

INTERIM FINAL TECHNICAL REPORT
September 1, 2003, through August 31, 2004

Project Title: **SYSTEMATIC EVALUATION OF VENTILATION AIR
METHANE IN ILLINOIS MINES**

ICCI Project Number: 03-1/7.1A-2
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ABSTRACT

This research study is aimed at developing a technique to accurately quantify the ventilation air methane (VAM) released into the atmosphere from gassy underground coal mines, and carry out a preliminary feasibility study of its utilization. As a first step, information about the overseas VAM utilization activities, sponsored by the US Environmental Protection Agency, was obtained. As project progressed, additional information was collected on the various VAM utilization alternatives available. Finally, effort was put into obtaining information about WestVamp, the world's first commercial VAM utilization project in Australia, with an anticipated 6 MW of electricity generation.

Along with the above continuous effort, a ventilation survey was carried out at a gassy underground coal mine in Illinois. This included airflow quantity and pressure (p-Q) measurements for all major branches of the mine ventilation network to estimate the airway resistances and pressure losses for use in a ventilation network simulation model.

In order to quantify the methane emission from the mine, quarterly methane liberation data was obtained from MSHA for six quarters. Weekly methane emission data for the return air was also collected, along with detailed daily data for two weeks, and for every few minutes for several days. For these particular days, coal production data was also obtained to enable correlating methane emission with mining activity.

A detailed analysis of the data revealed that the amount of methane emission from the mine is very consistent. However, if mining stops, very little methane is liberated. This has been interpreted in the past as most of the gas originating from the seam being mined. However, a correlation with the production data clearly indicated that the nearby coal seams are a substantial source of methane as well. This suggests that the permeability in the region is high, and the gas originating from other seams is able to move easily through the de-stressed coal and gob. This may also be due to favorable diffusion properties resulting in liberation of all of the gas fairly quickly. The interesting finding for VAM utilization is that the concentration of methane is fairly constant, which is favorable. Also, the emission is likely to increase as mining progresses, further disturbing the stress equilibrium in the surrounding rock. Finally, the most suitable techniques for VAM utilization for the mine would be the flow reversal reactors since the concentration of methane is fairly stable and the overall emission rate is high. These conclusions, however, must be considered premature at this time since additional work is ongoing.

EXECUTIVE SUMMARY

The ventilation air methane (VAM) emission from Illinois coal mines constitutes a significant addition of methane, a greenhouse gas, to the environment. On the other hand, it presents a good prospect for its utilization as a fuel source, while simultaneously preventing its release into atmosphere. However, the feasibility of a VAM utilization project depends primarily on the amount of methane emitted, consistency of emission, concentration of methane in air, and the overall cost effectiveness of the technology used, that is, capital cost involved in developing such a system as well as the subsequent cash flow generated from use/sale of energy. Hence, this study was aimed at developing a reliable technique to quantify the VAM emission into atmosphere from an underground coal mine, and carry out a preliminary feasibility study of its suitability for VAM utilization.

The research investigation started with a study and evaluation of the work carried out by the US EPA on VAM utilization. This was divided into two parts. The first one involved studying the various techniques available to extract the energy out of VAM, that is, different oxidation alternatives suitable for low and very low concentrations of methane. The second part included evaluating the case studies currently considering such options, mostly overseas mining operations with financial aid from the US EPA, and the basis for such plans. A review of this material revealed that Australia is going ahead with its second VAM project, referred to as WestVAMP, for the West Cliff mine. Hence, effort was made to obtain information on the first Australian pilot-project at the Appin and Tower mines, as well as the plan for the upcoming operation, which is designed to generate 6MW of electricity. Finally, effort was made to set up a meeting with the Australian operators in May 2005 in Alabama and, funds permitting, visit the Australian operation later that summer.

Before proceeding with the quantification of VAM at the mine, a mine-wide ventilation survey was carried out. This had two purposes. The first one was to get a good understanding of the ventilation system in place at the present time, and how it contributed to the removal of methane from the mine. Secondly, it is important to have a ventilation simulation network model of the mine in order to evaluate the different alternatives on a comparative (if-then) basis. The first part of the ventilation survey was carried out using the trailing tube (p-Q) method. This involved stretching a 300 feet length of a 3 mm diameter tube in the primary airways of the mine, and measuring the frictional pressure drop (p) resulting from the flow of air. Along with the measurement of pressure drop, airflow quantity (Q) was measured at all major stations of the mine. An evaluation of the ventilation system in place revealed that this survey alone was not going to be adequate to estimate the resistances of airway branches close to the shaft station. Hence, an altimeter survey was carried out, where a high precision altimeter was placed at a reference station on the surface, and measurements were taken every fifteen minutes. The second altimeter was taken underground and measurements were taken at all major stations. The surface measurements allowed correlating the underground measurements with the atmospheric conditions, since atmosphere is the starting point for ventilation air, and then estimating the pressure losses as air moved underground.

The existing ventilation model, developed by the mine personnel, was fairly complex, given that the size of the mine is still fairly small. During the development of the model, effort was made to represent every airway with continuous airflow as an individual branch, which is simply not necessary. Several airways in the area surrounding the shaft bottom can easily be “clustered” and represented as a single branch in order to simplify the model. The results of the ventilation survey conducted by SIU, jointly with the mine personnel, were provided to the mine personnel for use in modifying the model developed by them. A line plot of the proposed model was also presented. Furthermore, assistance was provided in simplifying the model significantly, reducing the number of branches in the model. This is being done at this time as well. Once the model is developed and validated, it will be updated by the mine personnel on a regular basis as mining progresses.

In order to assess the VAM emission, the ventilation system in place was studied carefully first. The mine has two exhaust shafts, one exhausting approximately 290,000 cfm (cu ft per minute), and the second one exhausting 150,000 cfm. The first one has practically no methane present on a regular basis. There might be some emission via this shaft, but only on a sporadic basis. Hence, any further effort into looking at utilization of this air did not make any economical sense. All effort to quantify VAM, therefore, concentrated on the second exhaust shaft. The mine personnel felt very strongly that all of the methane liberated at the mine comes from the coal being mined. The basis for this was a very strong correlation between mining activity and methane concentration in the return shaft. As soon as mining activity stopped, the methane emission went practically to zero. This might be due to the fact that the mine is relatively new, and the surrounding rock is not overly disturbed.

As a first step in quantifying the VAM, quarterly methane liberation data was obtained from MSHA. As a part of their routine inspection, MSHA conducts its own quarterly measurements of methane emission, although it is done on only one particular day every quarter. Also, the initial emission data obtained was for the entire mine. Later on, MSHA was requested to provide data only for the portion of the mine being studied under this investigation. The average daily emission, as estimated by MSHA for the portion of the mine being studied, was 2,500,000 ft³/day. This emission rate, for average daily coal production of 5,000 tons, translated to 500 ft³/ton of coal mined, which is significantly higher than the gas content measured by the Illinois State Geological Survey (ISGS) anywhere in the state. Hence, the reported values had two interpretations at the time: MSHA overestimates the liberation data; or, there must be additional source(s) contributing methane to the ventilation air.

In order to determine the actual amount of VAM in the exhaust shaft, a methane emission survey was carried out, which lasted for a fairly extensive period. The methane concentration in the return air (second shaft) was monitored on a weekly basis for several weeks. For two of the weeks, daily measurements were obtained. For a few days, the measurements were taken every few minutes. For two of the days when there was mining activity throughout the shift, the readings were averaged for every hour. Using the

airflow passing through the shaft, and this is fairly constant, hourly emission was calculated. The emission rate was very constant, which is a very positive piece of information from a VAM utilization perspective. The variation was between 68,000 and 71,000 ft³/hour, totaling to ~1.7 million ft³/day. For the particular day, the coal production was 4,422 tons, giving a gas content of 384 ft³/ton of coal mined. This is still higher than the gas content measured by the ISGS in the area, again, confirming that a major source of methane might be, in fact, the seams above and below the seam being mined. The methane emission data will be included in the model as model evolves. Also, the emission rate (ft³/ton of coal mined) will enable projecting future VAM emission as mining progresses, or rate of production changes.

The results of the methane emission data collected suggest that the source of the gas is not only the seam being mined, but “other” seams immediately above and below the working seam as well. This is expected since mining disturbs the stress equilibrium in the surrounding rocks, and results in an immediate release of free gas in the coal seams within the envelope of disturbance. The situation is very similar to the mines in Virginia/West Virginia, where degasification is a standard practice at several mines. The results do suggest that either the permeability of coal is very high, resulting in release of all of the methane almost immediately after mining. This would result in very little gas emission if the mining activity stopped for some reason, and concur with the observation that the gas emission decreases drastically when there is no mining activity. However, this could also mean that the diffusion properties of the coal are very favorable. In most cases, where gob wells produce gas for long periods of time after the formation of gob, the mechanism of the movement of gas is by diffusion alone, and this is usually an extremely slow process. It is not very clear at this time which mechanism is dominating the release of gas. From a flow perspective, either of the two favors any CBM/CMM activity in the region being studied. Finally, it is anticipated that, as mining activity progresses at this mine, there will be a greater stress release and re-distribution, resulting in higher emissions of methane from the seams in the vicinity. The result will be higher concentrations of methane in the exhaust air.

Based on the results discussed above, different VAM oxidation alternatives were studied. Of the Primary VAM utilization technologies, flow reversal reactors are considered to be a good option. During the next few months, the emission data will be used to develop a first design of a VAM utilization system at the mine. This will include an economic analysis of the alternative. Depending on the methane utilization capability of the system, the cost advantage will be determined.

Recently, there has been a setback in this study. MSHA has defined the air leaving the ventilation fan as return air even though it has separated from the fan. As of July 2004, MSHA has not given a defined point when it becomes ambient air. As a result, MSHA has suggested that oxidation equipment would be a part of the ventilation system. In addition, MSHA has said that oxidation equipment could be subject to the permissibility standards depending on the design and specifications. Although the final MSHA ruling is still not known, this may be a “killer” for any VAM utilization projects in the US mines in the immediate future. However, such projects will continue overseas, particularly

Australia, China, India, Ukraine, Poland, and Mexico. Just as longwall mining, once the success of these operations is proven overseas, MSHA might modify its stand.

This Abstract and Executive Summary summarize the project results through August 31, 2004. Since the project was granted a "no-cost extension", the final report will be available on March 1, 2005.