

INERTISATION, REDUCING THE RISK AND SOLVING THE PROBLEMS: THE LESSONS OF THREE YEARS EXPERIENCE USING INERTISATION EQUIPMENT IN THE NORTHERN BOWEN BASIN

Mark Blanch

Dip.Min., B.Sc.
Ventilation Engineer
North Goonyella Coal Mines Pty Ltd

Shane Stephan

B.Bus., M.B.A. (AGSM), M.A.I.T.D.
District Inspector of Mines (Mackay)
Queensland Department of Mines and Energy

SUMMARY

During 1997 both the Tomlinson Boiler low flow inertisation device and the GAG 3A jet engine were demonstrated to the industry as practical tools for inertising underground mine atmospheres. Since this time inertisation techniques have been used in the Mackay District to fight active fires, inhibit the development of spontaneous combustion and lower the risk of explosion following the sealing of goaf areas. There have been over a dozen applications of inertisation technology at the district's mines over this three year period. Tomlinson boilers have been utilised on four occasions as tools in the management of spontaneous combustion whilst the Queensland Mines Rescue Service (QMRS) GAG engine has been utilised in the inertisation of a large area of old underground workings associated with active fires in an opencut mine. The Tomlinson boiler has been utilised to proactively inert at least eight areas in underground coal mines over the past three years and is now routinely utilised to inert goaf areas at two underground mines in the Mackay District. One mine in the region recently introduced an innovation to the Australian industry through utilising the methane flow from an extensive in-seam drainage system to decrease the period taken to inertise a longwall goaf area following sealing.

The key lessons of this experience will be explained in three case studies that provide important information for the management of spontaneous combustion and fires. It is no exaggeration to state that the use of inertisation techniques has saved many scores of millions of dollars of our industries assets over the past three years since the early demonstrations of the techniques in 1997. In fact the application of inertisation techniques has dramatically changed the operational risk profile of investments in underground coal mining assets in Queensland.

INTRODUCTION

Inertisation equipment was first used in Queensland to assist the recovery of the Moura No.4 mine following an explosion in July 1986. The equipment utilised was the NSW Mines Rescue Brigade Mineshield™ liquid nitrogen vaporisation system. A total of 600 tonnes of liquid nitrogen was vaporised to produce approximately 500 000 m³ of gas¹. Significant logistical problems had to be overcome as the only appropriate sources of liquid nitrogen existed at Newcastle. Recommendations of the Moura No.4 and the Moura No.2 disasters related to the introduction of inertisation technology for Queensland coal mines. These recommendations were actioned resulting in the trial of a GAG unit at Collinsville No.2 and Tomlinson Boiler unit at Cook and Laleham Collieries during 1997. Presently two GAG inertisation units with associated hardware and trained operators are maintained by the Queensland Mines Rescue Service (QMRS) and five Tomlinson Boiler inertisation units are in use.

It is surprising that the need for such systems had not been realised earlier as records indicate that the problem of spontaneous combustion is relatively common with a total of 38 events being recorded over the last 25 years of the 20th century in Queensland. These spontaneous combustion events have resulted in significant loss of life, physical mining assets and coal reserves.

The following case studies illustrate that inertisation equipment must be seen as a tool which is part of a risk control system involving the use of seals of a high standard, state of the art gas monitoring technology and most importantly appropriately trained and educated personnel. In a period of just

¹ This particular application of inertisation technology was only partly successful with a hanging flame being discovered by the mines rescue teams during the recovery operations.

three years the coal mining industry has largely embraced this technology as it has proven to be able to extinguish active mine fires, inhibit the development of spontaneous combustion and lower the explosion risk following the sealing of a mine goaf. Tomlinson boilers have been utilised on four occasions as tools in the management of spontaneous combustion whilst the QMRS GAG inertisation device has been utilised for the inertisation of a large area of old underground workings associated with active fires at Blair Athol.

Similarly to when any new technology is first introduced, there has been a steep learning curve during the first three years of utilisation of inertisation equipment with many useful innovations being introduced along with the occasional failure. It is the purpose of this paper to describe through the use of three case studies some of the lessons of this experience so that the recurrence of past errors is inhibited and to assist mine personnel in future applications of inertisation equipment. Due to space limitations, only the essential points of each incident will be able to be described.

NORTH GOONYELLA 3 SOUTH DECEMBER 1997 INCIDENT

This event is generally recognised as the most serious spontaneous combustion event to have occurred in Queensland since the Moura No. 4 explosion. Following as it did only a few months after the trials of the Tomlinson Boiler it was to be a crucial event in proving the ability of low flow inertisation techniques to treat serious goaf heatings. A heating which would have historically resulted in the loss of at least the section and possibly the mine's ability to produce for many weeks was solved over a period of just five days saving many millions of dollars.

Background Information

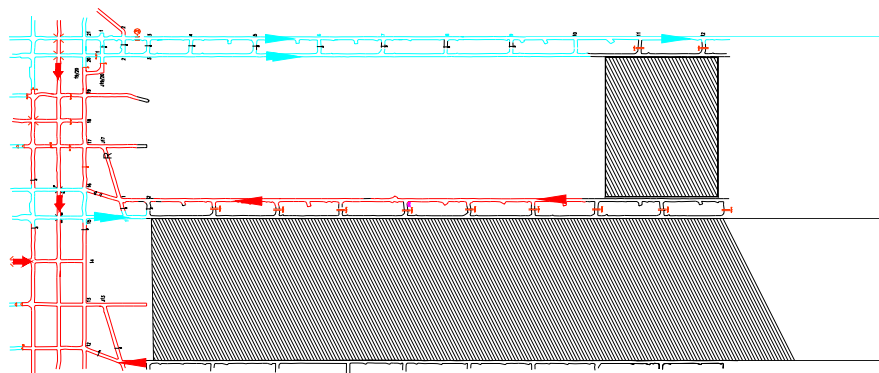
North Goonyella is a large modern longwall operation operating in the Goonyella Middle Seam. Due to the seam thickness significant quantities of roof coal is left in the goaf. At the time of this incident, at the end of 1997, the mine operated two longwalls, numbers 3 and 4 South concurrently. Three South face was only 9 metres from the take off line whilst four south face was just outbye 9 cut-through.

Development of the Problem

On the afternoon of the 28/12/97 a deputy detected 25ppm of Carbon Monoxide (CO) in the general body of 6 %_t in Longwall 4 Tailgate. This reading was followed up with bag samples from the Longwall 3 goaf out of the 5 and 7 cut-through seals. The 6 %_t seal sample pipes were blocked with mud and water. The manager ordered the evacuation of the mine at 5.55pm on the 29/12/97 following the confirmation of the results of these bag samples. The bag sample results were as follows:

	H ₂	CO ₂	Ethane	O ₂	CO	CH ₄
7 c/t	0.40%	14.0%	0.08%	3.15%	0.13%	2.09%
5 c/t	0.43%	4.60%	0.05%	14.86%	0.12%	0.90%

Figure 1 Longwall 3 South December 1997



This led to the first complication being encountered during the treatment of this incident. Without monitoring of the sealed area having been established prior to the evacuation of the mine there was significant reluctance on the part of some of the decision makers in allowing personnel underground to install tube bundle lines or take other corrective actions.

Initial planned corrective action included:

1. Taking further bag samples from around the goaf including the tailgate of the 4 South Longwall.
2. Installing tube bundle lines into 3 South Longwall goaf 4, 5 and 7 %_t seals.
3. Erection of a brattice wing at the maingate of the 3 South Longwall face.

At 7:50am on the 30/12/97 a team of personnel was permitted to undertake action items 1 and 2 and by 2:10pm of the 30/12/97 these tasks were completed and all personnel returned to the surface.

Some of the extensive monitoring data gathered during the incident is illustrated below. A review of this monitoring data, the mine ventilation plan and the history of the panel was undertaken by the Incident Management Team (IMT). Following much discussion within the IMT it was determined that the most likely scenario was that a spontaneous heating had developed over a two week period somewhere along the maingate edge of the 3 South Longwall goaf between 5 and 7 %_t.

Actions Implemented

1. A seal that was thought to have failed in 9 c/t be re-established remotely from the surface to restrict the ventilation differential between the 3 South Longwall maingate and the 4 South Longwall Tailgate.
2. Surface was dozer ripped and compacted.
3. Drill a 100mm borehole from the surface to a point 10 metres up-dip from the 5 %_t goaf edge.
4. Place dry ice (solid carbon dioxide) down the 5 %_t borehole.
5. Place liquid carbon dioxide down the 5 %_t borehole.
6. Place water down the 5 %_t borehole.
7. Connection of the prototype Tomlinson Boiler to the 5 %_t borehole.

Result and Lessons Learned

Action No.1 - A seal was reestablished using an existing road ballast drop hole without noticeable impact upon gas monitoring results. Action item 2 similarly was implemented without any noticeable impact upon the heating.

Action No.3 - A 100mm borehole to 5 %_t was started at 8:30am 31/12/97 and completed by 8:00pm on the 1/1/98 a total depth of 173 metres. Drilling over a goaf area is extremely difficult with a high likelihood of circulation failure and therefore hole abandonment. A bag sample from the bottom of the borehole indicated normal goaf gas concentrations were present.

Action No.4 – From 1:00am until 4:00am on the 2/1/98 400kg of dry ice was placed down the 5 %_t borehole. This proved to be totally ineffective and no impact was noticeable in the gas monitoring trends.

Action No. 5 – On the 2/1/98 from 3:25pm till 4:40pm 600 litres of liquid CO₂ was decanted down the 5 %_t borehole. This had a noticeable but short-lived impact upon the concentrations of the products of combustion although the impact of this action was masked by the introduction of water into the 5 %_t borehole. (See gas monitoring charts Figure 2 below)

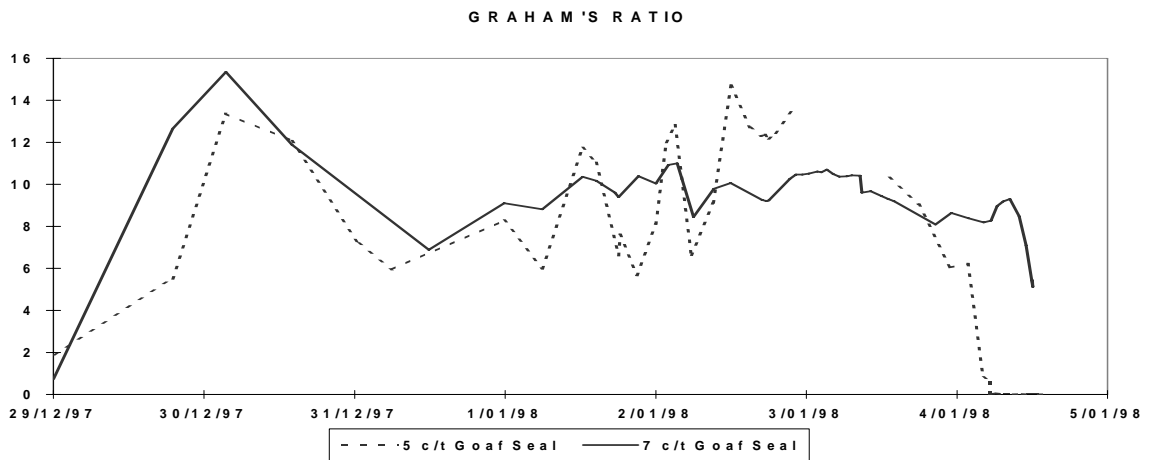
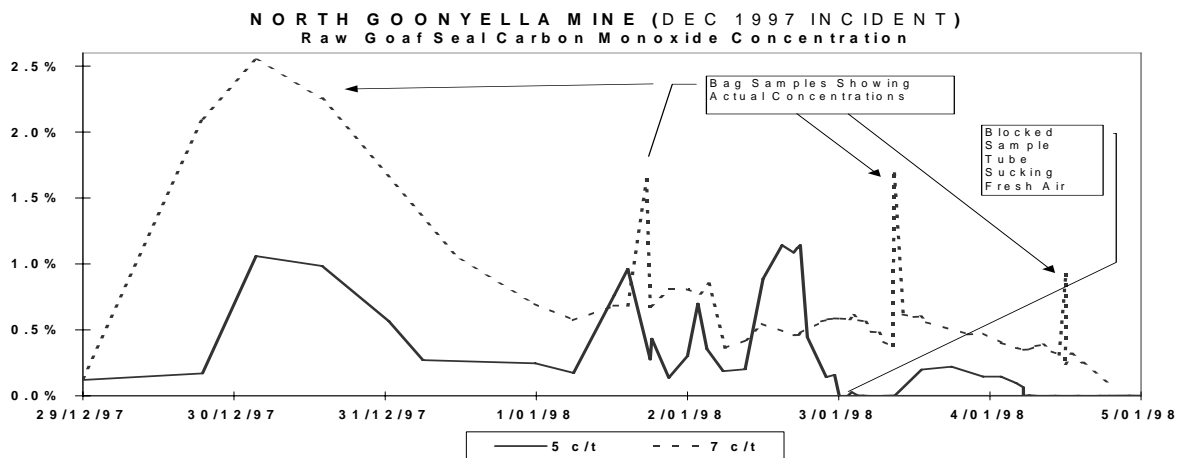
Action No.6 – The introduction of approximately 1.1 megalitres of water down the 5 %_t borehole in cognisance of the delay in implementing the Tomlinson Boiler, this decision was taken at 5:00pm on the 2/1/98. In retrospect, the decision to utilise water caused many problems and future IMT groups should very carefully consider the consequences of its use. Due to the haste in which the tube bundle monitoring lines had been run the tubes into 7 and 4 %_t were leaking, only 5 %_t monitoring line was reliable (see monitoring charts). Monitoring from 5 %_t was lost due to the monitoring point being flooded. A further 3,000 litres of liquid CO₂ was decanted into the 5 %_t borehole during which time a team of personnel were given the task of re-establishing monitoring from 5 %_t and if possible improve

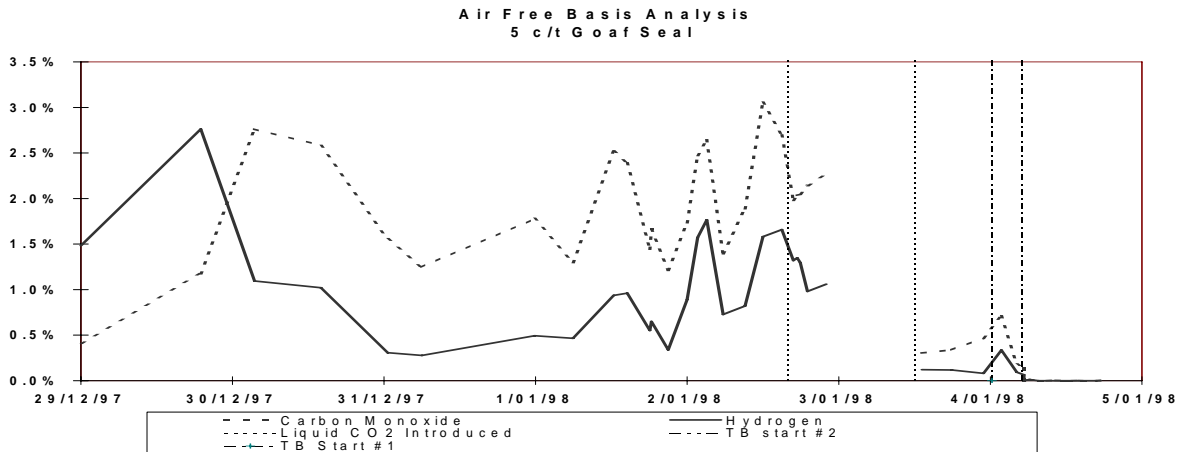
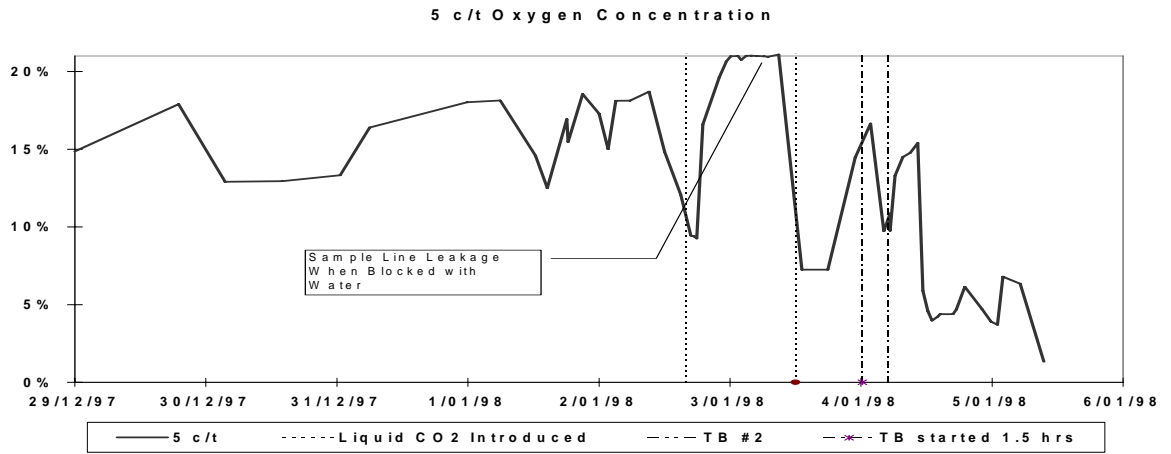
the reliability of the other monitoring points. This team also noted that there was significant water pressure upon the 6 c/t seal. Without gas monitoring the IMT is effectively blind. Monitoring results, post implementation of the water, did indicate that it had probably not inhibited the development of the heating.

Action No. 7 – The Tomlinson Boiler arrived on site at 11:00am on the 3/1/98, it was commissioned at midnight on the 3/1/98 and ran for 1.5 hours and then broke down, at 5:00am on the 4/1/98 the boiler was restarted. The boiler produces approximately 0.4m³/sec of inert gas. Monitoring results indicated that over the following few hours the boiler had a major impact upon the levels of oxygen available to the heating, the level of combustibles being produced and the pressure differentials in the goaf. By 1:30pm of the 4/1/98 a slow and steady increase in the concentration of seam gas was detected whilst CO and H₂ remained at extremely low levels. Oxygen levels of approximately 4% were evident at 5 c/t. The situation remained stable except for one occasion when the boiler's fuel filters became blocked and high concentrations of combustibles were detected at the underground monitoring points, this was quickly corrected.

A mine operation recovery plan was then implemented and the mine was back in operation six days after the detection of the spontaneous combustion event. The Tomlinson boiler was maintained in operation until longwall three had been completed and sealed. This was the first successful use of inertisation equipment in fighting spontaneous combustion in Queensland.

Figure 2 Gas Monitoring Results

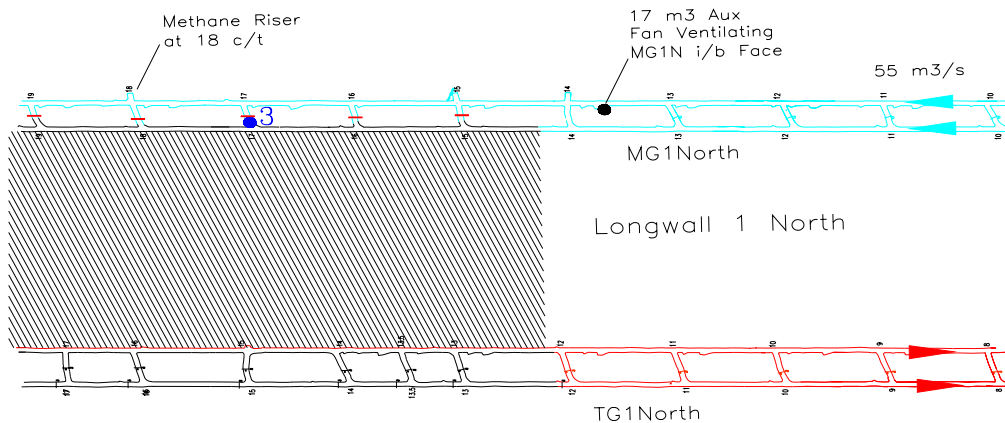




NORTH GOONYELLA - LONGWALL 1 NORTH NOVEMBER 1999

Longwall 1 North was the first block on the northern side of the lease extracted. Ventilated through a standard "U" layout with approximately 55 m³/s delivered to the face via twin heading intakes in the Maingate across the face and back to the Main Return via a twin heading tailgate. As opposed to ventilation layouts previously used during the extraction of the Southern Longwalls a bleed system was not utilised on Longwall 1 North. The Maingate roadway inbye of the face was ventilated using a 17 m³ forcing Auxiliary Fan located outbye of the last open cut-through in the Maingate and 900mm layflat ducting.

Figure 3. Longwall 1 North 14th Nov 1999.



Tailgate return CO make for October and the first 2 weeks of November ranged from 3 to 9 l/min with a daily average of 4 to 5 l/min for the same period. Peaks in Tailgate CO make were generally

experienced as a result of increased diesel activity in the panel or increased rates of oxidation broadly related to increased faulting and or reduced rates of extraction. For the same period the Tailgate return Graham's Ratio ranged from 0.02 to 0.18 with an average value of 0.05.

With the face approaching 14 c/t MG1N and completion of the 140kPa seal at 15 c/t MG1N, oxygen levels adjacent to the inbye seals fell away, CO levels behind 16 and 17 c/t seals quickly pushed through Levels 1 and 2 of the mine's Action Response Triggers of 100ppm and 200ppm respectively.

Gas monitoring levels fluctuated with diurnal barometric fluctuations but were generally upward.

DATE	17 c/t Seal O ₂	17 c/t Seal CO	TG Return CO Make	TG Return Graham's
29 th Oct	19 %	125 ppm	2.1 l/min	0.02
31 st Oct	17%	191 ppm	1.4 l/min	0.01
6 th Nov	14%	284 ppm	4.1 l/min	0.04
7 th Nov	13%	353 ppm	3.8 l/min	0.04
10 th Nov	11%	360 ppm	6.5 l/min	0.02
11 th Nov	11%	387 ppm	7.4 l/min	0.126

Bag samples taken on the 11th of November from behind the seal at 17 c/t Seal indicated CO levels of 387 ppm and O₂ levels 11%. Inspections around the area of concern gave no indication of abnormality, no hydrogen or higher hydrocarbons were detected. Tube bundle point No. 3 was relocated to the 17c/t seal to provide continuous monitoring.

Figure 4. 17 c/t MG1N Bag Sample Analysis

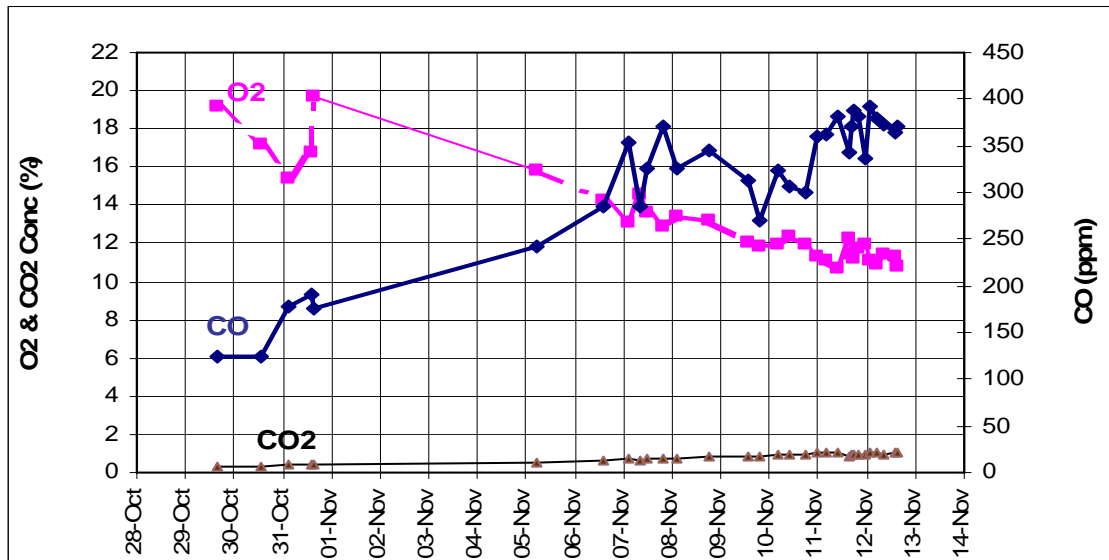
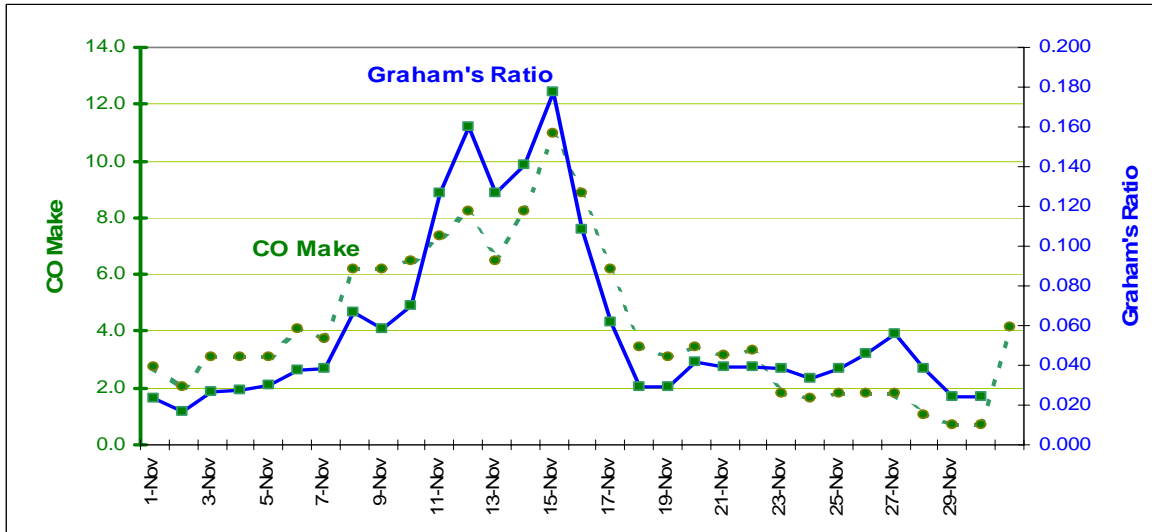


Figure 5. LW1N TG Return Gas Monitoring

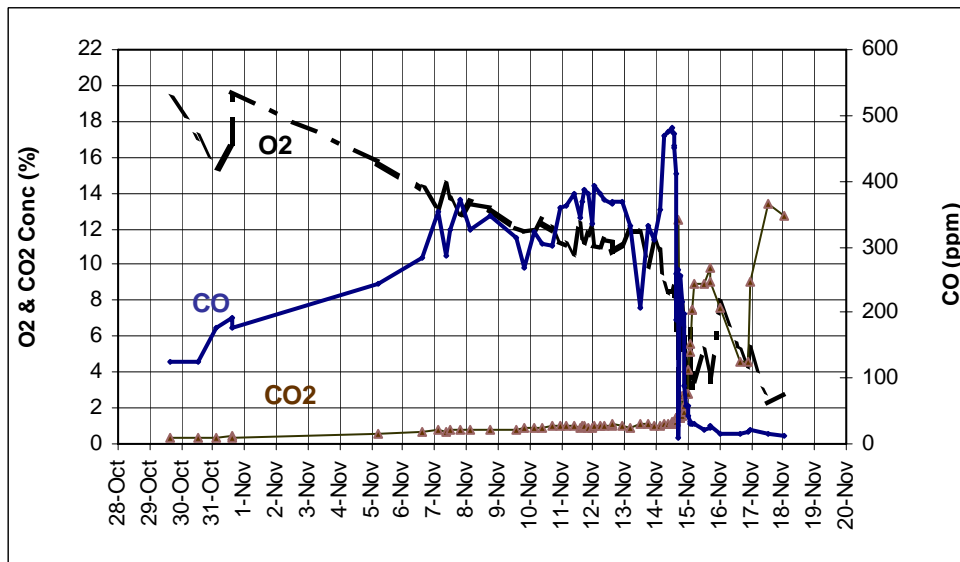


On the 11th of November the Management Team made the decision to inertise the area, where CO levels exceed 420 ppm. With North Goonyella's Boiler located on the southern side of the lease given the recent events of Longwall 5 South a Hire Boiler was mobilised.

Surface to seam access was gained via the MG1N 18 c/t methane drainage riser connected to the 18 c/t seal through a 6' flexible hose. At the time it was standard procedure to install a 6" pipe with butterfly valve in every second seal to facilitate inertisation. As such the inert gas would be delivered to 18 c/t, not directly to the site of high CO levels.

CO levels at 17 c/t MG1N reached 480 ppm just prior to delivering the boiler gas underground at 1pm on the 14th of November. By 3 pm CO levels were less than 200 ppm and less than 100 ppm by 7:30 pm (Figure 6).

Figure 6. 17 c/t MG1N Bag Sample Analysis



The Boiler successfully inertised the Maingate goaf fringe through a rapid and sustained reduction in local goaf oxygen levels. By the 16th of November Tailgate CO Make and Graham's Ratio were recorded as 4 l/min and 0.05 respectively. Bag samples from behind Maingate Seals at 16, 17, 18, 19 and 20 cut-throughs indicated gas composition along the MG fringe of the goaf to be essentially the same as the boiler product < 20ppm CO, < 2% O₂, 12-14% CO₂ and the remainder N₂.

With the boiler turned off on the 16th of November oxygen levels at 17 c/t varied through the influence of face ventilation and barometric fluctuations, increasing to approximately 5%. No abnormal activity has been detected in or around the 17 c/t area since this event.

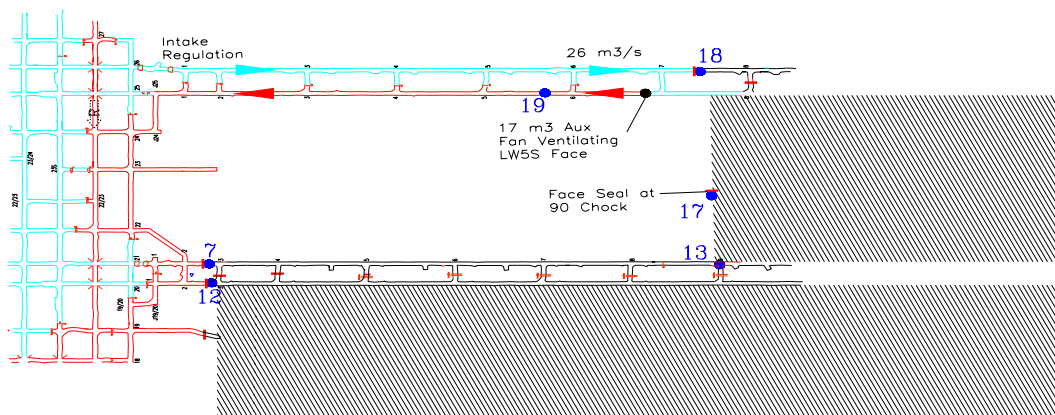
North Goonyella – Longwall 5 South September 1999 to March 2000

Longwall 5 South panel was originally sealed at the Maingate between 7 & 8 cut-throughs and in the Tailgate at 2-3 cut-through on the 25th of September 1999, due to high and increasing CO make in the Tailgate return. The Tomlinson Boiler was used during the Longwall 5 South September heating event initially to minimise oxygen ingress into the open goaf via a surface to seam boreholes adjacent to the BSL (delivered to the goaf behind No. 1 chock through a 6" pipe). Upon sealing both the NGC Boiler and a Hire Boiler were utilised to provide artificial inertisation through the Maingate borehole and directly into the goaf approximately 10m behind 115 chock.

After the initial sealing the Hire Boiler was demobilised on the 1st of October. The NGC Boiler was used to maintain oxygen concentrations below 2% through the delivery of approximately 370 l/s of inert gas into the goaf and pressurise not only the goaf of Longwall 5 South but all the Southern goafs, thus mitigating against barometric effects. Pressure surveys around the Southern goaf indicated differentials across the seals of up to 1300 Pa acting from the goaf outward. This figure being approximately 200 Pa in excess of the mines collar pressure at the time.

In late October the boiler was turned off and the goaf monitored closely for O₂ ingress, increasing trends in CO and traces of H₂ or higher hydrocarbons. After sealing, ventilation around Longwall 5 South was arranged to minimise ventilation pressures across this area, through the sealing of the Southern Bleed Headings and Shaft and the installation of an intake regulator in Maingate 5 South. The district was monitored via four tube bundle points in addition to weekly bag samples from the three 20 PSI Micon Seals by the mine's deputies. During this period the sealed area remained inert and stable.

Figure 7. Longwall 5 South Feb-March 2000.



Re-entry into the panel at Maingate 5 South B 7-8 on the 11th of February 2000, followed a full risk assessment of the proposed re-entry procedure and 2 separate inspections by Mines Rescue teams under oxygen prior to breaching the Micon seal in the Maingate. The Tomlinson Boiler was utilised to render an inert, fuel rich goaf environment inert and benign prior to the QMRS exercises and prior to breaching. An 18 m³ auxiliary fan sited in B heading between 6 and 7 cut-throughs was used to progressively re-ventilate the Maingate and face areas up to 91 chock.

The approach to re-ventilating the face area was one of minimising oxygen ingress into the goaf. This was achieved by:

- Maintaining a ventilation pressure differential across the panel in the order of 50 Pa.
- Breaching the Maingate Seal only and using an auxiliary fan and duct to ventilate the face area, thus avoiding the effects of through ventilation

- Maintaining low face airflows to minimise air ingress behind the face supports.
- The face line was sealed between 90 & 91 chocks and between supports from 90 chock back to the Maingate rib, to minimise air ingress into the goaf.
- Once sealing work along the face was complete the mine's Tomlinson Boiler was used to pump inert gas into the Longwall 5 South via a surface to seam borehole 10m behind 115 chock.

Monitoring during this stage included:

- The continuous monitoring of the goaf area - immediately behind the face seal between 90 and 91 chocks (Tube 17), Maingate 5 South A heading Seal (Tube 18), Tailgate corner (Tube 13), Tailgate Seal A 2-3 (Tube 7) and the district return air stream behind the auxiliary fan at Maingate 5 South B 5-6 (Tube 19).
- Deputies inspections and bag samples from each of the Longwall 5 South EMS tubes (3pm daily).
- 24 hr Barometric pressure forecasts were provided on a daily basis and a Web Page set up by the Bureau of Meteorology to provide weather forecasts and radar imaging of storm activity in the area. Both of which were directed at providing early warning of significant variations in barometric pressures.

The re-entry of the panel proceeded smoothly from both an operational and environmental perspective. On the 14th of February the Tomlinson Boiler was used to deliver inert gas via the borehole at 115 chock, following the installation of a seal across the face between 90 and 91 chocks and the sealing between face supports from this point back to the Maingate. The purpose in using the boiler was to minimise O₂ ingress caused by face ventilation and barometric effects. The inert gas generated by the boiler does however complicate monitoring for spontaneous combustion, in particular the use of ratios commonly used for indicating accelerated rates of oxidation.

Analysis of monitoring results when the Boiler is operating is further complicated when it runs out of tune. The Boiler's has been a valuable and reliable asset to operations at North Goonyella, however during the re-entry of Longwall 5 South it proved troublesome running off tune on a number of occasions and producing gas with concentrations of CO as high as 1000 ppm. Monitoring from all Longwall 5 South tube bundle points for CO, CO₂, CH₄, O₂, H₂, C₂H₄ or C₂H₆ indicated a stable environment with no consistently increasing trends in concentration other than at Tube 19. Similarly air free CO trends from goaf monitoring points for the period were stable.

At tube 19 – the district return Maingate 5 South B 5-6, EMS monitoring trends indicate a steady increase in CO concentration, CO make and Graham's Ratio over the 33 day period the area was opened (Figures 8 & 9).

Figure 8. Ventilation & Monitoring 4pm 14th March

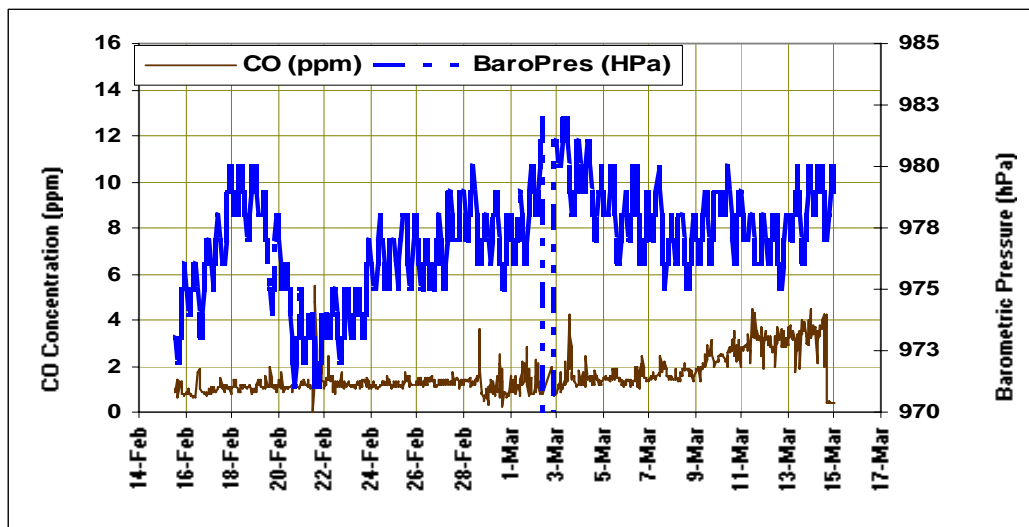
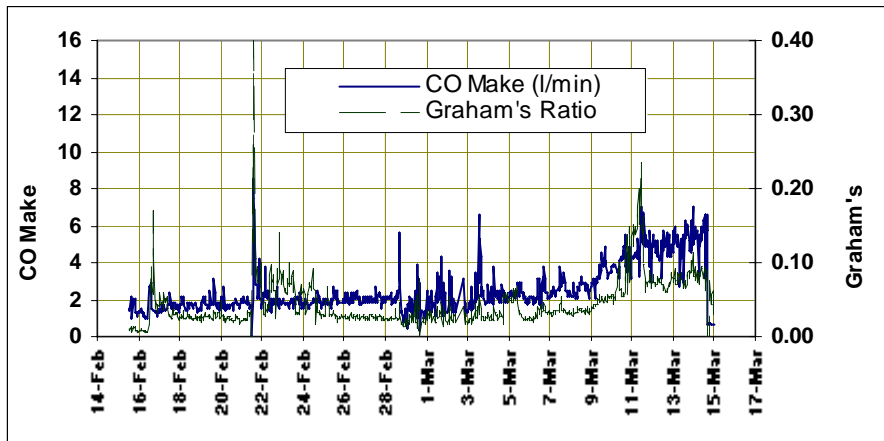


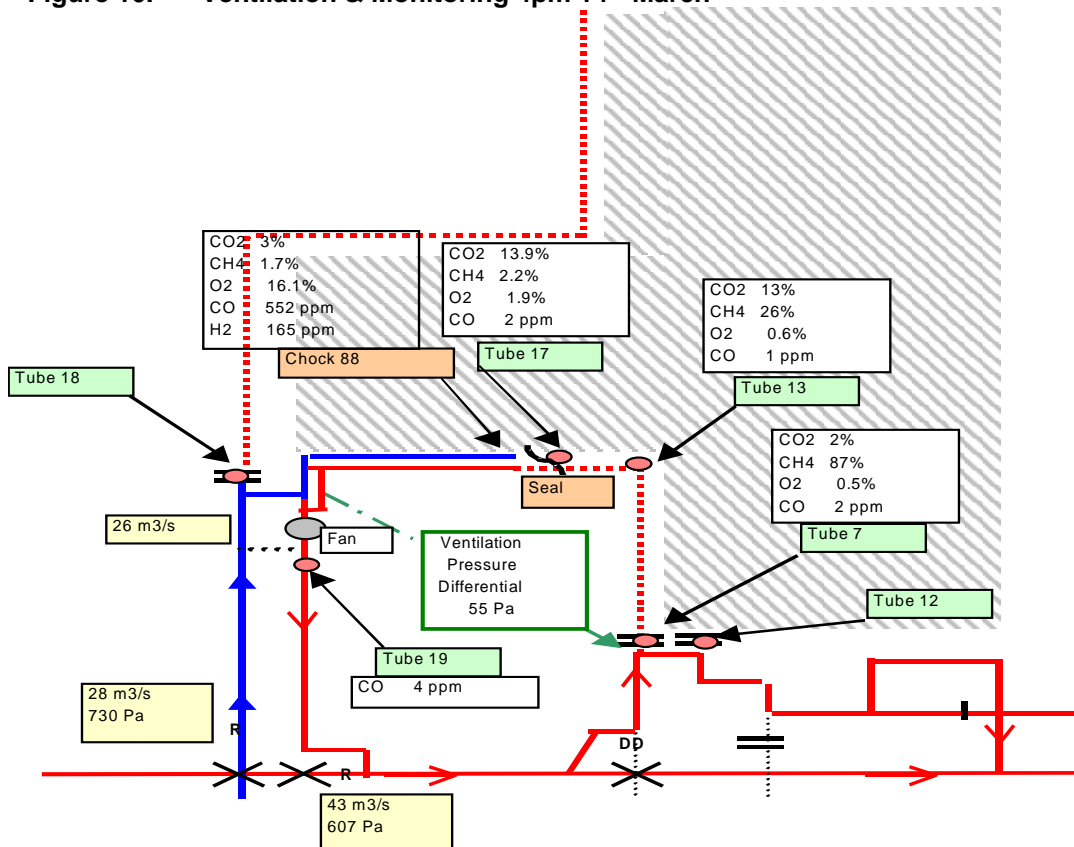
Figure 9. CO Make and Graham's Ratio



Just prior to the change of shift on the 14th of March the night shift Deputy reported a Minigas reading of 232 ppm CO he had taken in the roof canopy of 88 chock at 8am. The day shift deputy followed through on this inspection recording approximately 550 ppm CO at the same location at 11:50 am with both a Drager Tube and Minigas. The day shift deputy delivered a bag sample from 88 chock to the surface at 1pm for Gas Chromatograph analysis. The GC analysis confirmed the hand held instruments, the results were also confirmed by both Newlands Colliery and SIMTARS. Figure 10 depicts the ventilation and gas environment around Longwall 5 South on the 14th March.

Methane	1.17%	Hydrogen	165 ppm
Carbon Dioxide	2.65%	Carbon Monoxide	550 ppm
Nitrogen	74.6%	Ethane	0 ppm
Oxygen	16%	Ethylene	0 ppm

Figure 10. Ventilation & Monitoring 4pm 14th March



The 232 ppm of CO recorded on night shift and the 550 ppm recorded on day shift were found in a hole in the roof canopy of 88 chock after tracing a warm stream of air issuing from the hole. The deputies findings together with an evaluation of data derived from the mine's continuous monitoring system suggest the heating was discovered during the early stages of an accelerated oxidation and that the heating was relatively localised:

- The deputies were unable to detect CO concentrations greater than 4 ppm, 1-2 m either side of 88 chock. In an airflow of 8 m³/s this represents a CO make of less than 2 l/min.
- Continuous monitoring from tube bundle point 17, less than 5 m from 88 chock, indicated no increase in CO concentration.
- Data from all monitoring points around Longwall 5 South and from bag sampling from 70 chock gave no indication of any abnormal oxidation of coal.

As per the mine's Hazard Management Plan the decision was made to evacuate the mine, evacuation being completed within 35 minutes of notification. Given the history of the panel and the need to ensure the safety of the mine and its employees, the decision was made to seal the panel at Maingate 5 South B 7-8. With the permission of the Mines Inspector this was completed at 5:30pm and inertisation of both the face and goaf areas initiated at 6pm using the mine's Tomlinson Boiler via the inertisation pipe at the Maingate Seal and the 115 Chock borehole. Pre-shift inspections were undertaken at 11pm and normal mining operations commenced shortly after.

CONCLUSION

These three summarised case studies provide just a flavour of the amount of knowledge gained over the past three years in the Northern Bowen Basin in the use of inertisation equipment. Space limitations do not allow the detailing of the use of the GAG inertisation system through the use of a large diameter borehole, the use of a pressure swing absorption unit to inertise old underground workings or the innovative redirection of seam drainage gas into a sealed goaf area. Perhaps a collection of these case studies may be undertaken by someone as a project for the benefit of the industry.

The lessons of the first reactive applications of inertisation equipment have been proactively utilised by some mines as part of their safety management systems. Through such actions as installing tube bundle monitoring points behind their active longwall goaf areas which are leap frogged as the longwall retreats, installing inertisation pipeline systems and inertising their sealed goaf areas these mines are solving problems and reducing the risk of operating their mines.

The principle lessons of these past three years have been:

1. Without appropriate gas monitoring data the incident management team is effectively blind.
2. That understanding the pressure generation effects of inertisation equipment is critical to the effective implementation of the technology.
3. That inertisation equipment must be seen as a tool which is part of a risk control system involving the use of highly effective seals, state of the art gas monitoring technology and most importantly appropriately trained and educated personnel.

As Mr Howard Jones stated in a paper delivered at a previous Queensland mining industry safety conference in 1996, "Spontaneous Combustion is Deadly in Underground Coal Mines !" Our forbears did not have access to the inertisation or gas monitoring equipment that we do today and so when a spontaneous combustion was detected, usually by smell or smoke, they had few options but to either flood or seal the panel or entire mine. These techniques were always costly in financial terms and tragically often, resulted in explosions and deaths. They recognised the need for improvements and through their initiatives modern mining engineers now have access to inertisation systems which have proven to be able to solve such treacherous mining problems as spontaneous combustion. There will undoubtedly be more learned in future applications of inertisation equipment and this information should be recorded and shared amongst the mining industry. It is however fair to state that the expansion in the use of inertisation techniques over the past three years have laid a solid foundation of field experience upon which these further innovations can be made. In fact, the application of

inertisation techniques has dramatically changed the operational risk profile of investments in the underground coal mining industry in Queensland.

ACKNOWLEDGEMENT

The authors thank the management of the North Goonyella mine for granting permission for the details of incidents that have occurred at their operation to be included in this paper. Thanks must go to the management of mines where inertisation has been utilised as the lessons of their experience has been freely shared for the benefit of the entire industry.

REFERENCES

Bell, M., Bell, S., Caffrey, M., Allison, W., Inertisation of Mines Fires Using Pressure Swing Absorption Nitrogen Plant and Inert Gas Generators, Moura No.2 Tour Report.

Bell, S., Humphreys, D., Harrison, P., Hester, C., Torlach, J., A Report on the Demonstration of the GAG-3A Jet Inertisation Device at the Collinsville No.2 Coal Mine, ACARP Project No. C6019, ACARP, 1997.

Brady, J.P., McKenna, R.L., Sealing, Monitoring and Low Flow Inertisation of a Goaf, Proceedings of the QMIHSC. 1996.

Brady, J.P., Sealing, Monitoring and Low Flow Inertisation of a Goaf, ACARP Project No. C6002 Final Report, ACARP

Bureau of Mines USA, CMI Inert Gas Mine Firefighting System, Contract JO318080, USBM Report, 1982.

Cliff, D., Hester, C., Bofinger, C., Interpretation of Mine Atmospheres Particularly for Spontaneous Combustion, Mine Fires and Explosions, SIMTARS, 1999.

Enright, K., Nitrogen Inertisation Process in Underground Coal Mines, End of Grant Report No. 872, NERDAC, 1988.

Jones, H., Spontaneous Combustion is Deadly in Underground Coal Mines !!!, Proceedings of the QMIHSC 1996.

North Goonyella Coal Mines Limited., Review of Significant Incident at North Goonyella Coal Mine Longwall 3 Goaf Spontaneous Heating December 1997/ January 1998, Unpublished Report, 1998.

Queensland Department of Mines and Energy, Moura No.2 Inquiry Task Group 5 Inertisation Report, Unpublished Report 1997.