Predicting methane emissions from longer longwall faces by analysis of emission contributors

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ABSTRACT: As part of its mining health and safety research program, the National Institute for Occupational Safety and Health (NIOSH) conducted a longwall methane emission and mining time study at a mine operating in the Pittsburgh Coalbed to access the methane emission consequences of mining a longer face. The methane emission contributors from the mining of a longwall face are: 1) gas released from the coal broken by the shearer, 2) gas emitted from the coal on the face conveyor, 3) gas emitted from the coal transported on the belt, and 4) background gas emitted from the coal face and from the adjoining ribs. Based on the results of the study, a set of site-specific mathematical formulas and constants were developed to characterize each of the four longwall emission contributors. The mathematical formulas were then applied to longer longwall face mining scenarios to predict the methane emissions from these faces.

1 INTRODUCTION

The coal industry trend of mining wider longwall panels is continuing throughout the world as gateroad development mining struggles to keep ahead of production on the longwall face. The mining of longer longwall faces has the advantage of less development mining per ton of coal mined on the longwall, but can result in increased methane emissions. The question asked by ventilation engineers is how much of an increase in methane emissions can be expected with the longer longwall face, and how can this be mitigated to maintain a safe underground workplace? An increase in the ventilation airflow to dilute the expected increase in methane emissions might not be possible because many modern longwalls are at, or near, the reasonably practical airflow limits. Therefore, the extra methane emissions will generally have to be handled by a combination of increased ventilation airflow, methane drainage and/or production management.

As part of its mining health and safety research program, NIOSH conducted a detailed longwall methane emission and mining time study at a mine operating in the Pittsburgh Coalbed in southwestern Pennsylvania. The initial goal of the experiment was to determine the methane emissions from individual sections of the longwall face and to extrapolate that data to estimate emissions from a longer longwall face. Using this approach, the face is divided into segments to characterize how methane emission rates vary across the face (Diamond & Garcia 1999, Schatzel et al. 2006). A graphical solution is then used to predict face emissions at longer face lengths based on emissions data from shorter faces. One shortcoming of this approach is that it assumes that the defined segments of the longwall face will continue to emit methane at the same rate with increasing face length. The assumption that a 244 m (800 ft) long longwall face will have the same methane emissions as encountered at the 244 m (800 ft) ft point on a 305 m (1000 ft) long face is incorrect because of the variations in coal production, methane emission drainage characteristics and coal transport factors.

A detailed and more meaningful analysis of the methane sources and their individual contributions to the total longwall methane emissions can be obtained from methane concentration data collected at the beginning and end of the longwall face, along with the shearer location and other relevant ventilation and mining data. The methane emission contributors from the mining of a longwall face that were evaluated for this study are: 1) gas released from the coal broken by the shearer, 2) gas emitted from the broken coal on the face conveyor, 3) gas emitted from the coal transported on the belt, and 4) background gas emitted from the coal face and from the adjoining ribs in the intake airway gateroad entries. Once the methane contributions from the various sources have been defined for an actual longwall cutting sequence, the methane emissions from an ideal (i.e. delay-free) cut sequence can be predicted. The calculated methane emission contributions can then be extrapolated to longer longwall faces, taking into account the variations in coal production and transport factors, to more accurately predict future methane emission rates from longer longwall faces.

2 METHODOLOGY

2.1 *Underground field study*

Methane concentrations were continuously monitored and recorded on the longwall face for one production shift per day (of the 2 production shifts per day) for three consecutive days. There were a total of 157 shields on the 315 m (1032 ft) longwall face. The methane monitors were located at the 20th, 80^{th,} and 145th shield locations. Multiple methane sampling concentration values were measured and recorded as an averaged value for each minute. Periodic ventilation airflow measurements were made along the longwall face at the location of the methane monitors and at other key locations in the study area. The location of the shearer was recorded as part of the time study, which also included the time, duration, and reason for any mining delays due to the following factors: gas, belt problems, face conveyor problems (rock jam), calibration of methane sensors, and miscellaneous other problems.

The methane monitors for this study were located at shields number 20, 80 and 145. These positions were chosen based on previous studies that indicated possible air interactions at the corners of the head and tailgate (Diamond & Garcia 1999). Some of the headgate air for the first few shields on the longwall face can flow behind the shields before reaching the longwall face. Airflow from behind the tailgate shields can be pulled into the main exhaust system at various locations along the face, or face ventilation air can travel behind the shields into a bleeder system. This complex interaction of longwall face ventilation airflow and airflow behind the shields was to be reduced by the placement of methane sensors approximately 37 m (121 ft, shield 20) from the headgate corner and 21 m (69 ft, shield 145) away from the tailgate corner of the panel. The methane contribution interpretation does not take into account the possible effect of ventilation airflow interactions with the gob, which is consistent with the initial goal of the study.

2.2 *Site specific information*

The physical aspects, equipment, operational, and ventilation scenarios of the longwall panel (Fig. 1) are very important to the evaluation of methane sources because they determine the mathematical formulas used in the methane contribution model. The site-specific variables for this study are as follows:

- Three entry gateroad development [#1 belt (intake), #2 track (intake), #3 (return)] on the headgate
- Previous longwall panel mined on the tailgate side
- Exhaust ventilation via bleeder fan
- Bi-directional cut sequence
- Shearer depth of cut (web), 1.07 m (42 in)
- Some intake air brought to face via belt airway , therefore, belt coal methane component to account for
- Panel width (edge-to-edge), 315 m (1032 ft)
- Original panel length, approximately 3048 m (10,000 ft)
- Remaining panel length at the time of the study, 1195 m (3920 ft)
- Longwall face height, 2 m (6.5 ft)
- Shield width, 2 m (6.5 ft)
- Total number of shields, 157 (#1 is at the headgate and #157 is at the tailgate)
- Shearer average cut speed, 14 m/min (46 ft/min)
- Face conveyor length, 315 m (1032 ft)
- Face conveyor speed, 1.78 m/s (353 ft/min)
- Longwall face average airflow velocity, 2.54 m/s (500 ft/min)
- Belt speed, 4.06 m/s (800 ft/min)
- Belt airflow average velocity (intake), 1.93 m/s (380 ft/min)
- The shearer's location recorded at the location of the headgate drum

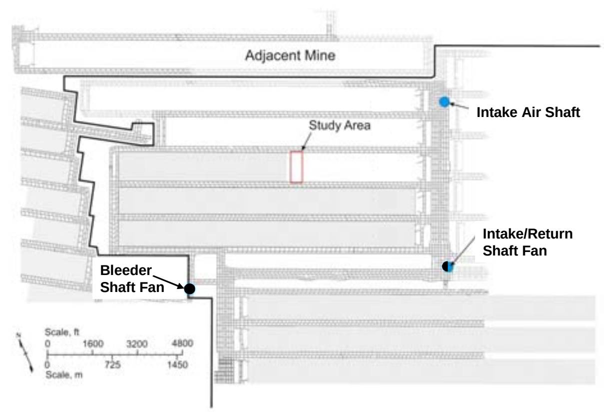

Figure 1. Study area for longwall face emission investigation.

2.3 *Assumptions*

Methane content of the coal is assumed to be consistent across the longwall face and consistent along the # 1 belt rib. No decay function for the components sources was modeled because the accuracy of the methane readings did not support such detail. Thus, the following assumptions have been applied to this study:

- Background methane emissions from the longwall face (active, not idle) are linearly dependent on longwall face length.

– Background rib methane emission from the #1 belt entry are linearly dependent on the remaining length of the longwall panel, but are independent of longwall face width or activity.
– There is no significant interaction between the face air and the air in the gob.
– Stage loader located at the headgate was not incorporated in the simulation.
– Methane liberation rate at the shearer is proportional to the cut coal volume.
– Methane liberation rate on the face conveyor is proportional to the coal tonnage × elapse time on the conveyor.

2.4 *Construction of formulas*

The calculations for the methane contribution model are empirical, and site-specific for the longwall panel, but the concept can be generally applied to other longwall panels. Since the location of the longwall shearer is known from the time studies, the change in shearer location and the depth of cut can be used to determine the volume of coal mined during each minute. The face conveyor and belt speeds are known, so the transportation times of the coal after cutting can be determined. The ventilation airflow rates along with the width and remaining length of the longwall panel determine the transit time of the airflow across the longwall face and for the belt entry.

The following describes the mathematical process used in the evaluation. The longwall face was broken down into 61 meter sections (200 ft) to correspond with the width of 30 shields. Since the face conveyor speed was 1.78 m/s (350 ft/min), the transport time for coal over 61 m (200 ft) of the face conveyor was (61 m / 1.78 m/s) = 34 seconds, and the transport time for the counter flowing ventilation airflow was (61 m / 2.54 m/s) = 24 seconds. Therefore, the time for the coal to be transported by the face conveyor and the time required for the counter flowing air to transit the same distance adds up to 58 seconds, which was rounded to 1 minute to match the methane concentration readings recorded every minute. The emission times for methane from the sources of interest as well as transit times for the associated ventilation airflows can be summarized as follows:
– Coal cut by Shearer, 0-2 minutes
– Coal on face conveyor, 1-3 minutes
– Airflow along longwall face, 2 minutes
– Coal on belt, 5 minutes
– Airflow along belt, 10 minutes

Therefore, when the shearer is cutting coal, the liberation of methane from the coal face will be recorded by the methane monitor located near the tailgate at shield 145, either instantly or up to 2 minutes later, depending on the shearer’s location. If the shearer is located on the tailgate side of shield 145, no extra methane liberated by the shearer will be recorded by the methane monitor. If the shearer is located within 61 m (200 ft) on the headgate side of shield 145, then methane liberation due to the cutting of the coal will be recorded for that minute. If the coal was cut nearer the headgate, it would take up to 2 minutes for the face air to travel to the methane sensor located at shield 145.

The contribution of methane emissions from the coal on the face conveyor is more complicated because coal cut by the shearer can be transported on the face conveyor for 1 to 3 minutes. To determine the transport time for methane emissions from the coal on the face conveyor, the counter flowing longwall ventilation airflow and the shearer location/direction-of-travel must be taken into account. As an example, coal cut at shield 145 will release methane that will be recorded at shield 145 instantly (0 minutes). Coal transported on the face conveyor will release gas into the face ventilation airflow for a total of 3 minutes (0-2 minutes), during which time the counter flowing face ventilation will take up to 2 minutes to reach shield 145, so methane emitted from the coal on the face conveyor will be recorded at shield 145 for 0-4 minutes in this example.

Continuing this example, methane emissions from the coal on the belt will be recorded at shield 145 for 5-19 minutes after coal was initial cut at shield 145 (2 minutes for the face conveyor, 2 minutes for the face airflow transit time, 1-5 minutes for the belt transport time, and 0-10 minutes for the belt airflow transit time). Therefore, coal mechanically cut by the shearer will affect methane emission levels near the tailgate instantly, and for as long as 19 minutes after being cut.

The contributions of methane from individual sources over time lead to a simple set of five linear equations for shearer, face conveyor, belt, background emissions from the coal face and background emissions from the adjoining ribs in the intake gateroads, which were solved for each minute of the three shifts monitored. Constants in each equation were calculated by least-squares, linear regression such that the calculated results best matched the actual readings at shields 20 and 145.

The shield 20 data led directly to calculations of the background emission for the #1 belt entry intake rib. The total background emission at shield 145 minus the contribution from the belt yields the estimated background component from the longwall face alone. Longwall production delays in the cutting sequence are used to define the methane emissions associated with individual component sources.

3 RESULTS

The calculated emission constants for each of the methane contributor components for each day of the study are shown in Table 1 including a three-day average value for these constants. Note that when both shield 20 and 145 are used to calculate the constants, the background methane emissions can be separated into the longwall face and intake rib components by the difference between the shield 145 and shield 20 values. During the evaluation it was determined that the readings from the methane sensor at the shield 80 location were erratic and gave conflicting results indicating incorrect data received from this sensor. Therefore, constants have only been calculated for the shield 20 and 145 locations.

Table 1. Calculated constants for the emission component

	Location used	Conveyor	Belt	Shearer	Background Shield 145	Background Shield 20
Day 1	Shield 145 only	6.16	1.85	9.03	119	
	Shield 20 & 145	6.51	1.63	7.95	129	-6
	Shield 20 only	8.82	1.42	2.95		1
Day 2	Shield 145 only	4.20	1.99	5.10	123	
	Shield 20 & 145	4.07	1.55	3.48	149	5
	Shield 20 only	4.69	1.12	4.26		24
Day 3	Shield 145 only	4.97	2.40	7.15	194	
	Shield 20 & 145	6.64	0.72	7.34	246	86
	Shield 20 only	6.20	0.51	7.23		94
3-Day Average						
	Shield 145 only	5.11	2.08	7.09	146	
	Shield 20 & 145	5.74	1.30	6.26	175	28
	Shield 20 only	6.6	1.0	4.8		40

The calculated emission constants are consistent for the three days of the study, except for the background methane levels at shield 20. The background at shield 20 represents the methane load from the intake ribs, which should be fairly consistent. However, this value varied considerably over the three days of the study, starting out as a minor negative value in day one, to a high positive value in day three. The reason for this dramatic increase is most likely caused by the intersection of a horizontal degas hole located outby and up wind of the shield 20 methane sensor. The background rib value at shield 20 for day one, calculated using data from both sensors, results in a small negative value, which translates to only 0.0014 m^3/s (3 cfm). After considering the consistency of the emission constants for the other three components (face conveyor, belt, and shearer) from shields 20 and 145 individually and combined, it was decided to use the three-day average for shields 20 and 145 for further evaluation of the background emission component. Using the average for shield 20 and 145 will also separate the background emission component into its two parts (i.e. methane emissions from the face and from the intake ribs), thereby giving a more accurate prediction for longer face lengths.

The calculated average methane emission rates for each contributor are shown in Tables 2 and 3. Table 2 shows the methane contributors solved using the daily constants for shields 20 and 145. Table 3 shows the methane contributors solved using the three-day average constants for shields 20 and 145. The 'total' values in Table 2-3 are the calculated average methane for the individual days. The 'actual' values are the recorded methane for the individual days, and in Table 3, they do not exactly match the calculated 'total' values.

Table 2. Daily methane emission contributor averages and percentages using daily shield 20 & 145 constants (top of table 1).

Shield 20 & 145 Daily results	Conveyor (m^3/s)	Belt (m^3/s)	Shearer (m^3/s)	Face (m^3/s)	Rib (m^3/s)	Total (m^3/s)	Actual (m^3/s)
Day 1	0.012	0.015	0.005	0.027	-0.001	0.057	0.057
Day 2	0.005	0.014	0.004	0.028	0.002	0.052	0.052
Day 3	0.007	0.006	0.005	0.030	0.019	0.068	0.068
Average	0.008	0.012	0.005	0.029	0.006	0.059	0.059

Shield 20 & 145 Daily results	Conveyor (cfm)	Belt (cfm)	Shearer (cfm)	Face (cfm)	Rib (cfm)	Total (cfm)	Actual (cfm)
Day 1	26	31	10	57	-3	121	121
Day 2	11	29	8	60	3	111	111
Day 3	15	14	11	64	40	143	143

Shield 20 & 145 Daily results	Conveyor (%)	Belt (%)	Shearer (%)	Face (%)	Rib (%)	Total (%)	Actual (%)
Day 1	22%	26%	8%	47%	-3%	100%	100%
Day 2	10%	26%	7%	54%	3%	100%	100%
Day 3	10%	9%	8%	45%	28%	100%	100%
Average	14%	20%	8%	49%	9%	100%	100%

Table 3. Daily methane emission contributor averages and percentages using average three-day shield 20 & 145 constants (bottom of table 1).

Shield 20 & 145 3-Day average	Conveyor (m^3/s)	Belt (m^3/s)	Shearer (m^3/s)	Face (m^3/s)	Rib (m^3/s)	Total (m^3/s)	Actual (m^3/s)
Day 1	0.011	0.012	0.004	0.028	0.006	0.061	0.057
Day 2	0.010	0.012	0.004	0.028	0.006	0.060	0.052
Day 3	0.008	0.010	0.003	0.028	0.006	0.056	0.068
Average	0.010	0.011	0.003	0.028	0.006	0.059	0.059

Shield 20 & 145 Average results	Conveyor (cfm)	Belt (cfm)	Shearer (cfm)	Face (cfm)	Rib (cfm)	Total (cfm)	Actual (cfm)
Day 1	23	25	8	60	13	129	121
Day 2	21	25	8	60	13	127	111
Day 3	18	21	6	60	13	119	143

Shield 20 & 145 3-Day average	Conveyor (%)	Belt (%)	Shearer (%)	Face (%)	Rib (%)	Total (%)	Actual (%)
Day 1	19%	20%	7%	49%	11%	106%	100%
Day 2	19%	22%	7%	54%	12%	114%	100%
Day 3	13%	15%	4%	42%	9%	83%	100%
Average	17%	19%	6%	48%	11%	101%	100%

3.1 *Gas delays*

The background face and rib emissions represent about 59% of the total daily emissions; however, this is somewhat misleading because these emissions continue throughout the entire shift, including during mining delays. In contrast, the shearer, face conveyor, and belt emissions are intermittent sources (i.e. they are only a factor during active mining on the face and during coal transport), but they are the primary contributor to longwall face gas delays, as shown in Table 4.

The calculated methane contributions (Table 4) clearly show that the head-to-tail passes experience higher methane concentrations than the tail-to-head passes. The time study data for the three days of the study showed 19 gas delays (shutdowns of mining equipment due to excessive methane concentrations) on 10 of the 11 head-to-tail passes. The average location for the gas delays on the head-to-tail passes was at about shield 119, 245 m (804 ft), or 78% of the distance down the longwall face from the headgate corner.

Table 4. Methane contribution percentages from longwall emission contributors during gas delays compared to daily averages for a 315 m (1032 ft) longwall face.

Methane contributions		Conveyor	Belt	Shearer	Background
Three day averages		17%	19%	6%	59%
Gas delays	No.				
Cutting gas delays	23	32%	18%	9%	42%
Head-to-Tail gas delays	19	33%	18%	9%	41%
Tail-to-Head gas delays	4	26%	18%	8%	48%

There were four gas delays recorded on three of the nine tail-to-head passes. The average location for the gas delays on the tail-to-head passes was at about shield 71, 146 m (480 ft), or 46% of the distance down the longwall face from the headgate corner. The average duration for all 23 gas delays was seven minutes irrespective of cutting direction.

The relative contribution of the components of the average daily methane emissions is not as significant as it is the relative contribution of the components in the peak levels that causes gas delays. Table 4 shows that during the periods of gas delays, the methane contributions from the face conveyor and shearer dramatically increase in total percentage.

3.2 *Cutting direction and delays*

The direction of cutting is very important to methane emissions on the longwall face because at the end of a head-to-tail pass, the face conveyor, shearer, and belt are all contributing gas at or near their maximum rate. The tail-to-head passes do not have coincidental maximums for face conveyor, shearer, and belt emissions, so a more consistent emission rate occurs over the entire cut sequence, which explains the less frequent gas delays on tail-to-head passes. Of the 11 head-to-tail passes over the three shifts that were monitored for this study, not one full speed cut was made without a gas delay. The first head-to-tail pass on day one had two belt delays. The remaining 10 cuts all had gas delays. Of the nine tail-to-head passes, three had gas delays, three were cut at a slower speed for unknown reasons, and three were cut full speed without any delays.

Figures 2-6 show the calculated methane contributor components for day one using the three-day average constants of shield 20 and 145 from Table 1. The calculated methane contribution is a multiplication of the three-day average constant of shield 20 and 145, and the formula results for each minute for day one. Figure 2 shows the actual methane emissions measured at shield 20 and 145, and the shearer's location for day one. Figure 3 shows the calculated shearer and conveyor emissions for day one along with the shearer's location. Figure 4 shows the belt and background emissions along with the shearer's location.

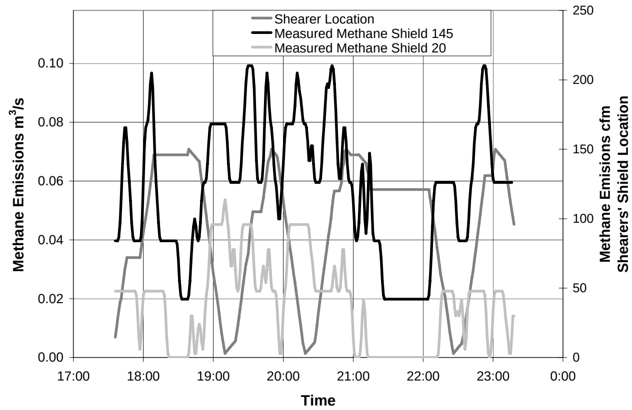

Figure 2. Recorded methane emission data at shield 20 and 145 and shearer's location, study day one.

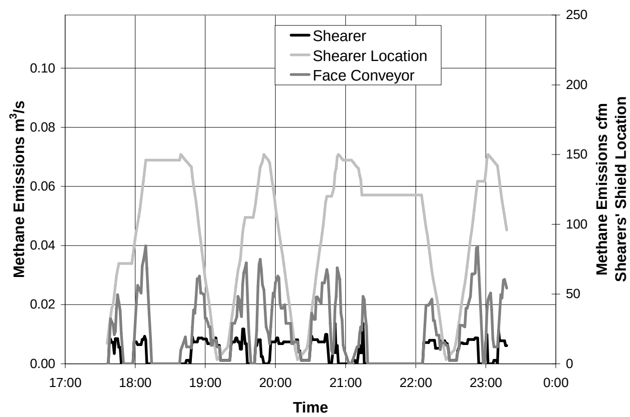

Figure 3. Calculated shearer and face conveyor coal transport methane contribution based on the shearer's location, study day one, 315 m (1032 ft) face.

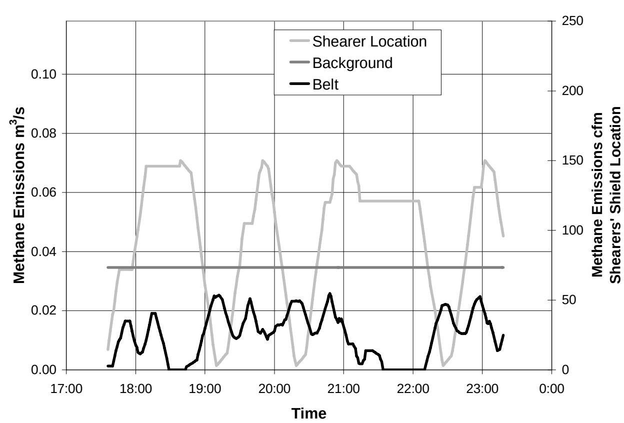

Figure 4. Calculated belt coal transport and background methane contributions based on the shearer's location, study day one.

Figure 5 shows all components and the calculated total methane emissions for day one. Figure 6 shows the calculated vs. measured methane for shield 145 during day one, along with the four gas delays that correspond to the to the high methane emissions.

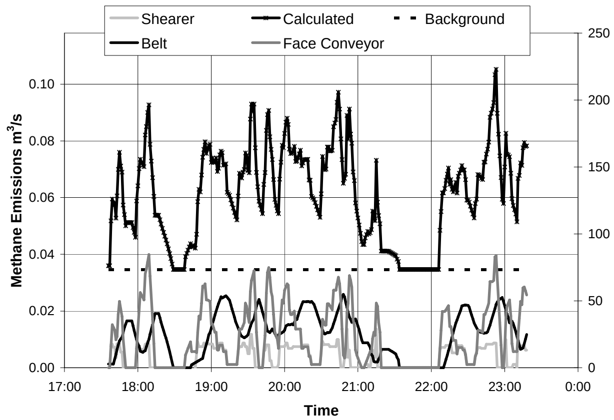

Figure 5. Calculated individual methane contributors and total calculated methane emissions for study day one.

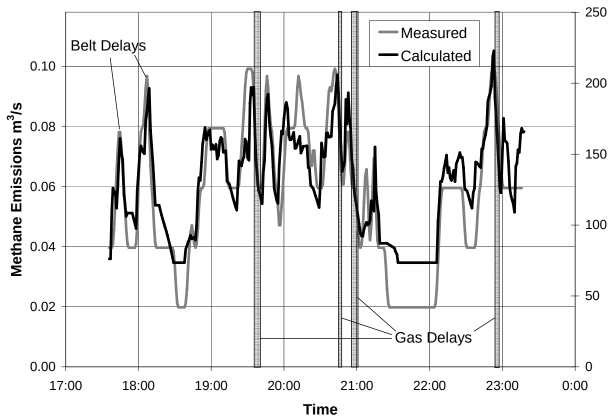

Figure 6. Calculated vs. actual measured methane emissions, 315 m (1032 ft) longwall face, study day one, using the three-day average, including four gas delays.

3.3 *Predicting methane emissions on longer longwall faces*

Simply determining the methane emissions at the corner of the tailgate and then linearly extrapolating the results to longer faces does not take into account the effect of coal production and transport factors. The simple assumption that a longer face will only have increased background face emissions and no contribution from the other components (shearer, face conveyor, belt) is incorrect, because productivity (coal volume mined/hour) will be increased for a longer face since the cut cycles are face length dependent. The mine used a bi-directional cut sequence. At longer face lengths, the wedge/sumping times are assumed to be the same as for the base case, but the cutting times will increase proportionally to the face length, minus the sumping distance.

Assuming that the longwall face conveyor can keep up with the shearer and the shearer cuts at the same speed over the greater face length, it then follows that the productivity of the shearer will increase because a greater percentage of time will be allotted to cutting, than sumping. Therefore, the total methane liberation from the mined coal during a shift would increase, but the shearer's emission rate during cutting will remain the same for a longer longwall face, if the cutting speed remains constant. The rib emission will be linearly dependent on the remaining length of the panel. The background emissions for the longwall face will increase linearly with face length, however where the belt line in used as a source of face air the background emission from the intake rib will remain constant.

The face conveyor, if operating at the same speed, will transport a greater volume of coal per hour for a longer longwall face because of the higher shearer utilization time for coal cutting versus sumping. In addition, the face conveyor will also transport the coal over a greater distance and for a longer time, thereby increasing the methane emissions from this component on a longer longwall face. The belt emissions are a function of the amount of coal on the belt and the transport time. The belt transport time (dependent on remaining panel length and belt speed), will be the same for different longwall widths, and only the increased amount of coal produced by the shearer working on a longer longwall face will effect the belt emissions. The belt emissions can also reach a steady-state maximum when the entire belt is full with coal, thereby limiting the upper limit of belt emissions regardless of panel width.

The calculated results for methane emissions on longer longwall faces are predicted for a location approximately 15 m (50 ft) outby the tailgate corner, before any possible interaction with the gob gas near the tailgate. Figure 7 shows two full cuts without delays for a 305 m (1000 ft) wide longwall panel. The predicted peak methane emission of 0.110 m^3/s (234 cfm) closely matches the maximum values recorded during the study, 0.099 m^3/s (210 cfm) (Fig. 2). Figure 8 shows the predicted methane emissions for two full cuts without any delays for a 488 m (1600 ft) wide longwall panel. The calculated peak methane emissions for the 488 m (1600 ft) wide longwall panel [0.152 m^3/s (322 cfm)] are 37% higher than for a 305 m (1000 ft) wide longwall panel [0.110 m^3/s (234 cfm)] (Table 5).

Coal on the face conveyor had the largest calculated increase in methane emission rates on the longer longwall faces, while coal cut by the shearer and on the belt had no increase (Table 5). The face conveyor's methane emission increase is due to the increased length and time that the coal will be carried by the conveyor. Keeping the length of the remaining panel (and hence, the length of the belt) constant at 1195 m (3920 ft) for each of the increased face length emission calculations precludes any extra peak methane load being emitted by coal on the belt.

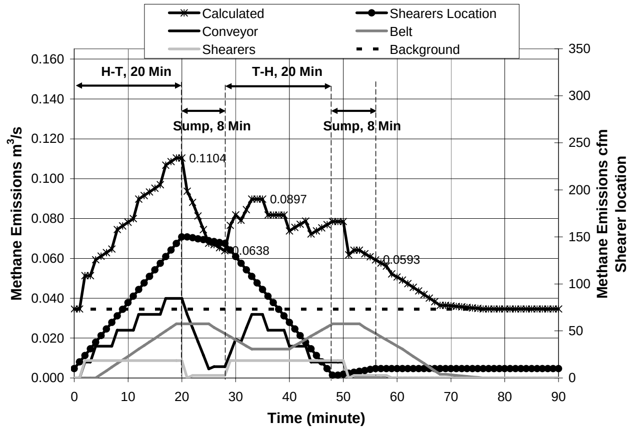

Figure 7. Two full-cut passes without delays for 305 m (1000 ft) longwall face length.

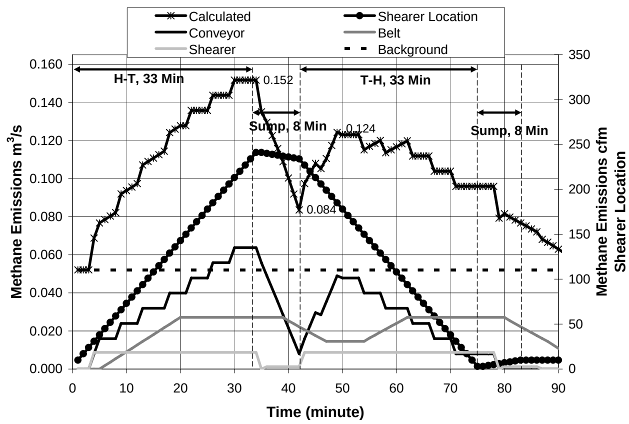

Figure 8. Calculated methane emissions for two full cuts without delays for a 488 m (1600 ft) longwall face.

Table 5. Calculated rates for methane emission contributors on idealized passes on longer longwall faces.

Face Width (m)	Conveyor (m^3s)	Belt (m^3s)	Shearer (m^3s)	Background (m^3s)	Peak (m^3s)
305	0.040	0.027	0.009	0.035	0.110
366	0.048	0.027	0.009	0.040	0.124
427	0.056	0.027	0.009	0.046	0.138
488	0.064	0.027	0.009	0.052	0.152

Face Width (ft)	Conveyor (cfm)	Belt (cfm)	Shearer (cfm)	Background (cfm)	Peak (cfm)
1000	85	58	18	73	234
1200	101	58	18	86	263
1400	118	58	18	98	292
1600	135	58	18	110	322

Percent relative to 305 m (1000 ft) longwall face

Face Width	Conveyor	Belt	Shearer	Background	Peak
305 m (1000 ft)	100%	100%	100%	100%	100%
366 m (1200 ft)	120%	100%	100%	117%	112%
427 m (1400 ft)	140%	100%	100%	134%	125%
488 m (1600 ft)	160%	100%	100%	150%	137%

The background emissions increase with increases in the face length due to the increase in exposed longwall face area. The methane contribution from the ribs in the gateroads does not increase because the length of the gateroads remains constant in these calculations.

One other consideration that should be noted in the evaluation of the influence of increased face length on longwall methane emissions is that the longer longwall faces will theoretically have higher coal productivity because a greater percentage of time will be spent cutting coal and not sumping. As an example, the 488 m (1600 ft) wide longwall panel will emit 37% more methane at its peak (Table 5, Fig. 8), but will also increase coal productivity by 11% (Table 6).

Table 6. Percent in total methane emissions and coal production for longer longwall faces.

Face Width	Peak Methane	Average Methane	Productivity Tonnage
305 m (1000 ft)	100%	100%	100%
366 m (1200 ft)	112%	113%	104%
427 m (1400 ft)	125%	128%	108%
488 m (1600 ft)	137%	141%	111%

3.4 *Reducing shearer speed to reduce peak methane emissions on head-to-tail passes*

As mentioned previously, the highest predicted methane emissions for longer longwall faces are near the end of the head-to-tail cuts when the emissions from the coal on the face conveyor and belt are at their highest (Table 4). During the three shifts monitored for this study, not one of the 11 head-to-tail passes was completed at full speed without a gas delay. The average gas delay occurred around shield 119, 245 m (804 ft) from the headgate and averaged seven minutes. Slowing down the shearer for the second half of the face traverse will reduce the peak methane emissions and give a more consistent emission level, as demonstrated by decreasing the shearer speed factor in the emission equations generated for this study. The results of the influence of shearer traverse speed on emissions for the 485 m (1600 ft) panel are shown graphically in Figure 9.

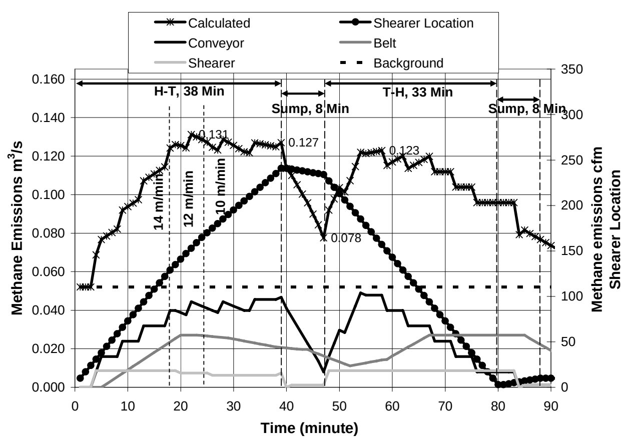

Figure 9. Calculated influence of reduced shearer transit time pass for 485 m (1600 ft) longwall face, shearer traveling at 14 m/min for the first 250 m of the head-to-tail cuts, then at 12 m/min, and finally at 10 m/min to the tailgate.

The reduction in methane emission rates resulting from slowing down the shearer transit time is dramatic, with only 86% [0.152/0.131 m^3/s (278/322 cfm)] of the peak methane emissions being encountered. The five extra minutes required to cut the head-to-tail pass due to the reduced shearer transit time (Fig. 9) is still less than the observed average gas delay of seven minutes for head-to-tail passes. With the slowing of the shearer transit time on head-to-tail passes, the calculated peak methane emission values based on the cutting direction are now within 7% of each other, as compared to the 20% difference for the full speed head-to-tail pass (Figure 8).

3.5 *Converting Belt entry to return to eliminate belt methane emissions*

The conversion of the #1 belt entry to return airflow, and the conversion of the #3 return entry to intake could increase total airflow at the longwall face, as well as eliminate the belt coal methane emission component from the total methane emission load reaching the tailgate corner of the face. The primary drawback to this arrangement is that the #3 entry ribs tend to have a higher background methane emission rate than the #1 entry, due to the virgin coal along the #3 entry's rib.

4 CONCLUSION

Coal production and transport factors have a dynamic effect on methane emissions experienced on the longwall face. With a detailed mining time study and associated methane concentration data across a longwall face, the methane emission contributions from the major coal production and transport components can be mathematically determined. The site specific layout and position of the longwall panel determines the regression constants for the calculations since methane emission contributions change throughout the mining of the panel. The mathematical concept can be used to estimate the methane emissions for wider and longer longwall panels. In addition, the concept can be used for evaluating mine design, ventilation as well as engineering and operating measures to control the expected increases in methane emissions. The component source approach can be applied to other coalbeds provided that coalbed-specific methane emission characteristics are known or can be measured.

The expected peak methane emission increases for wider longwall panels result primarily from the coal transported on the face conveyor and the background emissions from the exposed coal on the face. The methane emission increases related to the transport of coal on the face conveyor is unavoidable for longer longwall faces, unless the shearer's transit speed is reduced at the end of a head-to-tail pass. Methane emissions associated with the cutting of coal on the face by the shearer will remain constant at longer longwall face lengths, so long as the transit speed remains the same.

Methane emissions from the coal transported on the belt is the only component that can be altered by engineering and ventilation practices such as coursing the belt air away from the face. The background face methane emission contribution can be reduced by the use of or more extensive methane drainage techniques. Long-term methane drainage will also reduce the methane content in the coal and thereby reduce the shearer and conveyor methane components.

In summary, mine designers have several options to reduce or dilute methane emissions expected from wider longwall panels, such as the following:

- Increasing ventilation airflow quantities to the longwall face
- Reducing the shearer transit speed, especially on head-to-tail passes
- Utilizing or increasing methane drainage techniques will reduce emissions from all the considered sources by reducing the methane content of the coal
- Implementing ventilation design changes, e.g. not coursing the # 1 belt entry's ventilation airflow to the face

5 DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

6 REFERENCES

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