Ventilation Air Methane Measurement Methodologies

U.S. EPA Coalbed Methane Outreach Program

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Introduction

Measuring and characterizing ventilation air flows is a critical step in assessing the viability of potential ventilation air methane (VAM) projects at underground coal mines. The U.S. Environmental Protection Agency's Coalbed Methane Outreach Program (CMOP) researched available literature and current VAM data collection practices at some underground mines to investigate VAM measurement approaches. CMOP utilized sources such as ventilation engineering textbooks (e.g., *Subsurface Ventilation Engineering* by McPherson, 1993), questionnaires used by oxidizer manufacturers (MEGTEC Systems and Biothermica Technologies, Inc.), and interviews with U.S. mining engineers to compile this information. In addition, CMOP analyzed VAM data collected from several U.S. coal mines to ascertain data variability and to determine a suggested best practice for assessing coal mines for their VAM project potential. This fact sheet summarizes the discussions and findings regarding VAM measurements.

Minimum Requirements for VAM Measurements

A coal mine's potential for a VAM project can be assessed initially from its average annual ventilation air flow and the methane concentration in the ventilation air. Ventilation air flow measurements typically do not vary greatly because they are a function of the size and capacity of the ventilation fan. While the actual flow can be measured with instruments, it also can be calculated based on the fan horsepower and speed, adjusting for air pressure and temperature. The methane concentration can vary significantly with changes in daily coal production and changes in coal seam properties, so must be monitored more frequently than ventilation air flow.

MSHA[1] regulatory requirements specify that trained MSHA field inspectors perform periodic mine safety inspections at all underground coal mines in the United States and test methane emissions rates at each coal mine according to MSHA-approved sampling procedures. VAM sampling is conducted by MSHA inspectors by collecting air bottle samples at the mine's main fans, along with a measurement of total ventilation air flow rate. The sample bottles are sent to the MSHA lab for methane analysis and the results are provided back to the MSHA district offices for inclusion in the inspection report. These methane composition samples and ventilation flowrate measurements are taken at least quarterly at all mines. According to Section 103 (i) of the Federal Mine Safety & Health Act of 1977 (Public Law 95-164), if emission levels are greater than 200,000 cubic feet per day, more frequent spot inspections are mandated, with the frequency determined by the daily methane liberation rate calculated for the mine. Mines emitting greater than 1,000,000 cubic feet per day are subject to spot inspection every 5 days, greater than 500,000 cubic feet per day every 10 days, and greater than 200,000 cubic feet per day every 15 days. These spot inspections are safety checks and do not necessarily include additional methane concentration sampling unless warranted by the results of the spot checks.

More Frequent VAM Measurements

While MSHA may only measure VAM emissions quarterly, it is important for coal mines to measure VAM emissions more frequently in order to maintain safe working conditions at the mine. It is also important to know that the data collected are a representative sample of actual emissions. CMOP discovered that U.S. coal mines typically measure and record weekly VAM emissions, including flow rates and methane concentrations. These weekly recordings are usually measured with hand-held instruments inside the mine at the base of the ventilation air shaft. The data are checked against any continuous monitoring devices that may be associated with the VAM emissions. The continuous devices often serve as alarms for methane concentrations that rise above 1.0-1.5%, but their measurements are not recorded. Periodic gas sampling and lab analyses can ensure the accuracy of continuous monitoring devices used at a mine.

Details of industry-accepted gas sampling techniques and measurement of airflow across a cross-sectional area are described in *Subsurface Ventilation Engineering* (McPherson, 1993). However, the text does not prescribe the

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[1] Mine Safety and Health Administration. Revised based on information provided by MSHA on their current monitoring procedures.

frequency at which these measurements are needed. Site-specific conditions and mine safety regulations determine the appropriate measurement intervals. In a recent VAM prefeasibility assessment conducted at an Indian mine,[2] "investigators employed a VAM sampling frequency in which one measurement was taken (on a working day with full production) every month over a six-month period, one was taken each week during one of those months, one was taken each day during one of those weeks, and one was taken each hour during one of those days. That approach yielded what was considered to be a complete array of methane emission data that was adequate for the purposes of the preliminary assessment."

For mines with average annual VAM concentrations above ~0.2% (the lower limit of today's oxidizer technologies), the weekly records can show the variability that may be expected with the VAM emissions. Predicting VAM variability is important for two reasons: first, if the methane concentration falls below 0.2% for any length of time, the VAM oxidizer cannot operate without supplemental fuel; second, if the methane concentration rises significantly above 1.0% for any length of time, the VAM oxidizer can overheat and suffer thermal damage. At a minimum, 3-6 months of weekly data must be analyzed as part of the VAM assessment, although 12 months or more are preferred.

It is important to know what the sensitivity of the VAM emissions are to coal mining activities. Because of this, developing a greater understanding of the VAM variability will also require a sample of hourly readings during the course of a day. It is recommended to record VAM emissions throughout different mining activities such as shift changes (production vs. maintenance shifts), development mining vs. longwall mining, longwall equipment moves, etc. This will allow the VAM assessment to capture VAM variability that may not be fully understood from the weekly records. The characteristics and variability of the VAM emissions will determine the number of days needed to obtain a representative sample of data points.

[2] Harpalani and Prusty, Quantification of Ventilation Air Methane Emission from Gassy Underground Coal Mines in India, Final Report to the U.S. Environmental Protection Agency, Coalbed Methane Outreach Program, August 2009.

In addition to understanding VAM flows and concentration at coal mines, other characteristics of ventilation air flows, including presence of dust or compounds such as hydrogen sulfide and sulfur dioxide, could make potential VAM utilization technologies unfeasible if they cannot handle those contaminants. Australia's Commonwealth Scientific and Industrial Research Organization conducted measurements of methane variability and the aforementioned pollutants in a study at four Australian coal mines in 2005. Hourly data recordings were analyzed at the different mines over a three-month period. It was found that correlations between dust loadings and mining activities were mine specific, as was methane concentration variability. The report emphasized the need to characterize VAM flows prior to developing a VAM mitigation or utilization project. The results can be found in a report titled *Characteristics of Coal Mine Ventilation Air Flows* (Shi Su, 2006).

Mine-specific characteristics and preliminary conclusions can be drawn from an assessment of 6-12 months of data. To illustrate the range and variability of methane concentrations in VAM at U.S. coal mines, CMOP compiled the results of weekly VAM measurements from four coal mines (see Figures 1 through 4). The graphs show why annual average (or monthly) VAM measurements do not provide adequate data to assess the VAM project risk associated with methane concentration variability.

Conclusions

A preliminary assessment of historical monthly VAM readings (covering a year or two) can provide an indication as to whether a mine has VAM project potential. However, more frequent data sampling is needed to fully determine whether the coal mine site is viable for today's VAM technologies.

Characterizing ventilation air flows prior to VAM project development is paramount to a successful VAM project. It is of utmost importance to understand the methane concentration variability over time. Variations over the course of a day (hourly), a month (daily or weekly readings), and a year need to be measured and analyzed. The exact measurement intervals and durations are somewhat dependent on the mine-specific conditions. In addition, data needs to be collected on VAM flow rates and certain exhaust components such as dust loading, hydrogen sulfide, and sulfur dioxide.

Figure 1: Mine A – Very gassy mine with average methane concentration in VAM at 1.21%. Highly variable changes in VAM with numerous methane spikes above 1.5%

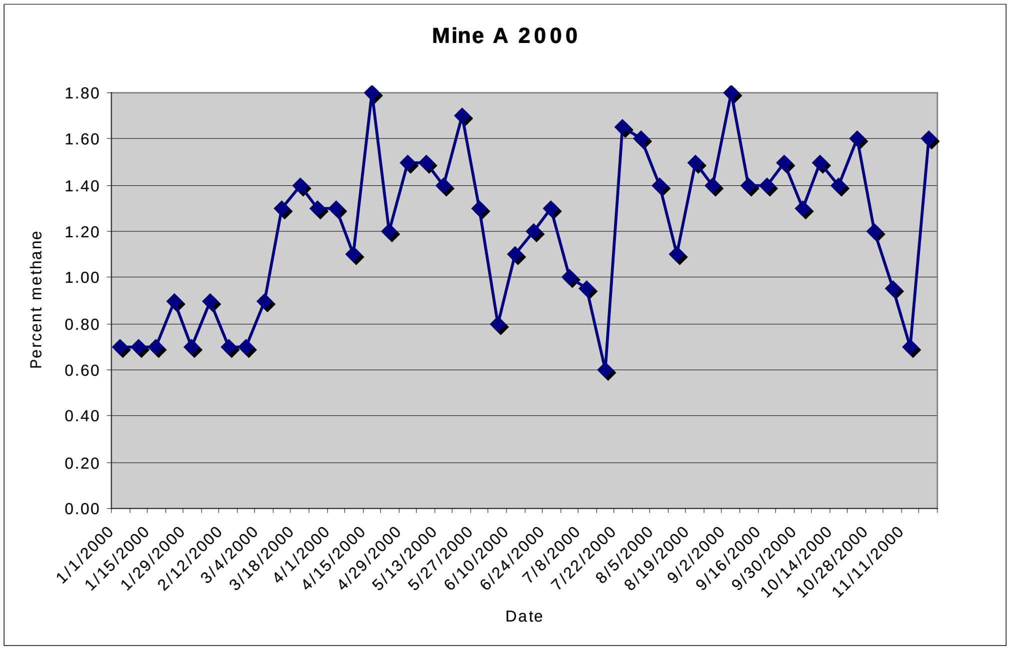

Figure 2: Mine B – Moderately gassy mine with average methane concentration in VAM at 0.35%. Low VAM variability with only four data points below 0.30%

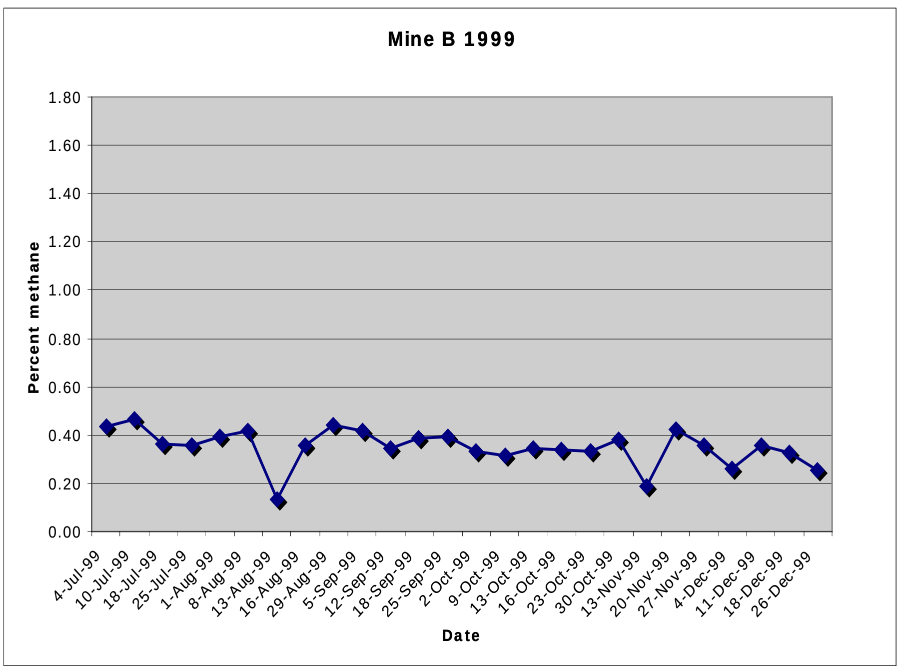

Figure 3: Mine C – Gassy mine with average methane concentration in VAM at 0.78%. Low VAM variability for three months (avg. 0.54%) and high variability for three months (avg. 0.91%)

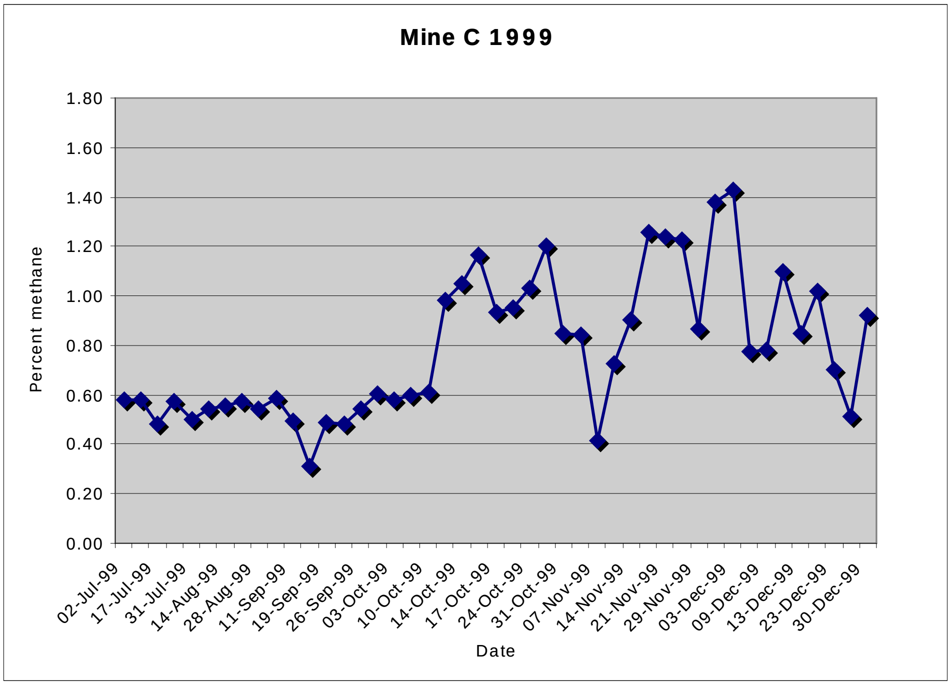

Figure 4: Mine D – Moderately gassy mine with average methane concentration in VAM at 0.53%. Highly variable changes in VAM with numerous methane data points dropping below 0.30%