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Method for Predicting Methane Emissions on Extended Longwall Faces

Objective

To provide longwall operators with a method to predict methane emissions from panels with increased face width.

Background

The explosion or ignition of methane has been a major cause of multiple fatalities in underground coal mines in the United States. Several factors are known to influence methane emissions during longwall mining, including (1) coal extraction rate, (2) gas content of the coal mined, (3) methane drainage practices, (4) gas in surrounding strata, particularly the proximity of these gas-bearing strata to the mined coalbed, and (5) the development of mining-induced fractures that provide pathways for gas migration to the active face or gob areas. One trend in longwall mining for which the methane gas emission consequences were largely unknown was the mining of larger panels. In an effort to increase mining efficiency, average longwall panel size increased from approximately 183 by 1,411 m (600 by 4,630 ft) in 1986 to 247 by 2,292 m (810 by 7,520 ft) in 1996. Unfortunately, gains in mining efficiency, along with the extraction of deeper, gassier coalbeds, may be accompanied by an increased flow of methane into the underground workplace.

The ability to predict the methane emission consequences of altering mine design parameters such as longwall panel dimensions, particularly face width, is desirable for maintaining a safe work environment. If higher emissions rates are the result of changing mining practices, it is preferable from a safety perspective to be prepared in advance, either with increased ventilation airflow or with appropriate methane drainage capabilities.

Approach

Two adjacent mines (1,600 m (1 mile) apart) operating in the Pocahontas No. 3 Coalbed in Virginia provided the test sites to investigate the methane emission consequence of extending longwall faces to greater width. Longwall face widths were to be increased from 229 to 305 m (750 to 1,000 ft) at these mines. However, because historically high methane emissions from the longwall face and gob were already being experienced, there was a concern for further increases in emission rates.

To predict the methane emission consequences of mining longwall panels of greater face width, it was first necessary to measure current emission rates to determine if a general increase in methane emission levels occurs progressively during the mining of a longwall pass. Methane emissions on the active faces were measured with sensors attached to shields over the pan line. One instrument was located close to the headgate; the other, close to the tailgate. Airflow quantities were periodically measured at the methane monitoring locations with a handheld anemometer. A production time study was conducted to correlate methane emission data to mining activity and shearer location on the face. Characterizing methane emission trends across the longwall face was facilitated by dividing each pass on the 229-m (750-ft) wide faces into three equal-length segments of 76 m (250 ft) and determining the average face emission rate during the mining of each pass segment (figure 1).

Results

At the first mine site, methane emissions on the longwall face increased by 17.4% (0.02 m^3/sec (41 cfm)) to 0.13 m^3/sec (276 cfm) from the first to the second 76-m (250-ft) pass segment (figure 2). Emissions increased by only 3.1% from the second to the third pass segment. At the second mine site, methane emissions also increased by 17.4% from the first to the second pass segment (figure 2); however, the actual average emission rate for the second pass segment was substantially higher at 0.21 m^3/sec (438 cfm). In contrast to the first mine site, the methane emission rate at the second site increased significantly (14.6%) from the second to the third pass segment. The average methane emission rate for the third 76-m (250-ft) pass segment was 0.24 m^3/sec (502 cfm).

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Predictions of methane emission levels for faces extended to 305 m (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. A power curve in the form $Y = 236.889X^{0.179889}$, where $Y =$ average measured pass segment methane emission rate and $X =$ individual 76-m (250-ft) pass segment number, fit the measured emission data from the first mine best ($R^2 = 0.95$). Projecting the regression curve to a fourth 76-m (250-ft) longwall pass segment yields an average methane emission rate of 0.14 m^3/sec (304 cfm), or a 7% (0.01-m^3/sec (20-cfm)) increase for a 305-m (1,000-ft) wide face (figure 2).

A linear regression curve in the form $Y = 309.6 + 64.25X$, where $Y =$ average measured pass segment methane emission rate and $X =$ individual 76-m (250-ft) pass segment number, fit the measured emission data from the second mine best ($R^2 = 0.99$). Projecting the regression curve to a fourth 76-m (250-ft) longwall pass segment yields an average methane emission rate of 0.27 m^3/sec (567 cfm), or a 13% (0.03-m^3/sec (65-cfm)) increase for a 305-m (1,000-ft) wide face (figure 2).

The relatively low predicted increase in methane emissions at the face for the first mine site would probably not result in additional methane control problems. However, it should be noted that the predicted average emission value for the additional 76 m (250 ft) of face width is not necessarily the "worst-case" scenario, which would include high methane emission events such as the floor gas bleeders common at this mine. In contrast, the predicted average face emissions for 305-m (1,000-ft) wide faces at the second mine site (0.27 m^3/sec (567 cfm)) are within the general range where methane-related mining delays were experienced during the study.

Face widths of 305 m (1,000 ft) have not been developed at the first mine site; therefore, the accuracy of the prediction could not be tested. Larger panels with 305-m (1,000-ft) wide faces were developed at the second mine site without experiencing the predicted higher methane emission levels. The mine's engineering staff credits an enhanced methane drainage program that provided both increased hole length and additional time for horizontal boreholes to drain gas in advance of mining with maintaining methane emissions at a lower than predicted level.

For More Information

To obtain a free copy of a technical paper on the prediction of longwall methane gas emissions or for more information on other longwall methane emission characterization studies, contact W. P. Diamond, National Institute for Occupational Safety and Health (NIOSH), Pittsburgh Research Laboratory, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236-0070, phone: (412) 892-6551, fax: (412) 892-6891, e-mail: **wbd5@cdc.gov** Mine operators using the prediction technique outlined in this Technology News are encouraged to discuss their application and results with the NIOSH contact listed above.

Mention of any company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

To receive additional information about mining issues or other occupational safety and health problems, call **1-800-35-NIOSH (1-800-356-4674), or visit the NIOSH Home Page on the World Wide Web at http://www.cdc.gov/niosh/homepage.html**

As of October 1996 the safety and health research functions of the former U.S. Bureau of Mines are now located in the National Institute for Occupational Safety and Health (NIOSH).

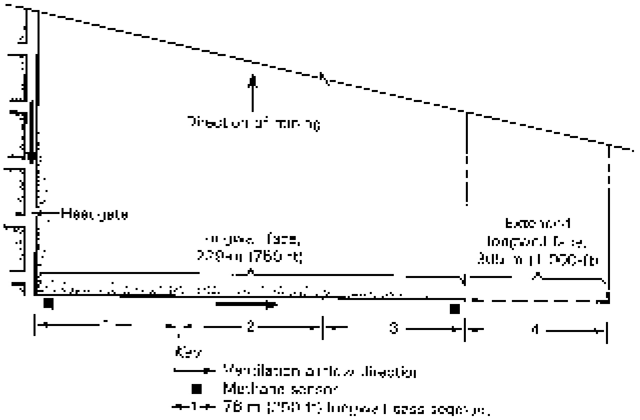

Figure 1.—Schematic plan view of longwall face divided into equal-length pass segments for analysis and prediction of methane emission trends during mining.

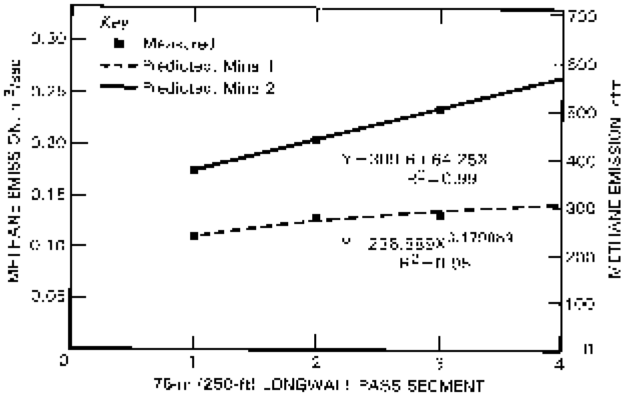

Figure 2.—Methane emission prediction curves for 305-m (1,000-ft) longwall faces in two mines operating in the Pocahontas No. 3 Coalbed in Virginia.