THE DETERMINATION OF GAS CONTENT OF COAL FROM BORECORES

by

S. BATTINO[1] and J. DOYLE[2]

ABSTRACT

The direct method of gas content determination developed by McCulloch and Diamond of the U.S.B.M. has been adapted to estimate the gas content of coal seams from slim exploration borecores in the Southern Coalfield. Emphasis has been placed on the measurement of this parameter without the physical destruction of the core which is required for subsequent chemical analysis.

In field and laboratory equipment is simple and inexpensive. It enables the determination of lost and desorbed gas from a fresh geological core. Residual gas is not measured but is considered to be relatively low and of no consequence in ventilation considerations.

Results to date show good correlation with those obtained from underground face samples.

Gas contents from the mined seams varying from 2 m^3/tonne to 14 m^3/tonne have been measured with this apparatus. Gas desorption characteristics of South Coast coals have been found to closely follow exponential mathematical models.

[1] Research Engineer,
B.H.P. Steel Division Collieries,
Wollongong. N.S.W. Australia.

[2] Geologist,
B.H.P. Steel Division Collieries,
Wollongong. N.S.W. Australia.

INTRODUCTION

Increased production rates and deeper mining have demanded a greater interest in the gas content of coal beds ahead of the working face. Rudimentary estimates of coal seam gassiness have been made during exploration boring for many years in the Southern Coalfield of New South Wales. In response to the demand for a quantitative measure of seam gassiness the methods of McCulloch and Diamond have been adapted to the evaluation of slim bore core.

THE USBM METHOD

The direct method of gas determination is described by McCulloch and Diamond (1976). The technique has found application in Australia in the determination of gas content of lump coal or coal cuttings from the mine face and considerable experience and data have been generated using the method.

Coal is introduced into a gas-tight container which is sealed. Gas is bled off once a day into an inverted graduated measuring cylinder filled with water. Total liberated gas is plotted against the square root of elapsed time. Elapsed time includes an estimate of the time between the exposure of the coal samples and its sealing in the gas bomb. The USBM method has been adapted to the Southern Coalfield using the simple equipment illustrated in Figure 1.

THE MODIFIED TEST

The equipment has been constructed to suit

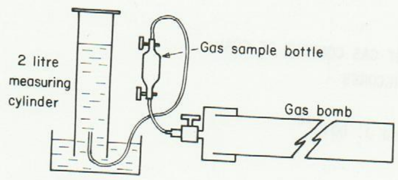

Fig. 1. Gas desorption equipment modified to suit practical conditions in the field

NQ wireline drill core of 47 mm diameter. Cores 3.05 m long are recovered using a triple tube barrel. Drill cores are recovered by withdrawing the inner core barrel through the drill rods on a wireline. At the surface the split triple tube is pumped out of the inner core tube. The split tube is opened briefly to verify the quantities of coal and non coal and overall core recovery (see Fig. 2). The splits are immediately closed, taped together securely and quickly inserted into the prepared gas bomb. Monitoring of the emitted gas commences immediately. The time from the instant of pulling the core off the bottom of a 400-500 m hole to the time it is sealed into the bomb is of the order of 15 minutes.

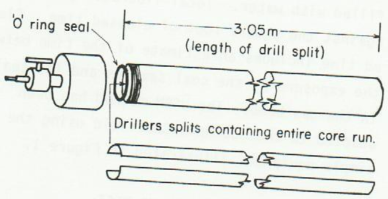

Fig. 2. Split tube with coal core to be inserted into the gas bomb

The drill core is monitored for one and a half hours, with readings of emitted gas being taken initially at 1 minute intervals. At the end of this period the gas bomb is sealed and transported to a laboratory for continued monitoring. Gas flow is monitored during working hours, the reading interval being extended as the gas evolution diminishes. In the first few days the gas bomb is sealed at night to prevent the measuring cylinder over filling and spilling gas. This has an effect on gas emission discussed below. Later, when the gas flow rate has decreased, the gas bomb is left open continuously. Glass gas bottles are inserted in the sample tube during the test for chemical analysis of the seam gas constituents.

Duration of the test is generally two or three weeks until no further gas is evolved. The core may then be returned to the geologist undamaged for logging and chemical analysis. During the chemical analysis, the apparent specific gravity is determined on the whole core. The total mass of recovered coal core is measured during this determination and is used to calculate the gassiness of the drill core.

The measurements of the cumulative gas desorbed from each coal core are carefully recorded as a function of time and curve fitting techniques are applied to derive a mathematical expression for the results. In general, the desorption-time graphs from the tests carried out on several AIS geological borecores followed exponential patterns which satisfied the relation of the form.

$$Q = A(1-Be^{-kt}),$$

Where Q = cumulative gas volume desorbed (mls
t = time elapsed (mins)
A, B, k = constants of proportionality

This expression clearly shows that for very large values of t, the curve levels off and Q eventually reaches an asymptotic value equal to A.

As the residual gas in the cores is not determined because of its requirement to physically destroy the sample thereby preventing any further geological data from being obtained, the sum of the lost gas and measured desorbed gas allows a reasonable estimate of the gas content of the coal core to be made. By dividing this total by the weight of the sample in the pressure vessel, the gas content estimate in cc/gram (or m^3/tonne) may be determined.

Closing of the sampling bomb valve during the test has a localised effect on the rate of gas release from the core. When the valve is reopened the gas flow is rapid for a period, slowing to the rate prior to the closing of the valve. On the plot of cumulative gas flow vs time this effect is evident as a saw tooth depression in the trend of the plot. This feature has no effect on the total gas evolved but should be allowed for in the calculation of the exponential equation.

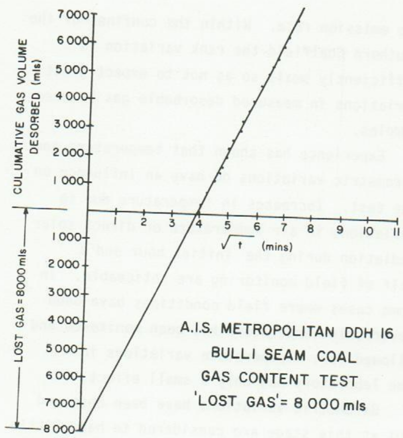

Fig. 3.

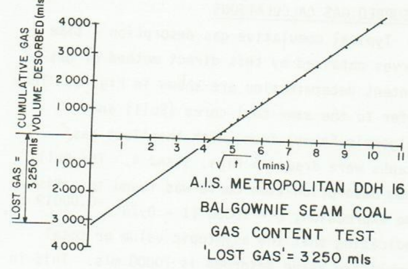

Fig. 4.

LOST GAS CALCULATIONS

To date, several such seam "gas content" evaluations have been conducted from AIS geological diamond drilled borecores, and all have yielded valuable information with regard to the volumes of desorbable gas and the gas composition. Typical 'lost gas' graphs are illustrated in Figs. 3 and 4 which were obtained from the Bulli and Balgownie seam cores from AIS Metropolitan DDH 16. It is clear from these graphs, and this confirms the previous results of McCulloch and Diamond (1976), that the initial gas emissions from the coal are the largest. A slow and gradual decrease in emission rate is noted with increasing time. It puts pressure on the investigator to attempt to minimise the time interval associated with the 'lost gas'factor. The rate of this initial gas emission is related to such variables as the porosity and permeability of the coal sample, moisture content, gas composition, coal rank and, possibly, the depth of the coal seam beneath the surface. Gas composition analyses conducted on certain coal samples at various stages of testing showed that CH_4 gas is emitted earlier than the CO_2 gas, this being attributed to their relative molecular weights. Because of the requirement to keep the core intact for further geological data evaluation, it has not been possible to conduct the necessary destructive tests to estimate the full effect of each of the other stated variables on the initial gas emission rate. Within the confines of the Southern Coalfield the rank variation is sufficiently small so as not to expect great variations in measured desorbable gas between samples.

Experience has shown that temperature and barometric variations do have an influence on the test. Increases in temperature due to variations in air temperature or direct solar radiation during the initial hour and a half of field monitoring are noticeable. In some cases where field conditions have been severe,air temperature has been monitored and allowed for. Temperature variations in the laboratory had only a small effect.

Barometric variations have been observed but at this stage are considered to have little influence on the accuracy of this practical test.

DESORBED GAS CALCULATIONS

Typical cumulative gas desorption - time curves obtained by this direct method of gas content determination are shown in Fig. 5. They refer to the same coal cores (Bulli and Balgownie Seams) from which the 'lost gas' graphs were drawn in Figs. 3 and 4. The Bulli Seam desorption-time curve was found to satisfy the expression, $Q = 70000\ (1 - 0.73\ e^{-0.00019\ t})$, indicating that the asymtopic value or total cumulative value desorbed is 70000 mls. This in turn yields a seam "gas content" of approximately 10.5 cc/gm, or 10.5 m^3/tonne. Tests conducted on fresh face Bulli Seam coal samples at Metropolitan Colliery have given rates of gas desorption within the range 7 to 10 m^3/tonne, which inducated a reasonable correlation between the two types of experiments. Furthermore, the results obtained from coal lumps collected from working panels contained predominantly CO_2 gas (85 to 98% CO_2) which, due to its higher molecular weight, has a lower diffusion rate than CH_4. The Bulli Seam coal core from Metropolitan DDH 16 bore contained approximately

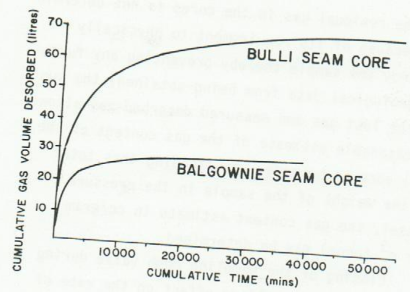

Fig. 5. Typical Gas Desorption Curves

61% CH_4 and 39% CO_2 on an air free basis.

The gas desorbed from the Balgownie Seam coal core was found to satisfy the equation $Q = 32000\ (1 - 0.71\ e^{-0.00019\ t})$, which yields a 'gas content' of approximately 9.6 m^3/tonne and the gas composition was approximately 55% CH_4 and 45% CO_2 on an air-free basis.

APPLICATIONS OF EARLY SEAM GAS CONTENT EVALUATION

Although there are limitations associated with the simple and inexpensive direct method of gas content measurement, the early results provided from exploration boreholes can be used beneficially in a number of ways. The volume of air required to provide the adequate ventilation of a panel or colliery can be estimated from such gas content assessments and their relationship with actual gas emission from active mines. This is particularly valuable in the case of a relatively new colliery which is planning a marked increase in output by, for instance, the introduction of a longwall system. Such a test case has been studied and actual applications of such figures can be found in a subsequent paper by Battino and Lunarzewski (1983), where projected estimates of gas emissions and appropriate ventilation requirements for gas dilution to statutory levels are shown.

The gas content of core samples can also be used to estimate the volume of gas contained in a coal bed. By constructing a graph of gas content versus depth, an overburden isopach, and a coal isopach, it is possible to estimate the gas content of a coal seam over a specific area.

Finally, the gas content of coal seams can provide an assessment of the economic potential of degasification of the coal seam prior to mining.

CONCLUSIONS

The techniques described by McCulloch and Diamond (1976) have been adapted to the geological field requirements of the Southern Coalfield. The equipment used is simple, rugged and portable, that, is capable of producing accurate data with non specialised field personnel. The results obtained to date using this method are considered sufficiently accurate to meet the requirements for colliery design and modelling in the early critical stages of mine planning and equipment specification.

ACKNOWLEDGEMENTS

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REFERENCES

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DISCUSSION

C. JEGER (Cerchar Laboratories, C. de France, Verneuil): The short time of the measurement is surprising, that is about 2 or 3 weeks for a core sample. Many measurements have been made in France showing that if coal is not micro-crushed for the measurement, in such a short time, only a part of the gas is emitted. Underground gas flows out from destressed or fractured coal over a longer period - even pieces of coal about 1 cm size need much longer time to lose their desorbable gas. It is acceptable that after 2 or 3 weeks the flowrate of gas going out of the cores can be very small. But even such a flowrate over a long time, for example 5 to 6 months, can give noticeable amount of gas, or from another practical point of view, still several months after mining of a panel total flowrate of gas from cracked and destressed overlying or underlying seams can be noticeable, because it is the sum of a lot of small flowrates flowing from each unit volume of the seams. This noticeable total flowrate normally lasts over a long time (several months) and pollutes the ventilation air. The quite big amount of gas due to this small flowrate is understandable if the shape of the isotherms (content of gas versus pressure) is taken into account. At first there is a quick release of gas from the quite high initial pressure, to a pressure still necessary to induce flowing of gas through the coal solid. The final pressure is low and therefore the flowrate of gas is small. But the phenomena correspond to the strongest curvature of the isotherm, and still a big content of gas can be desorbed during the last small pressure drop up to the residual pressure.

J. DOYLE (BHP Coal Geology): The test is taken to such a stage (normally about 4 weeks) when no measurable quantity of gas comes off into the measuring cylinder. So to all intents and purposes it is believed that the bulk of the gas is out. Residual gas is not measured at all. At the rank of the coal being tested it is approximately 10%. Probably the accuracy of the test is not any closer than that.

S. BATTINO (BHP Collieries Research): Talking about in situ tests, some in situ tests were conducted from fresh coal lump samples in mining faces; at least at two of the gassier collieries results very similar to those from the geological bore cores described in the paper were obtained. Similar testing was conducted from mined coal immediately as it came off the tail of the miner.

A.J. HARGRAVES:

It was a non-destructive test and the core was used for other tests later on.