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Gas Content Testing for Outburst Management Compliance

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GAS CONTENT TESTING FOR OUTBURST MANAGEMENT COMPLIANCE

Ray Williams[1]

ABSTRACT: It is fundamentally important to make sure that compliance for mining is not issued on the basis of gas content tests that are inadequately located, deficient in frequency or in error. This paper covers some of the issues in relation to location and frequency of cores and validation of gas content test results. Core locations are discussed in the context of recent findings on the reduction of gas drainage efficiency towards the end of in-seam, cross panel boreholes. Some guidelines for sample frequency are given, with increased frequency being required in circumstances involving departure from "normal" conditions as defined through analysis of past data. The gas content validation methodology is set up to provide rulings on gas content test results at the time of reporting, and is intended to aid mine staff in better evaluating test data as part of the process of issuing management plan conformance notices.

INTRODUCTION

Routine gas content testing is the prime means of protection against instantaneous outbursts of coal and gas. In applying gas content results to mining, the following elements are important:

- The gas content threshold
- The area around a roadway to which the threshold applies (the "barrier")
- Taking sufficient samples and in the right localities
- Minimising the chances that an error has been made in the gas content test

Gas content thresholds were initially determined for the Bulli seam on the New South Wales South Coast Lama (1995). They have been extended to the Hunter Valley, Bowen Basin and New Zealand (Mt Davy Mine) using GeoGAS's Desorption Rate Index (DRI) approach (Williams and Weissman 1995, Williams 1997).

In the DRI approach, outburst proneness is regarded as being directly related to the desorption rate of the coal. Bowen Basin coals (Goonyella Middle and German Creek seams) have higher gas desorption rates than the Bulli seam and accordingly, the gas content thresholds are lower. For CH_4, the Bulli seam gas content threshold is 9.5 m^3/t at 20°C and 1013 hPa m^3/t at a DRI of 900. For the same DRI, the Goonyella Middle seam has a gas content of 7.0 m^3/t and the German Creek seam (Middlemount/Tieri) a gas content of 7.7 m^3/t.

After a period of 20 years without outbursts[2] in the Bowen Basin, an outburst occurred at Central Colliery (German Creek seam) on 20th July 2001 followed by one at North Goonyella mine (Goonyella Middle seam) on 22nd October 2001. While the outbursts were small, they were significant in being the first to occur in these seams and in areas deemed safe, according to locally applied gas and outburst management plans.

Investigations into the incidents included coverage of gas content threshold, barrier width, sample location, sample frequency, and gas content test reliability. At this stage there has been no modification of gas content thresholds away from the 900 DRI basis and for this paper, there is little point in reiterating the DRI approach which has been given wide coverage. Advances in outburst mechanism understanding and the definition of an improved basis for the setting of thresholds/triggers are the subject of current research by Xavier Choi and Mike Wold, CSIRO Petroleum to be reported on in papers at this conference and workshop. The width of the barrier around a roadway is relevant, but is currently the subject of client confidential studies by Strata Control Technology Pty. Ltd. and GeoGAS.

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[2] Prior to 2001 the last outburst was at Collinsville No.2 Mine on 16th April 1981

The scope for this paper covers developments in two areas, these being:

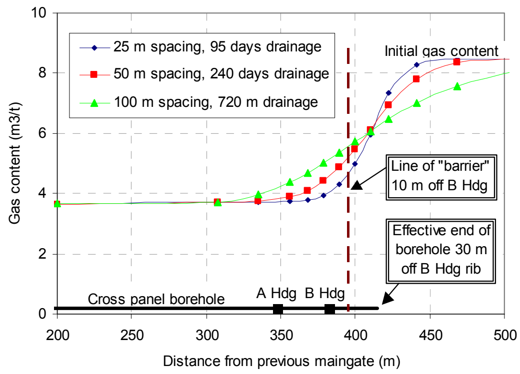
- Taking sufficient samples and in the right locations
- Minimising the chances that an error has been made in the gas content test

GAS CONTENT SAMPLING

Within any area being evaluated for compliance, subjective decisions are made concerning sample location and frequency. Samples need to be taken in the area where the gas content is likely to be highest, based on gas drainage borehole geometry and borehole gas flow rates. Ideally, the sampling regime should be prescribed as a minimum standard to be met, with operator discretion only being employed to take more samples than the minimum.

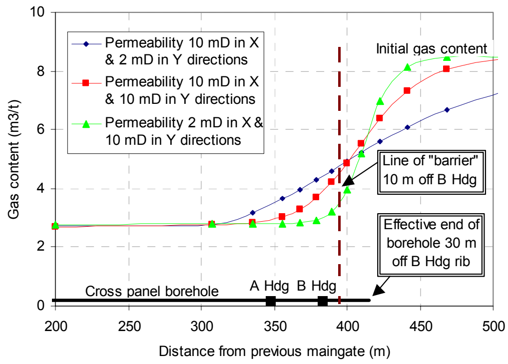
Sample Location

Gate roads are normally developed after cross block drilling and gas drainage. The regions where gas drainage is least effective is toward the ends of boreholes. Here, gas recharge results in a reduction in gas drainage efficiency toward the end of boreholes as evidenced in gas reservoir modelling and corroborated to varying degrees, by field measurements. Current GeoGAS-ACARP research Project C10008 entitled "Improved application of gas reservoir parameters" has shown this "end-hole-effect" to be sensitive to borehole spacing (Fig. 1), directional permeability (Fig. 2) and virgin gas content magnitude. This can cause the heading on the virgin coal side which is B Heading in Fig. 1 to be exposed to higher gas contents, depending upon the amount of over-drilling of the cross block borehole and if down dip, the depth and location of perforations in the dewatering tubing. In Fig. 1 the "X" direction is parallel to the borehole and at right angles to the gate-road drivage. The "Y" direction is at right angles to the borehole and parallel to the gate-road drivage. It should be noted that "End hole effect" is insensitive to the magnitude of permeability.



Permeability 5 mD X & Y directions
Virgin gas content 8.5 m^3/t at 100% CH_4

1a Effect of Borehole Spacing



Borehole spacing is 50 m.
Virgin gas content 8.5 m^3/t at 100% CH_4

1b Effect of Directional Permeability

Fig. 1 Increase in Remaining Gas Content Approaching the End of a Borehole

Experience of the "end hole effect" is variable. For example, North Goonyella mine appears to be sensitive to borehole "end hole effect" whereas Central Colliery in normal drainage conditions appears to have less sensitivity. Given similar borehole spacings, this may be a reflection of differences in directional permeability.

For cross panel drilling, cores for gas content testing should be taken midway between the two boreholes and along the line of the barrier on the virgin side (Fig. 2). It should not be necessary to take samples below the barrier line (ie closer to A Heading), unless failure to comply occurs. In that case, additional samples can be taken along the line of a barrier defined around A Heading to validate A Heading alone.

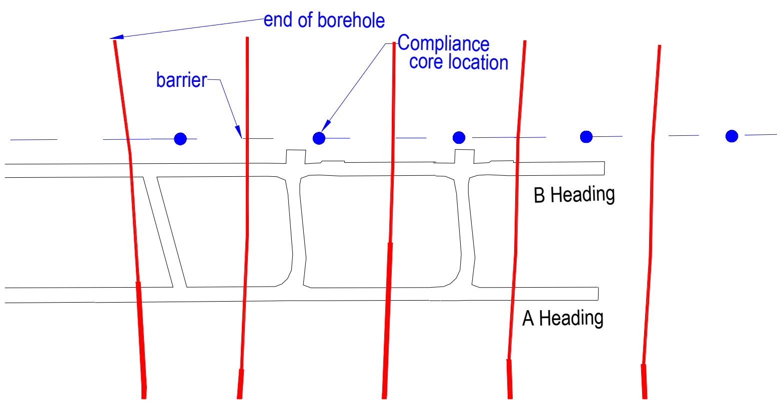


Fig. 2 Compliance Core Locations

The most important design requirement is to match the length of borehole over-drill beyond B Heading, with the barrier width and the end-hole-effect on gas content reduction, taking into account any additional deadening effect caused by the final location of dewatering tubing and the position of perforated sections. The end-hole-effect will probably be a function of borehole spacing and directional permeability. If over drilling is insufficient, there will be difficulty in achieving compliance along the barrier to B Heading.

Sample Frequency

Arriving at an optimum sample frequency requires examination of the past history, assessing the uniformity of results from test to test and linking that to environmental differences such as the time on gas drainage, ease of gas drainage and magnitude of gas content results in relation to the threshold value. Changes from the norm need to be carefully assessed.

Suppose compliance cores are routinely taken along a gate-road development with consistent placement with respect to the gas drainage-drilling pattern. Results are characteristically between 3 m^3/t and 5 m^3/t in an environment where the virgin gas content is 11 m^3/t and the gas content threshold is 8 m^3/t. What if the next sample gives a result of 7.5 m^3/t, which is below the gas content threshold? This result would be a departure from the norm and as such, should be a trigger to increase the sample frequency, in addition to seeking to understand what is happening.

Taking supplementary samples to check an abnormal result can be difficult. By the time the result is posted, the drill rig has probably moved to a new location. To minimise disruption it is important to plan the sample program to take account of potential problems identified during drilling and gas drainage. The consistency of borehole gas flows together with material balance calculations is a guide to the uniformity of gas drainage. Borehole gas drainage rates are shown in Fig. 3

In a fan of cross panel boreholes, additional samples can be planned for areas where gas drainage variability is above or below the norm for that area. For example, when a fan of boreholes behaves similarly, there is increased confidence that the drainage is proceeding according to plan (Fig. 3a). This can be backed up by material budget calculations and compared to expectations from modelling. Anomalous gas drainage requires more attention. For example, in Fig. 3b, there are three poor performing boreholes, two reasonable boreholes and one anomalously high flowing borehole. Apart from checking that gas drainage has been optimised by ensuring that there is no blockages or water accumulation an assessment of this area would require additional coring to confirm the state of drainage. This would hopefully be carried out early enough to enable timely remedial action. The high flowing borehole is probably the result of structural enhancement, so faulting should be suspected suggesting a review of drilling records.

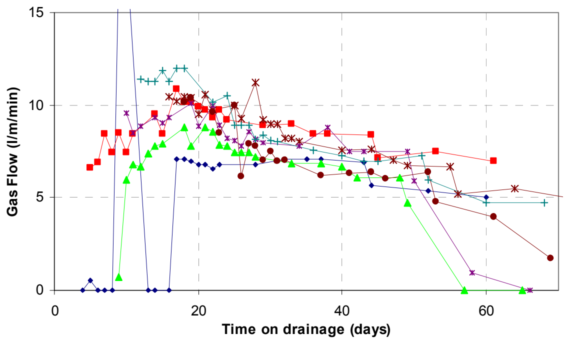


Fig. 3a Uniform Gas Drainage

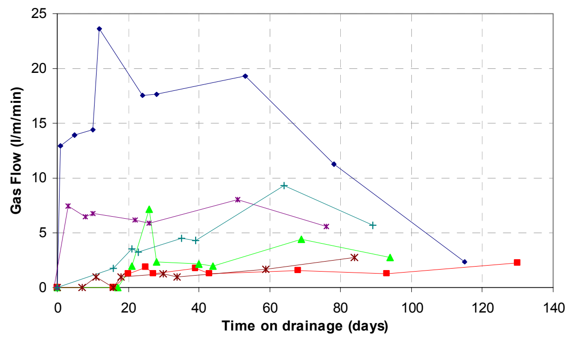


Fig. 3b Variable Gas Drainage

Fig. 3 Borehole Gas Drainage

RELIABILITY OF GAS CONTENT TESTING

A reliable gas content test result is probably the most essential ingredient in assessing an area for compliance with the management plan. Test failures do occur, and it is important that when they do, they are recognised prior to using the results. The most problematic part of the gas content test is connected with the field, "lost gas" (Q1) component. The main problem is leakage of canisters caused by not achieving a gas tight seal after placing core in the canister and/or failure of valves and fittings.

Persons who undertake the field Q1 testing are usually drillers or geologists. These persons need to be trained and certified as competent to carry out this important task. The training includes handling and final testing of canisters prior to use, avoiding contamination of the "O" ring seals and preparation for transport to the laboratory.

Validation of the gas content test results involves checking that leakage has not occurred during transport from the field to the laboratory.

The desorption rate or IDR30 which is the quantity of gas per unit mass desorbed in the first 30 minutes determined from the "Q1" measurements in the field and is related to the final reported gas content value Qm (Fig. 4). Normally, the faster the desorption rate, the higher the final reported gas content (Qm). Highly fractured core can produce a rate of desorption that is high compared to Qm. Other checks covered below are required to differentiate this condition . If a canister leaks between sealing in the field and receipt at the laboratory, Qm will be low compared to the IDR30, and the value will plot well down in the region of abnormally high desorption rate or potential leakage in Fig. 4.

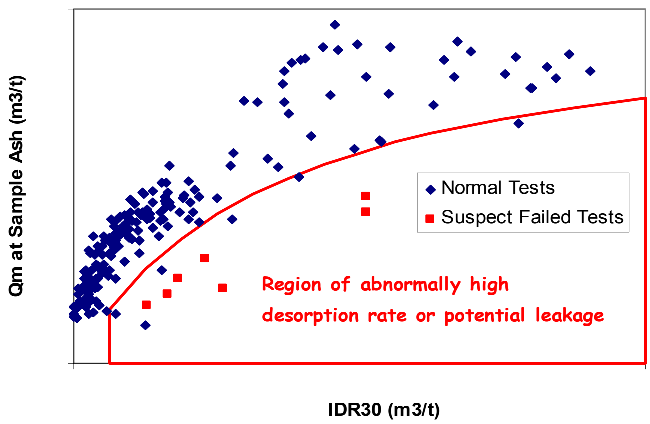


Fig. 4 Identifying Abnormal Data Based on Initial Desorption Rate

When canisters are received in the laboratory, they are immersed in water for signs of leakage, then the pressure build up in the canister is measured. The canister is then depressurised and the volume of gas released called "initial Q2" or "Q2init" is measured

Both the canister pressure and the volume of gas immediately desorbed (Q2init) upon release of pressure are a function of the –

- Mass of coaly material in the canister
- Void space in the canister
- The rate of gas desorption
- The time taken between sealing the canister in the field and relieving the pressure in the laboratory

These parameters are defined and are calculated for each test and a multivariate analysis undertaken. Equations defining Initial Q2 and canister pressure are:

$$\mathbf{Q2init} = A_1 * \mathbf{TCP} + B_1 * \mathbf{VS} + C_1 * \mathbf{M} + D_1 * \mathbf{DesRate} + E_1$$
$$\mathbf{CanP} = A_2 * \mathbf{TCP} + B_2 * \mathbf{VS} + C_2 * \mathbf{M} + D_2 * \mathbf{DesRate} + E_2$$
$$\mathbf{DesRate} = 1/(1 + k * \mathbf{IDR30})$$

Where:

- **Q2init** is the measured volume of gas desorbed upon depressurisation of the canister on receipt in the laboratory (ml).
- **CanP** is the measured canister pressure on receipt in the laboratory (kPa).
- **TCP** – Time in days that canister is pressurised between sealing in the field and receiving in the laboratory.
- **VS** – void space (ml)
- **M** – mass coaly material (g)
- **IDR30** – initial desorption rate after 30 minutes from time zero (m^3/t)
- A, B, C, D, E and k are constants

Using the above formulae, a comparison of calculated and measured "Q2init" and canister pressure is made Figs. 5 and 6.

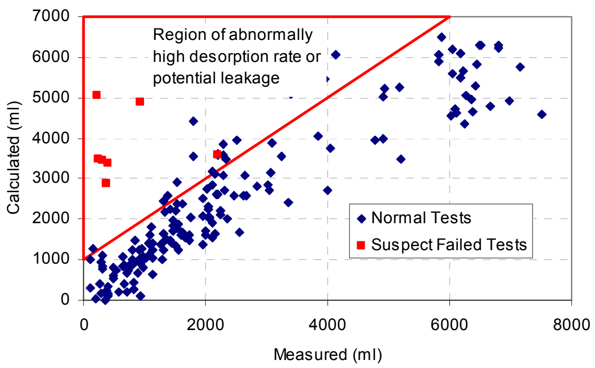


Fig. 5 Identifying Abnormal Data Based on "Q2 Initial

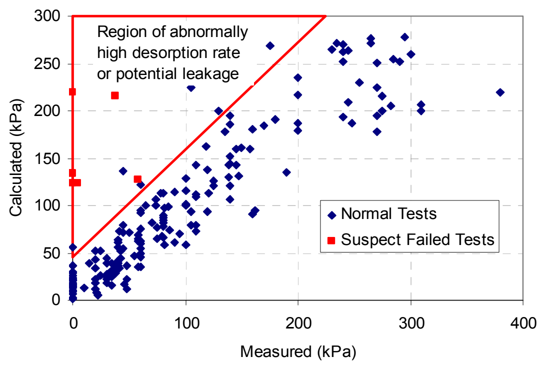


Fig. 6 Identifying Abnormal Data Based on Canister Pressure

The tests whose values are denoted by "red" squares in Figs. 4, 5 and 6 have failed all three tests, according to where the threshold boundaries have been placed. "Failed" tests are can be supported by other evidence, such as visible signs of coal debris on the "O" ring seals of the canister.

The main point to undertaking these checks is to provide the mine with a reliability evaluated test at the time of first receiving the gas content results. A test valid that fails all three checks may still be, but it is definitely abnormal, and as such, warrants closer consideration.

The equations for each check are specific to each mine and are embedded into the spreadsheets for that mine, so that the rulings are made automatically as each test result is calculated. To date, only near pure CH_4 Bowen Basin coals have been assessed.

Additional reliability information is added to the gas content test report, covering core condition, evidence of any abnormalities and correction to a determined density. Density correction is especially important in thick seams, where there is a chance of reporting a low gas content due to a high ash sample being inadvertently taken.

CONCLUSIONS

While it is generally accepted that cores need to be taken in areas of suspected worst gas drainage, understanding the borehole end-hole-effect provides a basis for the sample location rationale. In addition to the direct use of core results for compliance, they should significantly aid in the better design of borehole length and spacing combinations.

Barriers against outbursting have historically involved differentiating normal from abnormal conditions. This approach is similar, involving identification of normal and abnormal conditions in relation to sample location, frequency and gas content test characteristics.

It is suggested that routine gas content compliance results be augmented by the validation methods described.

ACKNOWLEDGEMENTS

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REFERENCES

Lama R.D., 1995: Safe gas content threshold value for safety against outbursts in the mining of the Bulli seam in Int. Symp. Cum Workshop on Management & Control of High Gas Emission and Outbursts, Wollongong 20-24 March 1995.

Williams R.J. and Weissman J.J., 1995: Gas emission and outburst assessment in mixed CO_2 and CH_4 environments in ACIRL Underground Mining Seminar Brisbane Sept. 95.

Williams R.J., 1997: Definition of outburst threshold limits from core testing in Symp Safety in mining - role of geology, Coalfield geology council of NSW, Newcastle November 1997.