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Gas reservoir and emission modelling to evaluate gas drainage to control tailgate gas concentration and fugitive emissions

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ABSTRACT

The process of longwall coal extraction coal causes fractures in the overlying and underlying strata and these fractures become pathways for gas released from adjacent coal seams to flow into the mine workings and contaminate the ventilation air. If the rate of gas emission exceeds the diluting capacity of the ventilation air, the gas concentration will increase and exceed the statutory limit resulting in production delays.

All potential gas sources within the planned mining area, including coal seams located above and below the working seam, should be identified and sufficient gas data collected and used to determine the specific gas emission from each gas source. Gas reservoir and emission modelling is recommended to determine specific gas emission and changes in gas emission from individual sources over the planned mining area. Accurate gas reservoir and emission modelling provides the information required to accurately design gas drainage programs to effectively manage gas emissions and minimise the risk of 'gas-outs'.

Given the increasing occurrence of incidents of gas concentration in ventilation air exceeding the 2.0% statutory limit and changes to mine plans to avoid 'difficult-to-drain' areas, it is apparent that many operations are not effectively utilising gas reservoir and emission modelling to identify high gas emission areas and are not completing sufficient gas drainage in advance of planned mining.

The process of gas reservoir and emission modelling to support gas drainage design to control tailgate gas concentration and fugitive emissions is presented and discussed.

INTRODUCTION

The process of excavating and mining coal causes fractures in the overlying and underlying strata. The fractures provide pathways for gas released from coal seams and other gas-bearing strata to flow into the mine workings. Coal seam gas typically contains high concentrations of methane with lesser concentrations of carbon dioxide. Low concentrations of other gases such as nitrogen, hydrogen sulphide and ethane may also be present in some coal seams. In certain geological settings, particularly in close proximity to geological structures, such as faults and dykes, the concentration of gases contained in a coal seam can vary significantly between methane-rich to carbon dioxide-rich.

In mine design and planning it is vital that mining engineers gather sufficient information to accurately determine the content and composition of the gas present in the coal seam and develop an understanding of changes in these parameters within the planned mining area.

The longwall method of mining coal causes fracturing of the overlying and underlying strata behind the retreating longwall face. Where coal seams and other gas-bearing strata are present within the caving zone, gas will be released from the strata leading to contamination of the mine workings. If the rate of gas emission exceeds the diluting capacity of the mine ventilation, the concentration of gas in the mine may exceed the statutory limit, resulting in production delays and potentially unsafe conditions.

DISCUSSION

The maximum permissible concentration of methane in any area where persons work or travel in a NSW underground coal mine is 2.0%, and shall not exceed 1.0% in areas where diesel-powered machines are to be operated (WHS Regulation, 2014). In the case of a longwall panel, with 60 m^3/s ventilation air crossing the working face and exiting the panel via the tailgate return airway, the maximum allowable gas emission rate is 1,200 litres per second at a return airway gas concentration of 2.0% CH_4 and 600 litres per second at a return airway gas concentration of 1.0% CH_4.

Therefore to manage the gas concentration in a longwall ventilation circuit it is important to understand the gas emissions from the numerous potential sources within the panel, which include: (a) emissions from coalface as the coal is cut and loaded onto the conveyor; (b) conveyor emissions – gas desorbed from the coal as it is conveyed out of the panel; (c) rib emissions – gas desorbing from the coal seam that mixes with intake ventilation air; and (d) goaf emissions, which typically represent the most significant source of gas emissions in a longwall panel.

The mine design and planning process must consider the potential gas emission from each source and assess the risk that the total gas emission rate will exceed the dilution capacity of the ventilation system resulting in production stoppages. In cases where preliminary design indicates high gas emission and potential production delays, mine management must investigate the use of gas drainage methods to remove gas from the coal seam(s) and goaf areas. A variety of pre-drainage and goaf drainage drilling design and gas extraction methods are available for use in most mining conditions (Black and Aziz, 2009). However, many factors can impact gas drainage performance (Black and Aziz, 2010) and once understood, can be effectively managed to maximise the efficiency and effectiveness of the gas drainage program (Black and Aziz, 2011).

Modelling the reservoir is recommended to identify the relative impact of all potential sources of gas emission within the goaf and to evaluate the impact of pre-drainage to remove gas from particular coal seams to reduce total specific gas emission (SGE), prior to longwall extraction. Figure 1 provides details of the reported thickness and gas content of coal seams intersected by a vertical borehole (BH240) and shows the distance of each coal seam above and below the working seam (G seam).

Using the Flugge Goaf Caving Model (MEA, 2006), the specific gas emission from each coal seam is calculated. In the case of BH240, the total specific gas emission, calculated before considering the impact of pre-drainage, is 27.7 m^3/t. The model shows high SGE contribution from three coal seams; 9.0 m^3/t SGE from the G seam (working seam), 7.0 m^3/t SGE from the overlying F seam, and 4.0 m^3/t SGE from the underlying GL seam. Modelling the impact of pre-draining these three coal seams, to reduce the gas content of the F, G and GL seams to 4.5 m^3/t, 3.5 m^3/t and 5.0 m^3/t respectively, prior to mining, reduces the total specific gas emission from 27.7 m^3/t to 14.4 m^3/t.

Coupling the gas reservoir model to the mine production schedule produces a forecast of future gas emissions that can be used to identify periods of high gas emission where general body methane concentration is expected to exceed statutory limits. In addition to modelling and assessing the impact of varying pre-drainage on reducing SGE, the coupled model is also used to assess the impact of varying the rate of gas extraction from the goaf (goaf drainage) to further reduce total longwall gas emission into the ventilation air and the resulting impact on general body methane gas concentration in the ventilation air.

Figure 2 shows results produced from the coupled model for this mine example which has a planned 16-year mine life, with longwall production from years 5 to 16. The graph shows the average annual gas flow rate required from pre-drainage and goaf drainage to reduce total longwall gas emission to levels sufficient to maintain the general body methane gas concentration well below the 2.0% statutory limit. The average annual flow rate of methane gas exiting the mine through the ventilation system, known as ventilation air methane (VAM), is also presented in the forecast.

CONCLUSION

To reduce the risk of high gas emissions that adversely affect mine production, it is recommended that mine management utilise a coupled gas reservoir and mine production model to forecast gas emissions and the relative emission from each gas source within the reservoir. A key feature of the coupled model is its ability to readily assess the impact of varying the level of gas drainage, both pre-drainage and goaf drainage, to reduce the rate of methane gas emission into the ventilation air and maintain the gas concentration within the mine at safe levels.

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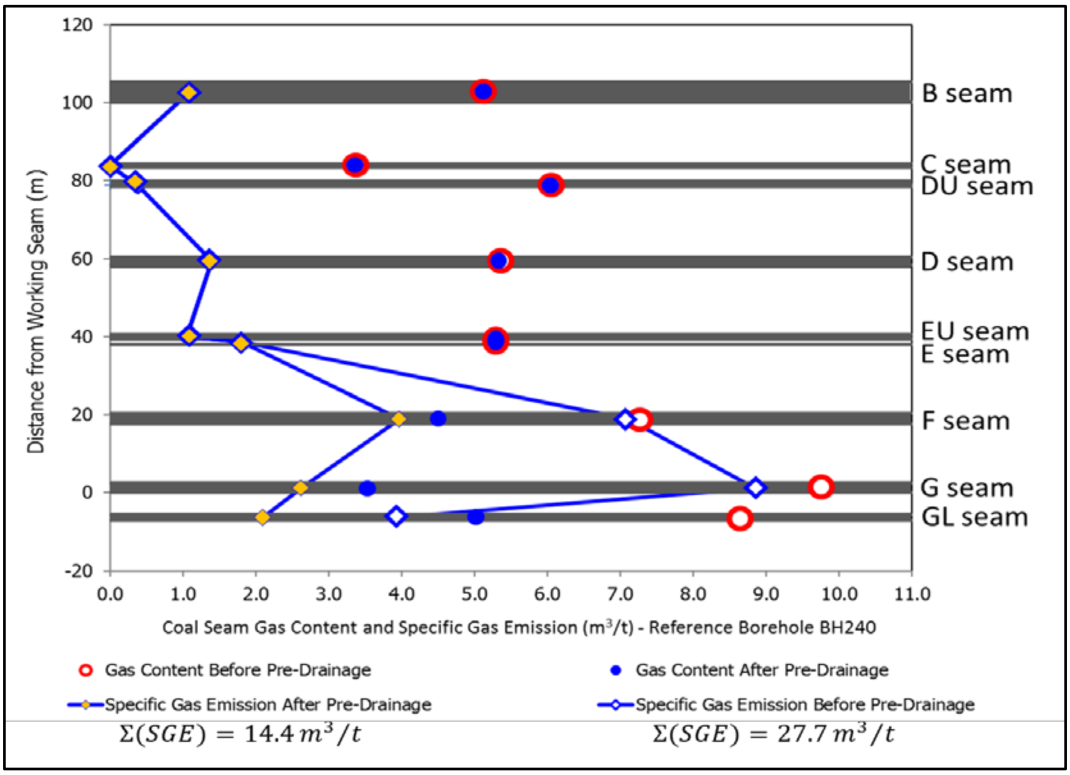
FIGURE CAPTIONS

FIG 1 – Gas content and specific gas emissions determined by reservoir modelling for coal seams intersected by borehole BH240.

FIG 2 – Gas emission forecast summary showing average gas drainage flow rate to maintain longwall return air methane concentration below 2.0% and average methane flow in mine ventilation air.

FIGURES



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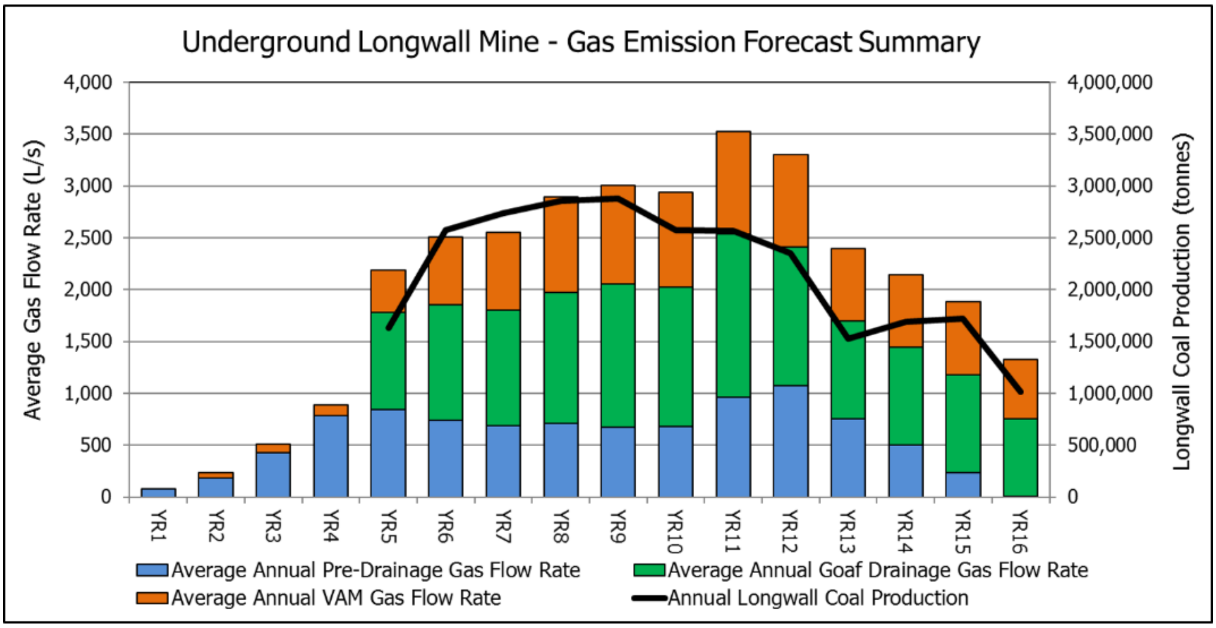

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