changes in the rate of methane gas emissions across the longwall face, each pass on the 229 m (750 ft) wide faces was divided into three equal length segments of 76 m (250 ft). Average methane emission rates of the second and third segments of a pass were compared to the respective previous segment to evaluate emission rate trends during the mining of an individual pass. Emission trends established by this methodology were then extended to forecast the expected methane emission rate of an additional 76 m (250 ft) longwall pass segment, i.e., a 305 m (1,000 ft) face.

Baseline emission data were collected over the weekend prior to the start of production shifts on Monday. Three full days and two partial days of monitoring (three production shifts per day) were completed in the VP-1 Mine. During this time the face was

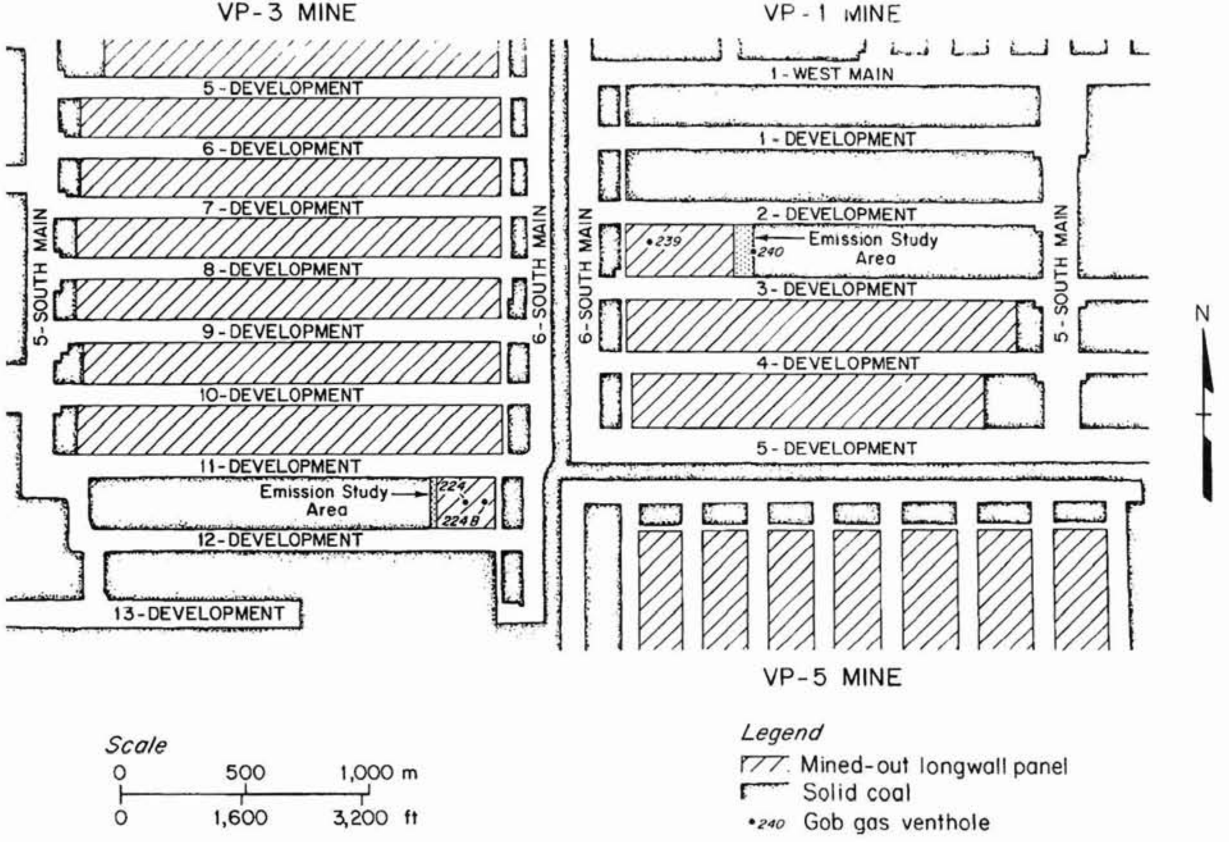

Figure 1. Map of VP-1 and VP-3 study areas.

advanced approximately 79 m (260 ft). Methane emission monitoring data and production time study data were collected on 83 individual passes, of which 77 had complete data sets foranalysis. Two full days and one partial day (two production shifts per day), and 37 m (120 ft) of face advance, were monitored at the VP-3 Mine site. A total of only 38 passes were monitored (23 with complete data sets) due to a substantial number of delays. Delays accounted for 42 percent of the time to complete a pass during the VP-3 study. In contrast, delays only accounted for 13 percent of the time to complete a pass during the VP-1 study.

Due to the expected influence of delay time on face emission rates, a data analysis method was devised that would facilitate a direct comparison of results from the two study sites. Methane emission data were evaluated on three bases related to the relative amount of delay time (Table 1). The first basis included all the passes with complete methane emission and time study data. The second basis eliminated any pass with delay time equal to or greater than 50 percent of the total time to complete the pass, and any pass that had a delay equal to or greater than 15 minutes on any pass segment. Any pass that experienced a reported meth-

Table 1. Average methane emissions summary, VP-1 and 3 Mines

Calculation basis	Number of passes used	Average pass segment methane flow rate					
		1st ⅓, m^3/min (cfm)	2nd ⅓, m^3\min (cfm)	2nd/1st, percent difference	3rd ⅓, m^3\min (cfm)	3rd/2nd, percent difference	Total, m^3\min (cfm)
				VP-1 Mine			
All with data	77 of 83	6.6 (233)	7.4 (262)	+12.4	7.8 (276)	+5.3	7.1 (250)
<50% delay	69 of 77	6.6 (232)	7.7 (271)	+16.8	8.0 (281)	+3.7	7.2 (254)
<25% delay	60 of 77	6.7 (235)	7.8 (276)	+17.4	8.0 (284)	+3.1	7.3 (257)
				VP-3 Mine			
All with data	27 of 38	10.2 (359)	11.7 (415)	+15.6	14.0 (494)	+19.2	11.4 (403)
<50% delay	11 of 27	10.6 (374)	12.4 (438)	+17.4	14.2 (502)	+14.6	12.1 (427

Baseline flow rate VP-1 Mine = 1.4 m^3/min (50 cfm).
Baseline flow rate VP-3 Mine = 4.2 m^3/min (150 cfm).

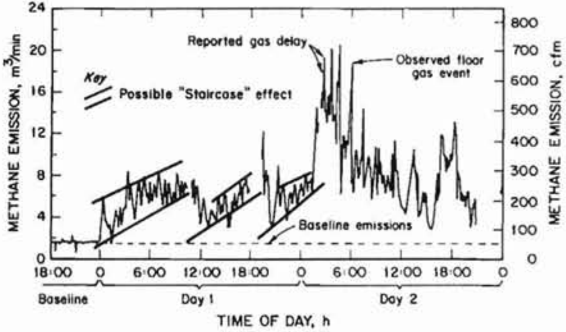

Figure 2. Methane emissions for the baseline and days 1 and 2, VP-1 Mine.

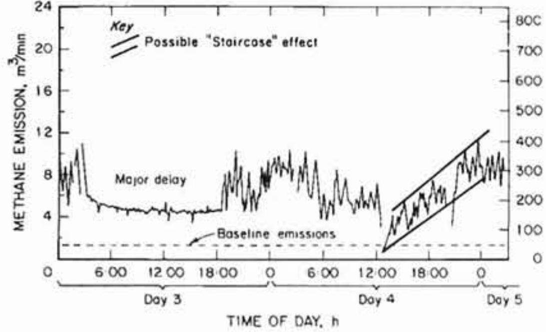

Figure 4. Methane emissions for days 3-5, VP-1 Mine.

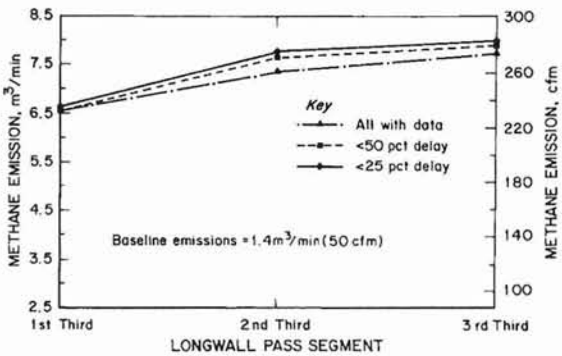

Figure 3. Average methane emissions by pass segment, VP-1 Mine.

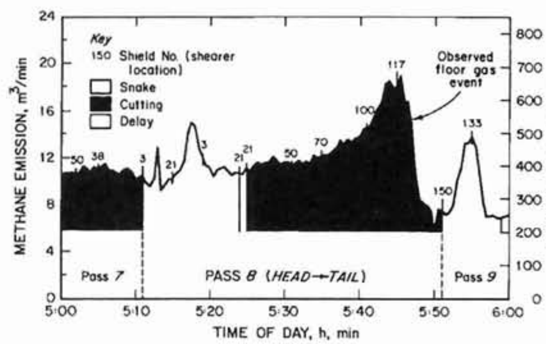

Figure 5. Methane emissions during floor gas event, pass 8, day 2, VP-1 Mine.

ane delay that would skew the comparison of emission levels between the pass segment with the methane delay and the pass segments before and/or after the delay, were also eliminated. For the VP-1 Mine site, 69 of the 77 passes with "complete data" were evaluated for this second delay time basis, compared to only 11 of 23 passes for the VP-3 Mine site.

The final basis for evaluating the emission results was the most stringent, reducing the previous delay time criteria by one half. This basis eliminated all passes having a delay time equal to or greater than 25 percent of the total time to mine a complete pass, or a delay equal to or greater than 7.5 minutes on any segment, and any pass that experienced a methane delay. This basis resulted in 60 of 77 passes with "complete data" being evaluated for the VP-1 Mine site. Only 5 of 27 passes met this more stringent criteria for the VP-3 Mine site, a number judged to be insufficient for meaningful comparisons.

VP-1 Mine Results

Baseline methane emissions for the VP-1 Mine were 1.4 m³/min (50 cfm) (Fig. 2). Methane emissions during the VP-1 study increased about 12 to 17 percent, depending on the delay time basis, from the first to second pass segment (Table 1, Fig. 3). As would be expected, the evaluation basis with the least amount of delay time generally had the highest methane emission levels. Emission rates were 6.7 and 7.8 m³/min (235 and 276 cfm), respectively, for the first and second pass segments for the <25 percent delay evaluation basis. Emissions increased only slightly from the second to third pass segment, averaging from 3 to 5 percent higher on the final third of the pass as compared to the second third. The average methane emission rate for a complete pass ranged from 7.1 to 7.3 m³ (250 to 257 cfm), depending on the delay time basis.

Delays were generally minor during the VP-1 emission study, with the exception of one major delay on day 3 that lasted approximately 16 hours (Fig. 4). This delay was caused by a problem with the aerial tram used to remove mine refuse material from the preparation plant. Reported delays of 13 minutes and 1 minute on day 2 were attributed to methane (Fig. 2). Methane levels actually began to climb early on day 2, before the reported methane gas delays. Emission rates increased from about 7.1 - 8.5 m³ (250 - 300 cfm) to over 19.8 m³/min (700 cfm). High methane gas levels experienced during day 2 of the VP-1 study (Figs. 2 and 5) were attributed to a floor gas bleeder, as evidence by gas bubbling in

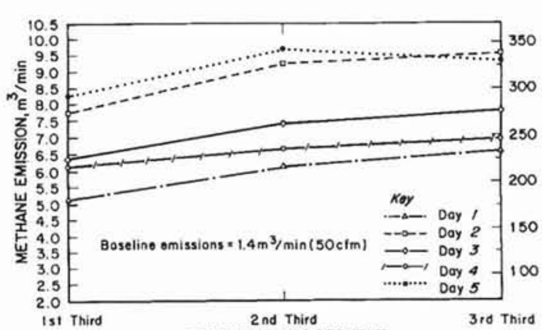

Figure 6. Average daily emissions, all passes with data, VP-1 Mine.

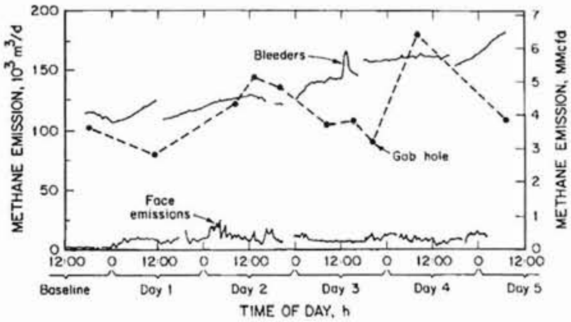

Figure 7. Methane flows and emissions during the mining of the VP-1 Mine study site.

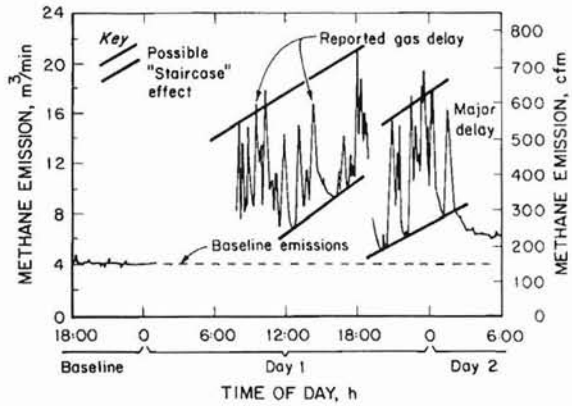

Figure 8. Methane emissions for the baseline and day 1, VP-3 Mine.

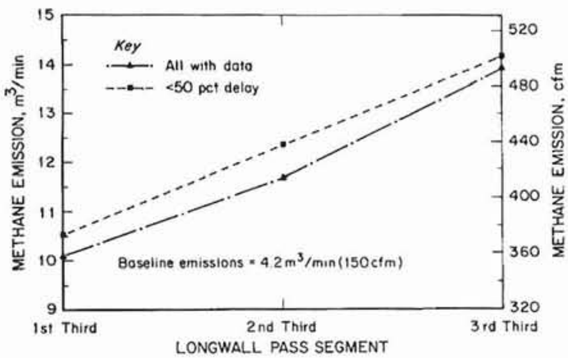

Figure 9. Average methane emissions by pass segment for all bases, VP-3 Mine.

standing water near the face.

Average daily methane gas emissions for each pass segment, for all passes with data, during the VP-1 study are shown on Figure 6. The first day of emission monitoring had the lowest methane emission levels, probably due to the two idle days prior to the start of mining on Monday. The average methane gas emission rate for a complete pass on day 1 was about 5.7 m^3/min (200 cfm). Day 2 showed a marked increase in methane gas emission rates to an average of 8.5 m^3/min (300 cfm) due to the floor gas event. After this steep rise, average daily emissions declined on days 3 and 4 (Fig. 6). This decline is probably due to a diminishing influence of the floor gas bleeder that occurred on day 2, the 16-hour delay early on day 3, as well as numerous shorter delays on day 4. The evaluation of emission trends with time, i.e., a day to day "staircase effect," was essentially lost due to the impact of the floor gas event and major delay that interrupted any longer term trends developing early in the study. However, a visual inspection of the methane emission curves (Figs. 2 and 4) suggests several time intervals during continuous mining operations, prior to the floor gas event, where the general emission rates were trending upward.

In addition to the longwall face emission study, the bleeder system associated with this area of the VP-1 Mine was monitored to obtain a more comprehensive evaluation of the study panel's gas contribution to the mine's ventilation system. The bleeder system monitoring location included methane contributions from the study panel as well as from the gobs of the two previously mined panels. Methane volumes above the baseline (established over the idle weekend) are attributed to emissions associated with mining on the active study panel. The bleeder system had a base flow rate of 105 x 10^3 m^3/d (3.7 MMcfd) (Fig. 7). As soon as mining began on the study panel, the methane gas flow rate began to climb, and generally continued to climb throughout the five days of the emission study. The maximum methane gas flow rate of 184 x 10^3 m^3/d (6.5 MMcfd) was measured on the final day of the study. Therefore, a maximum of 79 x 10^3 m^3/d (2.8 MMcfd) of methane attributed to mining of the study panel was liberated into the mine's bleeder ventilation system. This is significantly more methane than the average of 11 x 10^3 m^3/d (0.4 MMcfd) measured on the longwall face during the emissions study, as shown in Figure 7.

VP-3 Mine Results

Mining delays were substantially more frequent during the VP-3 Mine emission study than experienced during the VP-1 Mine study. The most stringent delay time basis for which a sufficient number of passes were available to establish any meaningful trends is the <50 percent delay time data (Table 1) for average total emissions and average emissions by pass segment. Due to the small number of passes available for analysis of daily emission trends at the more stringent delay time bases, these trends were only evaluated on the all passes with data basis. Baseline methane emissions (Fig. 8) were 4.2 m^3/min (150 cfm), or 2.8 m^3/min (100 cfm) higher than that of the VP-1 study. Methane emissions during the VP-3 study increased by about 17 percent from the first to the second pass segment on the <50 percent delay time basis (Table 1, Fig. 9). This is essentially the same percentage increase in emission levels noted in the VP-1 study on the same delay time basis. However, the actual VP-3 average emission rate for the second pass segment was substantially higher, 12.4 m^3/min (438 cfm) vs. 7.7 m^3/min (271 cfm) for VP-1.

There is one significant departure in the emission trends between the two mine sites. The emission rate at the VP-3 study site continued to increase from the second to third pass segment. This increase of 14.6 percent is in marked contrast to the minimal 3.7 percent average increase observed at VP-1. The average methane emission rate for the third pass segment reached 14.2 m^3/min (502 cfm), and the average emission rate for the VP-3 longwall passes was 12.1 m^3/min (427 cfm). Average daily pass methane emission rates progressively increased from 10.6 to 12.4 m^3/min (373 to 438 cfm) over the three days of the study, indicating a general "staircase effect" (Fig. 10). A visual inspection of the emission curves for the VP-3 study (Figs. 8 and 11) suggest several shorter time intervals where emissions were also trending

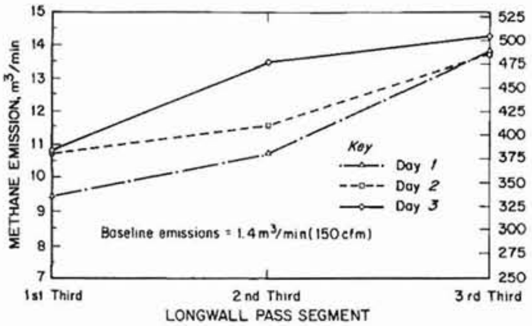

Figure 10. Average daily emissions, all passes with data, VP-3 Mine.

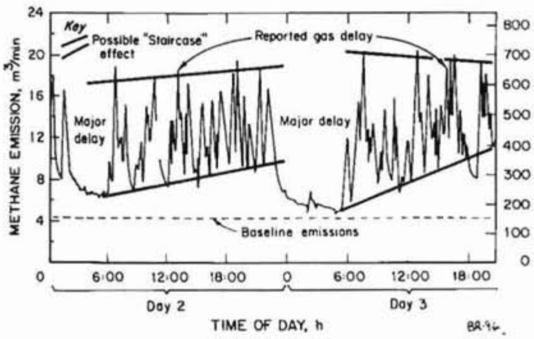

Figure 11. Methane emissions for day 2 and 3, VP-3 Mine.

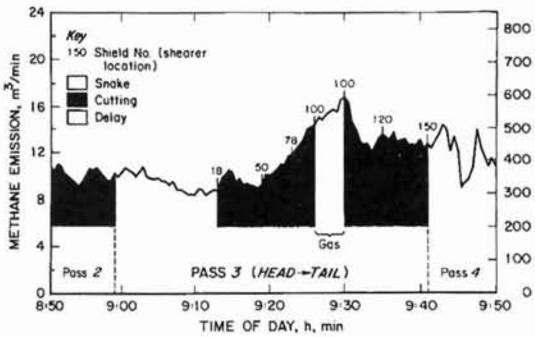

Figure 12. Methane emissions for pass 3, day 1, VP-3 Mine.

upward. There were four methane delays noted during the VP-3 longwall emission study. Methane delays of 4 minutes (Figs. 8 and 12) and 1 minute (Fig. 8) occurred on day 1. Emission rates at these points reached approximately 17.0 m³/min (600 cfm), similar to the rates associated with methane delays during the VP-1 study. However, emission rates prior to the methane delays were approximately 9.9 to 11.3 m³/min (350 to 400 cfm), or 2.8 m³/min (100 cfm) higher than those during the VP-1 study. Since methane delays were observed at about the same emission rate at each mine, there was less margin for methane emission increases at the VP-3 site. Additional methane delays of 4 minutes and 8 minutes were reported on days 2 and 3, respectively, at emission rates of about 18.4 m³/min (650 cfm) (Fig. 11).

Methane flow rates in the bleeder system associated with the study panel were also monitored (Fig. 13). In addition to the study panel, ten other previously mined panels to the north were part of

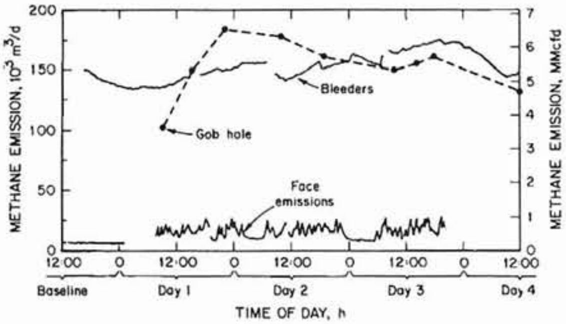

Figure 13. Methane flows and emissions during mining of the VP-3 Mine study area.

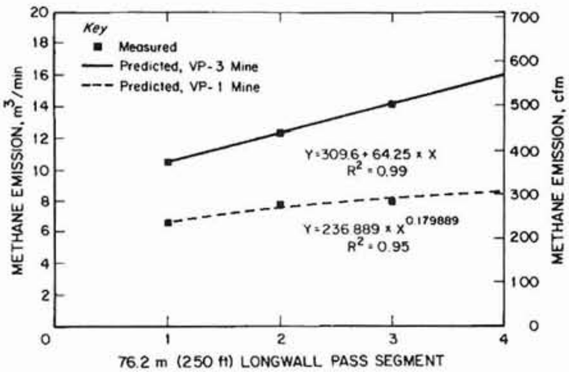

Figure 14. Methane emission prediction curve for 305 m (1,000 ft) face, VP-1 and VP-3 Mines.

this same bleeder system, complicating meaningful analysis of the data and comparisons to the VP-1 study. Baseline monitoring indicated a minimum methane flow rate of about 136 x 10³ m³/d (4.8 MMcfd), approximately 31 x 10³ m³/d (1.1 MMcfd) greater than that for the VP-1 study.

Methane flow rates in the VP-3 bleeder system peaked at about 176 x 10³ m³/d (6.2 MMcfd), slightly lower than observed at the VP-1 Mine. The difference of 40 x 10³ m³/d (1.4 MMcfd) between the maximum and base methane levels is inferred to be an estimate of the methane liberation into the bleeders as a result of mining on the active study panel, and is significantly less than the 2.8 MMcfd differential on the VP-1 study panel. This lower differential in the VP-3 bleeders, in spite of the higher face emissions, may be related to the large associated gob area, or to the higher base level bleeder flow rates. As was seen with the VP-1 study site, the maximum increase in methane flow rate in the bleeder system is higher, but in this case, not substantially higher, than the 17 x 10³ m³/d (0.6 MMcfd) of methane measured on the active longwall face (Fig.13).

PREDICTION OF METHANE EMISSIONS FOR 305 M (1,000 FT) FACES

Predictions of methane emission levels for faces extended from 229 to 305 m (750 to 1,000 ft) were made by regression analysis of the average longwall pass segment emission values from the 229-m (750-ft) wide faces at each mine. The minimum "delay time" basis with sufficient data for meaningful analysis was selected for regression analysis for each mine to best represent a "typical" pass with optimum mining rates. The predicted emission values for the additional 76 m (250 ft) of face width are not necessarily the "worst case" scenario, which would include sporadic high methane emission events such as the floor gas bleeder observed at the VP-1 Mine.

VP-1 Mine

Longwall pass segment methane emission data for the <25 percent delay time basis (Table 1) was selected for regression analysis at the VP-1 Mine. A power curve in the form $Y = 236.889X^{0.179889}$, where Y = average pass segment methane emission rate, and X = individual 76-m (250-ft) pass segment number, fit the measured data best ($R^2 = 0.95$). Extending the regression curve to a 4th, 76-m (250 ft) longwall pass segment (Fig. 14), i.e., to a face width of 305 m (1,000 ft), yields an average methane emission rate of 8.6 m^3/min (304 cfm) for the additional segment. This predicted value is a 7.1 percent (0.6 m^3/min [20 cfm]) increase over the average measured methane emission value of 8.0 m^3/min (284 cfm) for the third 76 m (250 ft) segment of the 229 m (750 ft) wide faces. At this relatively low predicted increase in methane emissions at the face, it is unlikely that methane emissions would be a limiting factor for the increased coal production expected from a 305 m (1,000 ft) wide longwall face.

VP-3 Mine

The <50 percent delay time basis (Table 1) was selected for regression analysis at the VP-3 Mine.

Due to the small number of passes meeting the more restrictive <25 percent delay time basis for the VP-3 Mine study, this basis could not be used for prediction of emissions from a "typical" 305-m (1,000-ft) pass. A linear regression curve in the form $Y = 309.6 + 64.25X$, where Y = average pass segment methane emission rate, and X = individual 76 m (250 ft) pass segment number, fit the measured data best ($R^2 = 0.99$). Extending the regression curve to a longwall face width of 305 m (1,000 ft), yields an average methane emission rate of 16.1 m^3/min (567 cfm) for an additional 76-m (250-ft) pass segment. This predicted value is a 12.9 percent (1.8 m^3/min [65 cfm]) increase over the measured methane emission value of 14.2 m^3/min (502 cfm) for the third 76 m (250 ft) pass segment of the 229-m (750-ft) wide longwall faces at the VP-3 Mine. Face emissions in the 17.0 to 19.8 m^3/min (600 to 700 cfm) range at the VP-3 Mine had occasionally resulted in short delays during the study. These higher emission rates may require additional ventilation airflow on the face, or increased levels of methane drainage in advance of longwall mining.

VARIATION IN METHANE EMISSION LEVELS

The methane emission characteristics were quite different at the two study sites. Baseline methane emission levels were 2.8 m^3/min (100 cfm) higher, and average longwall pass emissions (<50 percent delay basis) were approximately 4.8 m^3/min (170 cfm) higher at the VP-3 site. Methane emission levels were higher at the VP-3 Mine in spite of the fact that there were only two daily production shifts compared to three at the VP-1 Mine. There were also significantly more mining delays (non-methane related) at VP-3, which should have further allowed for additional "natural" bleed-off of methane. Additionally, there was a floor gas bleeder at the VP-1 Mine, which generally raised the average methane emission levels for about two days. Everything else being equal, lower methane emission rates would have been expected at the VP-3 Mine.

At first glance these methane emission observations are perhaps somewhat unexpected for two sites located only about 1,600 m (1 mile) apart in the same coalbed. However, a closer look at the mine design factors associated with the sites may to a large extent explain the observed differences. Probably the most significant mine design factors influencing the variation in methane emission levels at the two sites are their relative exposure to the virgin coalbed gas reservoir and gas bleed-off time prior to longwall mining. At the time of the studies, the VP-1 study panel was the third in a series of five longwall panels that were progressively mined to the north (Fig. 1). This block of five panels in the southwest corner of the mine had been outlined by main entries three and one-half months prior to the mining of the first panel. The area to the north of this five panel block was mined 3 to 12 years prior to the outlining of the block. This part of the VP-1 Mine is also bordered by the VP-5 Mine to the south and the VP-3 Mine to the west. The adjacent areas of the VP-5 and VP-3 Mines were mined approximately one to three years prior to the mining of the study panel. The extensive mine development surrounding the VP-1 study panel has very effectively isolated the area from methane migration from the downdip virgin coalbed gas reservoir.

This mining sequence is optimum from a methane control viewpoint. In addition to the general isolation of the southwest corner of the VP-1 Mine from gas migration, the in situ gas volume within the five-panel block had a substantial period of time to bleed-off into the surrounding entries. Gas was able to bleed-off for about six months prior to mining of the first panel in the block, and for eighteen months prior to mining of the study panel. This relatively long period for in situ gas content reduction for the isolated five-panel block, in particular the later-mined panels, should have resulted in progressively lower gas emissions at the face. Company engineering staff reported that the first panel mined in this isolated block was one of the gassiest at the mine, and that supplemental horizontal methane drainage boreholes had to be drilled to control the higher emissions. As each new panel in the block was mined, it is reported that methane emissions generally decreased. However, even with the additional bleed-off time prior to mining, it was still necessary to utilize horizontal methane drainage boreholes on the study panel to further control methane emissions.

Mine design parameters for the area of the VP-3 Mine where the study panel was located were quite different, and less desirable, from a methane control viewpoint. The study panel was the 11th in a series of panels mined in the southeast corner of the mine. Virgin coal reserves were adjacent to this area of the mine both to the west and south. Unlike the isolated block of five panels at the VP-1 study area, the series of panels in the VP-3 Mine had not been surrounded by main entries prior to mining of the panels (Fig. 1). The panels in the VP-3 study area were progressively developed and mined to the south. Each successive panel in the series was therefore connected to the virgin coalbed gas reservoir until the development entries for the panel were completed. The VP-3 study panel was surrounded by development entries and ventilation airflow just three and one-half months prior to the start of mining on the panel, and less than five months prior to the emission study. Therefore, there was very little time for in situ gas content reduction by horizontal methane drainage boreholes or bleed-off into the ventilation system prior to mining of the study panel.

This gas bleed-off time difference also had an influence on gas production from the horizontal boreholes at the two study sites. Total horizontal borehole methane production was 66 percent higher at the VP-3 Mine [3,828.5 x 10^3 m^3 (135.2 MMcf), or 226.5 x 10^3 m^3 (8.0 MMcf)/borehole], than at the VP-1 Mine [2,307.8 x 10^3 m^3 (81.5 MMCF) or 76.5 x 10^3 m^3 (2.7 MMCF) / borehole], where the gas from the panel had a longer time to dissipate into the ventilation system prior to the drilling of the horizontal holes. Methane production from the active gob gas ventholes was almost identical [116 x 10^3 m^3/d (4.1 MMcfd) and 119 x 10^3 m^3/d (4.2 MMcfd)] during the emission studies for the VP-1 (Fig. 7) and VP-3 (Fig. 13) Mines, respectively.

It is probable that at the time of the emission studies, the in situ gas content on the VP-3 study panel was higher than that on the VP-1 study panel due to the shorter time for bleed-off of gas into the mine's ventilation system prior to mining. It is also possible that the virgin gas content may have been higher at the VP-3 mine site. The VP-3 Mine study panel lies under a depth of cover that is about 183 m (600 ft) greater than the VP-1 Mine study panel. In general, gas contents of a coalbed increase with increasing depth (Diamond, 1982). Based on limited available gas content data from the mine complex area, it is estimated that the gas content of coal at the VP-3 study site could be about 1.3 cc/g (40 ft^3/t) higher than that at the VP-1 study site. This is probably not a significant enough difference to account for the substantial difference in longwall face methane emissions or horizontal borehole production observed between the two mines.

SUMMARY

The primary purpose of this investigation at the VP-1 and VP-3 Mines was to predict the methane emission consequences of increasing the longwall panel face width from 229 to 305 m (750 to 1,000 ft). The predictions were based on emission trends established by continuous monitoring of methane emission rates on the existing 229-m (750-ft) wide faces. It was predicted that average emissions would increase from 8.0 to 8.6 m^3/min (284 to 304 cfm) or 7.1 percent on longwall faces extended an additional 76 m (250 ft) to 305 m (1,000 ft) at the VP-1 Mine. This level of increase alone would probably not present any particular mining problem. In contrast, a similar analysis of emission trends from the VP-3 Mine study site suggested that average methane emissions could increase from 14.2 to 16.1 m^3/min (502 to 567 cfm), or 12.9 percent on faces extended to 305 m (1,000 ft). This level of methane emissions predicted for the additional face width at the VP-3 Mine is just below the general range of 17.0 to 19.8 m^3/min (600-700 cfm) where methane delays were occasionally experienced. At this level of increase for a "typical" pass, additional methane delays could be experienced. It is likely that increased ventilation airflow, and/or additional methane drainage would be required to safely realize the gain in coal production anticipated from mining larger panels.

Since this study was completed, the mine engineering staff reports that several panels with 305-m (1,000-ft) wide faces have been completed at the VP-3 Mine without experiencing the predicted higher methane emission levels. An enhanced methane drainage program that provided both increased hole length and additional time for the horizontal boreholes to drain gas in advance of mining is credited with maintaining the methane emissions at a lower than predicted level.

Methane emission levels were significantly different between the two mine study sites that were only about 1,600 m (1 mile) apart. Baseline methane emission levels at the VP-3 Mine study site were 2.8 m^3/min (100 cfm) higher than those at the VP-1 Mine. Average longwall pass methane emission levels were 12.1 m^3/min (427 cfm) at the VP-3 Mine, and only 7.2 m^3/min (254 cfm) at the VP-1 Mine. Study panels at both mines utilized in-mine horizontal borehole and vertical gob gas venthole methane drainage to supplement the mine's ventilation system. The higher level of methane emissions at the VP-3 Mine study site is attributed to (1) the closer proximity and longer exposure to the adjacent virgin coalbed gas reservoir and (2) to the shorter time for in situ gas content reduction by horizontal methane drainage boreholes and bleed-off into the ventilation system prior to mining.

In addition to the influence of isolation time on methane emission levels, it also affected methane drainage rates from the horizontal boreholes at the study sites. The horizontal boreholes on the VP-3 study panel produced 66 percent more total gas than those at the VP-1 site. In contrast, methane production from the gob gas ventholes was actually quite similar at both mine sites, indicating that gas bleed-off in the mined coalbed had little if any influence on gob gas.

The final point of interest evident from this study is that methane released at the face during active mining is only a relatively small portion of the overall methane liberation from an active longwall section. At the VP-1 Mine site, methane emissions from the active longwall face averaged about 11.3 x 10^3 m^3/d (0.4 MMcfd), or only about 5 percent of the 210 x 10^3 m^3/d (7.4 MMcfd) total methane emissions/borehole production attributed to the mining of the study panel. However, it was a higher percent of the total at the VP-3 Mine where the study panel had been directly connected to the virgin coalbed gas reservoir until shortly before mining began. At this study site, methane emissions from the face averaged about 17.0 x 10^3 m^3/d (0.6 MMcfd), or about 9 percent of the 18.1 x 10^3 m^3/d (6.4 MMcfd) total methane emissions/borehole production attributed to the study panel. The importance of methane drainage in supplementing the face ventilation system is quite clear. If even a small fraction of the gas handled by the methane drainage systems was diverted to the face area, both mine safety and the expected increase in coal production would be adversely affected.

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