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## **Goaf Inertisation and Sealing Utilising Methane from In-Seam Gas Drainage System**

C. Claassen  
*Centennial Mining, Australia*

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# GOAF INERTISATION AND SEALING UTILISING METHANE FROM IN-SEAM GAS DRAINAGE SYSTEM

**C Claassen**

**ABSTRACT:** In the past the process for sealing longwall goafs at Mandalong has been to simply seal access points to the goaf and monitor the goaf as it self inertised. Due to changes in legislative requirements an improved method was required. A number of different methods utilising N<sub>2</sub> or CO<sub>2</sub> have been utilised at other mine sites. However, at Mandalong it was decided to use methane from the in-seam gas drainage system to purge and inertise the goaf. According to our knowledge this is the first time this method of utilising methane for goaf inertisation and sealing has been implemented.

The aim of the sealing process is to seal the goaf in a safe manner without disruption to other parts of the mine. This is achieved by controlling the inertisation process through the introduction of methane from the gas drainage system with the intent of purging the critical zone of the unsealed goaf of any oxygen.

Methane from the mine's gas drainage system and existing pipe arrangement is re-directed to the seals behind the longwall take-off face and injected into the goaf fringe under seam pressure. The goaf atmosphere is monitored via a tube bundle system and is allowed to enter and exit the explosive range under controlled conditions. When the tube bundle monitoring shows the goaf atmosphere is inert, final sealing of the goaf is carried out.

The principal hazard associated with the sealing of a goaf area in a gassy mine is the ignition of an explosive atmosphere resulting in an explosion. To reduce this risk to as low as reasonably possible (ACARP) numerous controls are implemented.

Mandalong has successfully utilised this method four times since February 2008. Longwall 5 (LW5), Longwall 6 (LW6), Longwall 7 (LW7), Longwall 8 (LW8) and Longwall 9 (LW9) were sealed in this manner, and it is intended future longwall goafs be sealed utilising the same methodology. The results of these will be presented and discussed.

## INTRODUCTION

Mandalong Mine is located 50km south of Newcastle, New South Wales, Australia. The mine operates a 150 m wide retreat longwall system in the West Wallarah Seam of the Newcastle Coalfield. The seam varies in thickness from 3.5 to 6.5 m and has a gas content up to 6 m<sup>3</sup>/t. The predominant seam gas constituent is methane. In-seam gas drilling and drainage is applied to the seam to lower the gas content to sufficient levels to prevent statutory limits being exceeded in the mine general body gas make.

The Fassifern seam underlies the West Wallarah seam at 4 to 8 m with a gas content of 4 to 6 m<sup>3</sup>/t. During LW retreat the interburden between the West Wallarah and Fassifern seam is fractured, liberating methane from the Fassifern seam to the active LW goaf. This in turn creates self-inertisation of the active goaf at a distance of approximately 1 000 m inbye of the working LW face.

## GOAF SEALING AND RESULTS

### Sealing LW1 – LW4

Sealing of the first four LW goafs consisted of constructing 138 kPa (20 psi) seals (with man doors in the seals) in the maingate and tailgate. These seals were constructed in parallel to LW face recovery. Upon completion of face recovery, a 138 kPa (20 psi) seal was constructed at the take-off cut through location and upon completion of the seal in the take-off cut through, the man doors in the seals in maingate and tailgate were closed, effectively sealing the goaf. The goaf was then allowed to self-inertise over time, as can be seen from the gas trend attached in Figure 1.

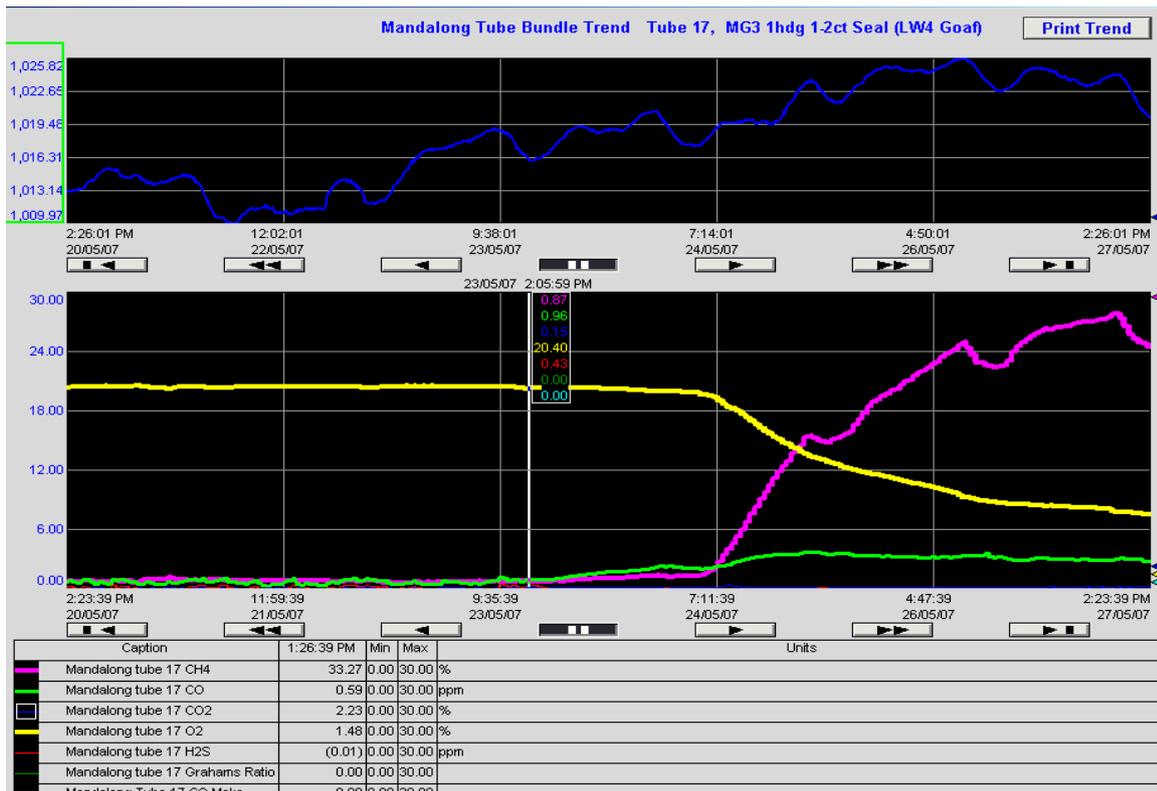


Figure 1 - Self-inertisation trend for LW4 final sealing

**Legislative sealing requirements**

Since 2007 the requirements of the Department of Industry and Investment (previously Department of Primary Industries) is that goaf areas be inertised prior to final sealing. Coal Mine Health and Safety Regulations 2006 clause 49 relating to High Risk Activities (NSW Govt, 2006) require that notification be submitted to the Department of Industry and Investment at least 30 days prior to sealing.

**Inertisation options available**

To achieve an inert atmosphere in the goaf area, different mines have adopted different methods; either nitrogen or carbon dioxide is used, with nitrogen appearing to be the more commonly used method. Mandalong assessed the options available and opted to utilise methane (CH<sub>4</sub>) from its in-seam gas drainage system.

**Seal specifications**

All seals constructed for purposes of goaf containment are constructed to minimum 138 kPa (20 psi) rating. Line seals with a life span of less than 18 months are concrete mesh block type, while life-of-mine (LOM) seals are of a type able to withstand a degree of floor heave and roof convergence evident in the Mandalong workings.

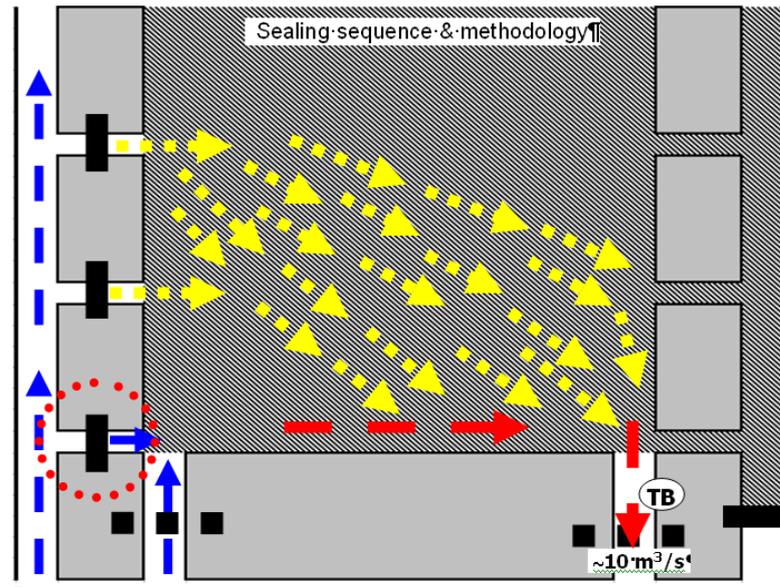
**Sequence and methodology**

Monitoring has shown that self-inertisation of the goaf generally occurs approximately 1000 metres behind the LW operating face. Self-inertisation occurs primarily due to the liberation of CH<sub>4</sub> from the underlying Fassifern seam via floor cracks between the Fassifern seam and West Wallarah seam subsequent to LW retreat, and is assisted to some small degree by CH<sub>4</sub> liberation from coal left in some parts of the goaf area.

In lieu of this, in February 2008 Mandalong utilised the method of injecting methane (CH<sub>4</sub>) into the goaf for purging and inertisation of the goaf for the first time. CH<sub>4</sub> is injected at seals inbye of the recovery face. Methane is conduited under seam pressure via the existing gas drainage range and 4 inch (100 mm) diameter pipes installed from the gas range to the seals during the pre-work phase.

Once the E-frame is established in the tailgate, construction of the final maingate (MG) and tailgate (TG) seal commences. Both seals on the MG and TG side are equipped with man doors to allow for continued airflow via these sites as required. Upon completion of the TG seal, CH<sub>4</sub> is directed to the seals on the maingate (MG) side inbye of the recovery face, with flows of 300 – 600 L/s achieved under normal seam pressure. Ventilation flow across the recovery face is maintained at 30 - 40 m<sup>3</sup>/s to allow for operation of diesel equipment within prescribed statutory limits. CH<sub>4</sub> injected on the maingate side of the goaf serves to displace oxygen from the goaf atmosphere during face recovery.

Once face recovery is completed, the airflow across the recovery face is regulated to 10 m<sup>3</sup>/s. A 138 kPa (20 psi) seal at the take-off face cut through is constructed while face ventilation is maintained via man doors in the MG and TG seals as shown in Figure 2.



**Figure 2 - Methane injection on MG side purging oxygen from goaf atmosphere, while maintaining ventilation across the recovery face**

Upon completion of the seal in the take-off cut through, the man door in the MG seal is closed and flow at the TG seal is reduced to < 2 m<sup>3</sup>/s. CH<sub>4</sub> injection via the take-off cut through seal commences simultaneously as shown in Figure 3.

The quantity of air/gas mixture flowing from the TG seal is reduced incrementally with the aim of achieving a higher volume of gas input on the MG side than air/gas bleeding from the TG seal, thus pressurising and purging oxygen from the goaf atmosphere.

Prior to final sealing a comprehensive checklist is completed to ensure that all actions are completed. The spontaneous combustion TARP (Trigger Action Response Plan) applies before, during and post the inertisation and sealing process. Should any spontaneous combustion indicators be present, actions as per the TARP are implemented.

### Monitoring

Monitoring of the goaf atmosphere occurs via tube bundle points installed in the TG seal and selected MG seals. The tube bundle gas analyser is situated on surface and gas analysis results are accessible via a number of terminals.

Routine bag samples are also taken and analysed by gas chromatograph. Sealing/purging progress via tube bundle is monitored via Safegas and the results trended utilising either Ellicott's or Coward's triangle, both facilities of which are incorporated in the Safegas/Segas trending software.

Final sealing does not occur until such time as the monitoring results indicate that the goaf atmosphere has reached at least < 80% explosibility as shown by Figure 4. This allows for a "barrier" to compensate for fluctuations in goaf atmosphere composition due to barometric fluctuations and migration of CH<sub>4</sub> away

from low lying areas in the seam, ingress of oxygen into the goaf via seals due to pressure differentials created by operational conditions, etc.

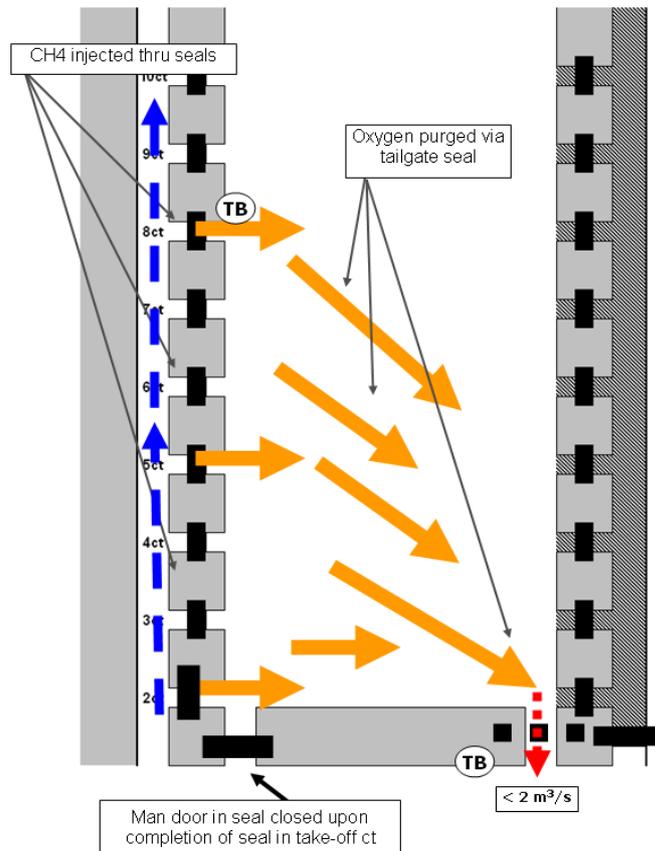


Figure 3 - CH<sub>4</sub> injection via MG seals continues while airflow via TG is reduced

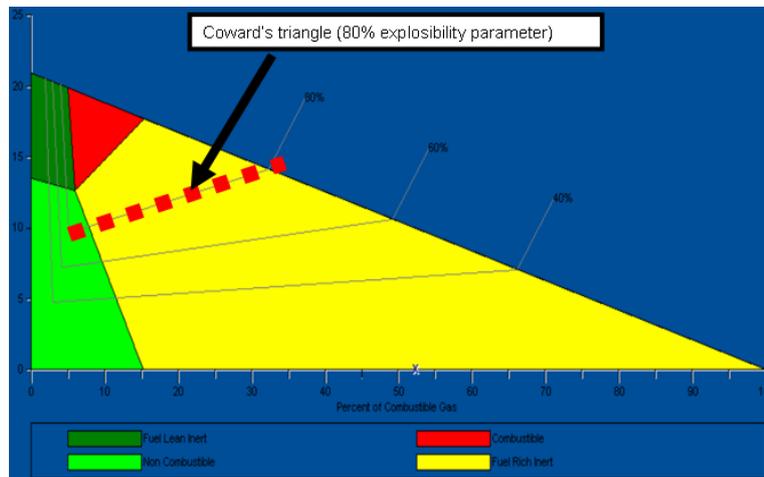
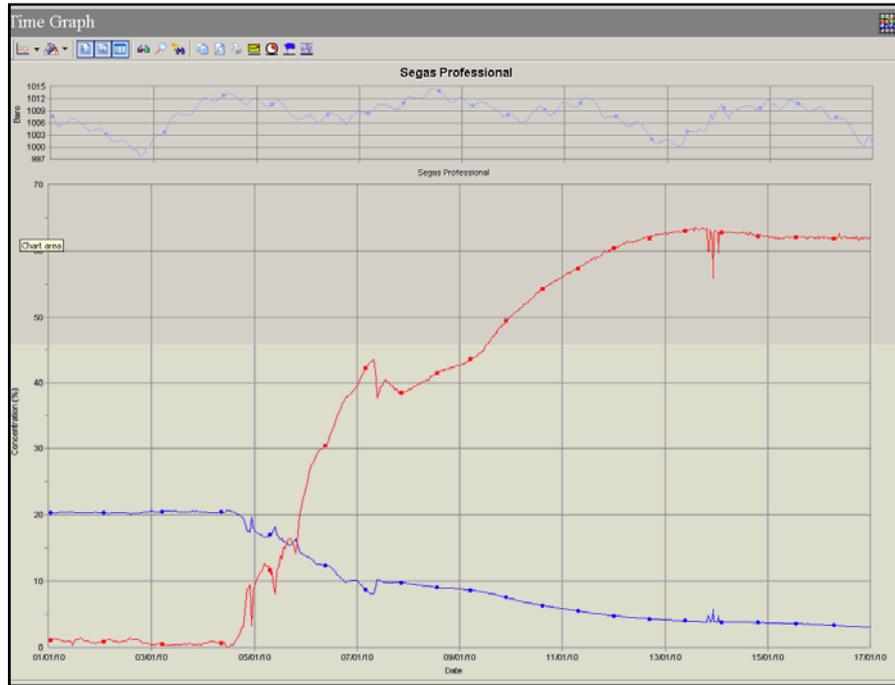


Figure 4 - Coward's triangle showing 80% explosibility parameter

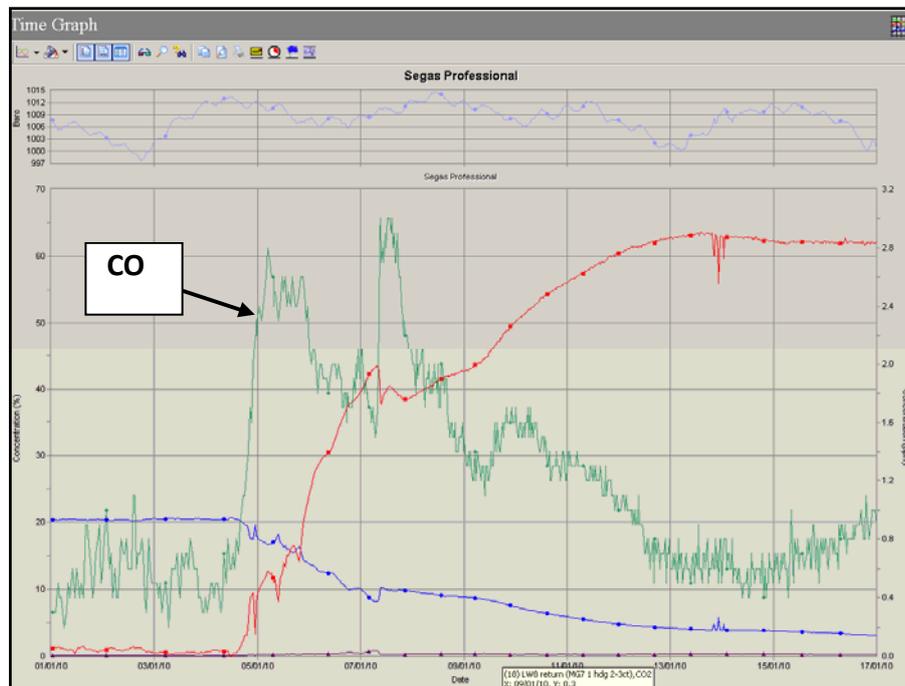
**Results**

The Safegas trend in Figure 5 shows a typical CH<sub>4</sub> versus oxygen trend over time for the TG seal during the inertisation process while CH<sub>4</sub> is injected on the MG side.



**Figure 5 - Safegas trend showing CH<sub>4</sub> and oxygen during sealing**

The objective during inertisation is to achieve CH<sub>4</sub> content >25% and oxygen content less than 10%. What is achieved in reality is a CH<sub>4</sub> content of 30-70% and an oxygen content of <2%, with the balance being nitrogen. Some low level carbon monoxide (CO) is present behind the immediate LW face during LW retreat, due to low level oxidation of fractured coal exposed to oxygen. In addition to this varying levels of ethane (C<sub>2</sub>H<sub>6</sub>) is detected by gas chromatography, and hydrogen (H<sub>2</sub>) of up to 30 ppm have been detected in select locations in the older goafs, due to the hydrogen being in isolated pockets it is presumably the result of chemical reaction of water and galvanised pipes.



**Figure 6 - Safegas trend showing carbon monoxide (CO) during inertisation process**

Figure 6 shows the corresponding CO level at the TG seal pre- and post-sealing. As mentioned before, CO levels in the goaf atmosphere are relatively low. CO presence and trending can thus be used as an accurate early spontaneous combustion indicator.

## CONCLUSIONS

CH<sub>4</sub> is used to displace oxygen from the goaf atmosphere, thus creating an inert atmosphere. The process is closely monitored for signs of spontaneous combustion and a well defined TARP applies during and after sealing. A rigorous monitoring system is in place in the form of both tube bundle monitoring and bag sampling/gas chromatography.

## REFERENCE

New South Wales Government, 2006. Coal Mines Health and Safety Regulations, 2006. [on line] <http://www.legislation.nsw.gov.au/etc>.