COAL MINE GAS EMISSION ASSESSMENT FOR SEALED GOAF AREA OR ABANDONED MINE

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ABSTRACT

Throughout Australia, no methodology exists for the estimating gas emission from sealed goaves or abandoned coal mines in relation to local mining, gas and geological conditions. This paper presents the current information in relation to the existing gas emission decline curves, which are used as a standard model of sealed goaves and inactive mine gas emission prediction for specific local conditions. This is commensurate with underground coal mine safety guidelines, including control of methane-air explosive mixtures and coal spontaneous combustion when a high percentage of oxygen is present, as well as with the Australian commitment to control and reduce greenhouse gases from all gas sources. The major application is where justification is needed to support the utilisation of the gas contained in these areas for commercial or environmental gain. Coal mine methane utilisation project capital is not likely to be available unless there is demonstrated confidence in the predicted gas availability over time. From the work conducted to date, a strong correlation exists between gas predicted by existing modelling and that measured in practice at a number of sites. Apart from the gas utilisation aspect, mine operations benefit from predicting gas emissions and relating them to ventilation design to provide adequate dilution. Another outcome is a unique PC software, which provides longwall goaf gas emission decline curves and is applicable for both coal mine gas management projects and coal mine methane utilisation purposes.

STATE OF THE ART

In Australia, there are currently numerous inactive or abandoned underground coal mines. Gas emission predictions from operational mines are calculated using various models and techniques on the basis of coal seams gas content, thickness and distances, gas reservoir other parameters such as: in situ pressure, permeability, sorption isotherms, strata relaxation zones, local lithology and mining system used. Some specialists estimate remaining gas quantity, which will be available (after the coal extraction is completed) as the difference between total quantity predicted and that measured during mining activities.

Intense extensive study regarding gas emission from sealed goaves and abandoned coal mines has been carried out by Lunagas, using data predominantly from Australian underground coal mines, as well as statistics from other sources and selected information from other countries. However, no comprehensive study on underground gas emission from sealed goaf areas and abandoned coal mines in Australia has been undertaken with the aim of specific local mining, gassy and geological conditions, as well as
underground safety such as goaf explosive air-gas mixtures and coal spontaneous combustion problems.

Long term research and application of the original decline curves allows for utilising the existing model at a number of sites, which has confirmed that a strong correlation appears to exist between gas emission quantity predicted and measured in practice (Figures 1, 2 & 3).

**GAS EMISSION DECLINE CURVES**

**DEFINITION**

Gas emission decline with time phenomenon being considered for DRY MINE cases only, assuming that the equilibrium between the quantity of gas released and recovered (captured plus vented) vary with time and depends on the gassy, geological, mining and barometric pressure conditions of the area.

In many countries the longwalls goaf and vast sealed goaf areas are used for temporary storage and long term gas liberation. Gas can be vented to the atmosphere or coal seam methane can be utilised, using various techniques and targets. Depending on the situation, sealed goaf areas and abandoned underground coal mines may represent producible gas sources, where gas release and exploitation can be planned and controlled from both a time and quantity perspective.

Specific gas information and data have been collected and analysed from selected coal mines in Australia and other countries since 1983. The data represents gas emission rate changes with time for the individual longwalls, districts and abandoned coal mines, and have been analysed in relation to various geological, mining and gassy conditions. A multi longwall database and an appropriate software have been used by Lunagas, to predict whole mine gas emission rate, and the contribution of individual longwall and its goaf to the total mine gassiness. Previous work (L. Lunarzewski, 1998) has been carried out on a regular basis to predict the absolute gassiness for operating longwalls and the entire mine, as well as gas emission rate decay with time for sealed goaves or abandoned mines.

**LUNAGAS SOFTWARE**

All selected and analysed data have been classified into four (4) categories in relation to mining activities, gas sources, gas release phenomenon and migration-transportation system utilised (L. Lunarzewski, 1999), they are:

1. Individual longwalls sealed goaf;
2. Multi - longwall sealed goaf area;
3. Surface gas wells; and
4. Abandoned coal mine.

All analysed data allows for representative analysis and graphical illustration of methane emission decline curves. Most of the data represents a fortnightly
period of measurement, however, some data were adopted for the available period in particular cases. All results are presented in pure methane and standard unit of litres CH\textsubscript{4} per second. Two basic periods of gas emission are analysed during and post production (Figures 1, 2 & 3):

I - DURING PRODUCTION - Gas emission changes are related to the gas source type, coal production level, advance- retreat rate and time (Figure 1).

II - POST PRODUCTION - Gas emission decay are related to the final gassiness’ time, gas sources characteristics, volume of gas reservoir and barometric pressure changes. In post production period, there are two physical processes/stages controlling gas emission versus time; rapid gas decay – ‘Stage 1’ and slow gas decay – ‘Stage 2’ (Figures 1, 2 & 3):

**POST PRODUCTION STAGES** (Figure 2).

STAGE 1 - Three initial periods of gas decay from the cessation of longwall have been identified:

1. One month - the most rapid decay - up to 50% of final gas emission;
2. Two months - second rapid decay - up to 70% of final gas emission; and
3. Six to fourteen months - stabilised period.

For this phenomenon the logarithmic approximation curve, is the most appropriate equation for curve of best fit.

\[
\text{Gas Emission Rate} = -A \cdot \ln (\text{Time}) + B
\]

Coefficient ‘A’ is dependent on:
- roof and/or floor gas sources position;
- gas emission rate (permeability);
- mining depth; and
- barometric pressure changes.

Coefficient ‘B’ defines gas emission initial range and strata permeability and is dependent on:
- the final methane emission rate;
- goaf capacity;
- specific gas emission (SGE); and
- sealed goaf area tightness.

STAGE 2 - Gas decay is reaching equilibrium between desorption and capture (vented plus recovered) rates, and depends on gas reservoir type, time and barometric pressure changes.

For this phenomenon the exponential approximation curve is the most appropriate equation for curve of best fit.
Gas Emission Rate = $C \cdot e^{-D \cdot \text{Time}}$

Coefficients ‘$C$’ and ‘$D$’ define gas reservoir capacity and are dependent on:
- the final methane emission rate,
- goaves capacity,
- roof and/or floor gas sources position, and
- virgin and remaining in situ gas contents.

Figure 1. Longwall extraction and sealed goaf gas emission trend changes

Figure 2. Longwall extraction and sealed goaf gas emission trend changes
SAFETY IMPLICATIONS

The most beneficial aspect to the underground coal mining industry is enhanced safety through sound risk management when using modelled outcomes to protect operating underground mines from methane-air explosive
mixture existing in goaves, and the possibility of coal spontaneous combustion when a high percentage of oxygen is present. The utilisation of the innovative method of gas emission prediction using the Lunagas Pty Limited unique software ROOFGAS® & FLOORGAS® (Figure 4), specific for local conditions, will lead to long term improvements in underground safety and performance, reducing costs of planned and design gas drainage and ventilation networks which directly affect coal production continuity, and the reduction in greenhouse emissions. Some control of the released gas toward the grounds surface is possible. Long distance coal mine gas travel causing accidents were reported up to 3 km from the source through the over layering strata of the mined and/or relaxed gassy seams, including gas explosions in closed spaces on the surface.

OUTCOMES AND BENEFITS

There are several expected outcomes and benefits when utilising the gas emission prediction model of ROOFGAS - FLOORGAS and the DECLINE CURVES:

1. Most important is a firstly foundered estimate of gas emission decline trend in relation to local conditions and to the underground mine safety, concerning the existence of methane-air explosive mixture in goaves, and the possibility of coal spontaneous combustion when a high percentage of oxygen is present.

2. A PC computer model uniquely designed to provide an engineering tool for designing and optimisation of gas underground management & recovery system.

3. Quantitative and qualitative justification in order to support utilisation of the gas contained in sealed goaves for commercial or environmental gain.

4. Apart from the gas utilisation aspect, mining operations would benefit from predicting gas emissions and relating them to ventilation design to provide adequate dilution.

5. From work conducted to date, it is clear that a strong correlation appears to exist between gas predicted by current modelling and that practically measured at a number of sites.

REFERENCES
