SEALING, MONITORING AND LOW FLOW INERTISATION OF A GOAF

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SUMMARY

ACARP has agreed to support a proposal to conduct research, trials and experiments into the sealing, monitoring and low flow inertisation of a waste working panel at Cook Colliery.

The primary motivation for this project is the findings and recommendations of the Moura No 2 Inquiry and our total agreement with a comment of the Inquiry panel who stated:

"It is with this grave concern that the following recommendations have been drafted- a concern that there must be fundamental and permanent change in the current approaches and attitudes in the coal industry."

This project is designed to investigate the entire sealing operation and to develop a standard template, for a Sealing Management Plan.

We will, with expert assistance, identify the most appropriate, monitoring protocols and mine atmosphere interpretation techniques, which will ensure the safety of the mine and persons engaged in the sealing process.

Finally, we will investigate the feasibility of using a Tomlinson Inert Gas Generator, to effectively inertise a goaf and prevent the atmosphere behind the seals from entering or passing through the explosive range.

Cook Colliery has a large area of waste workings with an estimated total void of about 420,000 cubic metres and we believe that this area presents a wonderful opportunity to test and refine inertisation techniques.

The project team is committed to the success of this project and we are asking for your assistance in the development and introduction of fundamental and permanent change in current approach and attitude to panel sealing.

INTRODUCTION

Cook Resource Mining Pty Ltd has applied for ACARP funding to enable it and other interested parties to conduct research, trials and experiments on the Sealing, Monitoring and Low Flow Inertisation of a Goaf.

This project will be conducted at Cook Colliery, south of the township of Blackwater, where large scale mining has been carried out in the Castor or top seam, since 1975.

The Castor seam, which is presently worked by bord and pillar methods, has an average thickness of about 3 metres. The seam consists of a dull top ply and banded bright layers in the lower ply. The coal is of medium rank and considered to be in the medium volatile range.

Coal from Cook Colliery has been tested for spontaneous combustion characteristics by the peroxide method and the results of these tests suggest that the coal is not prone to spontaneous combustion. To support this, there has been no evidence of spontaneous combustion since the mine commenced operations in 1975.

It should be noted however, that there are many instances of spontaneous combustion occurring in Cook raw, product and reject stockpiles and that spontaneous combustion events have occurred in neighbouring mines located in the same coal measures. The seam gas is predominately methane with, in situ gas levels of about 13 cubic metres per tonne of coal.

The Aims and Objectives of this project are:

- To develop, test and refine a Safety Management Plan for the sealing of a panel
- To identify gas monitoring protocols which will ensure the safety of persons engaged in the sealing process
- To clearly understand the natural, physical changes which occur in a goaf, after sealing
- To demonstrate that low flow inertisation, provided by a Tomlinson Inert Gas Generator, of a sealed area will:
  - prevent the atmosphere behind the seals from entering or passing through the explosive range
  - be achieved without interruption to the normal production cycle.
  - be cost effective
- To develop a computer model which will enable future predictions of the inertisation of mine areas using either external inert gas generation, natural processes or a combination of both.

DEFINITION OF THE PROBLEM

The Moura No 2 Inquiry recommended:

That no part of a mine be sealed without prior written approval of the District Inspector of Mine.

The mine manager should be required to submit to the inspector a formal proposal to seal an area of the mine and this should include:

- a complete specification for the seals proposed
- a risk assessment of the potential hazards introduced by sealing or not sealing the area
- the gas monitoring system
- a management plan for the sealing operation

Persons should not be allowed to remain in or enter a mine following a sealing without the manager first having obtained the written consent of the District Inspector of Mines.

In framing its recommendations the Inquiry took careful note of and received encouragement from various reported undertakings of the Minister for Minerals and Energy to fully implement, so soon as practicable, the recommendations of the Inquiry.

Our project will attempt to solve many of the issues identified in the above recommendation.

Problem solving is rarely easy and when one looks at the above recommendation, some will declare that we don't really have a problem, we have been sealing panels for many years without inciden;, while others will seek a quick solution, without any real analysis of the problem. Both reactions are flawed and are not consistent with an important finding of this Inquiry, which identified a clear need for fundamental and permanent change in our approach and attitude to a wide range of problems in our industry.

For this project we have attempted to clearly define the problem we wish to resolve, to identify and collect relevant facts and to analyse the information carefully before selecting a course of action.

SEALING OF A PANEL

The sealing, of abandoned workings in longwall and bord and pillar mines, is an activity that has for many years been taken for granted. We have generally recognised and accepted the fact, that any sealed area, with methane as the predominant seam gas, has the potential to explode and that such sealed areas, will sooner or later, enter and pass through the explosive range.

For mines with a high methane desorption rate and for a high make of other inert gases, the atmosphere in the sealed area may not pass through the explosive range or it may pass through very quickly and the risk may not be great. However, if the make of flammable gas is lower, or the area to be sealed is large and contains many voids, then the potential for an explosive mixture to develop somewhere in the goaf is very high.

Two elements of the Fire Triangle are complete and we have to gamble on:

(a) The oxygen content dropping below 12 percent; before
(b) Flammable gas levels exceed 5 percent; and
(c) That there is no heating or other potential ignition source in the goaf.

The normal practice is to allow the sealed area to self inert; i.e. to erect the seals and allow the desorbed seam gas to replace the atmospheric oxygen over time.

EXAMPLE OF SELF INERTISATION

Total void m^3	420 000	
Seam gas make m^3/day	17 000	
Days to reduce oxygen to 12%	14	
Methane make @ 2.7 m^3/min	3 900	m^3/day
Time to reach explosive range (5%)	4	days
Days in explosive range	10	days

We have therefore under normal operating conditions, taken a stable atmosphere and created an unstable or hazardous state. This is fundamentally wrong, and not in accordance with any safety management principle or our obligation under Duty of Care.

We now have the situation where an Inquiry has recommended that persons should not be allowed to enter or remain in a mine without the written consent of the Inspector of Mines and the Unions have enforced a resolution whereby their members will not enter or remain in a mine in which a panel has been sealed, until they are satisfied that it has passed safely through the explosive range.

The above decisions will no doubt ensure the safety of the miners. However, we should not under-estimate the commercial impact of this action. For mines with a high methane desorption rate and/or a high make of other inert gasses, the sealed area may not pass through the explosive range, or it may pass through very quickly and the impact of clearing the mine may not be great. In mines where there are large voids and the make of gas is much lower, the impact of clearing the mine could be very serious.

The fact remains, the atmosphere in the goaf may in many cases, be potentially explosive and the strength of the seals may be inadequate, therefore a serious potential hazard exists. For this reason alone, we should focus on eliminating the hazard by preventing the atmosphere from passing through the explosive range by effectively inerting the goaf by external methods.

ASSISTED INERTISATION

The basic technology is available and our calculations indicate that a Tomlinson Boiler Inert Gas Generator can effectively inert a standing goaf and prevent the atmosphere from reaching or passing through the explosive range and thereby eliminate this potential hazard.

Worked Example

	Self Inertisation	Assisted Inertisation
Total Void m^3	420 000	420 000
Seam gas make m^3/day	17 000	17 000
Assisted inertisation m^3/day		43 000
Days to Reduce O_2 to 12%	14	5
Methane make @ 2.7 m^3/min	3 900	3 900
Day to reach explosive range	4	nil
Days in explosive range	10	nil

This example assumes that there is no nett increase in the volume of gas in the goaf and that a reasonable allowance has been made for leakage and inefficient mixing of the various constituents.

The Tomlinson Boiler Inert Gas Generator burns diesel fuel to produce about 1 800 cubic metres of carbon dioxide rich exhaust gas, which is cooled and compressed prior to delivery via bore hole and pipe line, to the goaf. A typical analysis of the gas produced is as follows:

Oxygen	< 2.0%
Carbon Monoxide	2 ppm
Carbon Dioxide	13.5%
Nitrogen	balance

The temperature of the inert gas may be regulated and consistently delivered at any required range between 150 and 45 degrees Celsius and this may have a beneficial effect on the mixing of the atmosphere in the goaf.

We believe that a major benefit may be the ability of this unit to effectively inertise a sealed area, from a remote location on the surface. A potential hazard will be eliminated and business interruption will be minimised.

SEALED AREAS AND SPONTANEOUS COMBUSTION

Should we have to seal a panel with a known heating or a panel in a seam with a high propensity to spontaneous combustion, then the risk of explosion is much greater. If we adopt the SIMTARS, Gas Awareness Course, basic philosophy that:

> "All coals will spontaneously combust if the conditions favour it. There is no such thing as a non spontaneously combustible coal."

Then we must assume that the potential for a heating is ever present. It is generally agreed that effective monitoring of the mine atmosphere is critical if we are to identify the very early stages of oxidation and take appropriate action before spontaneous combustion and open flame develops.

When coal at ambient temperature oxidises and heat is generated, various gasses are produced or evolve. This process has been known for many years and many hundreds of papers and millions of dollars has been spent on research into this complex subject. Despite this vast research and the development of sophisticated monitoring systems and instruments, this industry has had little success in the early identification of low level oxidation or accelerated oxidation of coal.

The development of spontaneous combustion is generally depicted by Fig. 1. And this industry has generally agreed that the basic tell tale signs of a heating are in accordance with the findings of Graham, Chamberlain, Hall and Thirlaway. Why then, have we not been able to detect or recognise these early warning signs?

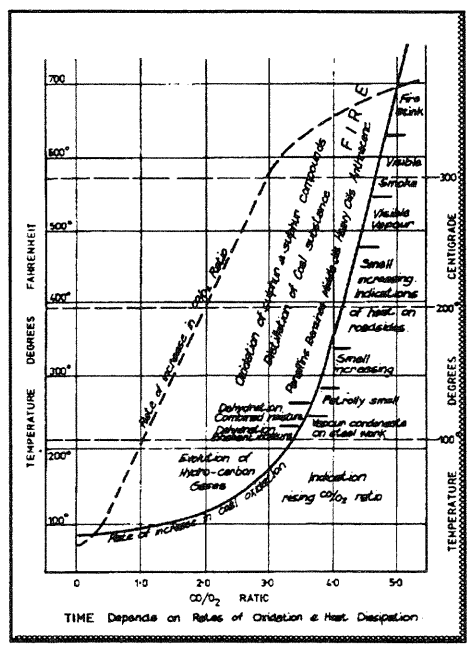

Figure 1

In almost every reported case of spontaneous combustion, the first real indication has been the presence of smoke in a roadway or at best, a strong smell and visible heat or smoke haze. When we examine all available data on spontaneous combustion events at:

Box Flat	Disaster	1972
Laleham		1975
Kianga	Disaster	1975
Leichhardt		1981
Laleham		1982
Moura No 2		1986

We find that in every case, the first indication was a moderate to strong smell and smoke and within hours the mine exploded and lives were lost, or the place was sealed and serious business interruption followed.

In the Leichhardt Colliery event, mines rescue teams effectively dealt with the fire, however the mine was closed.

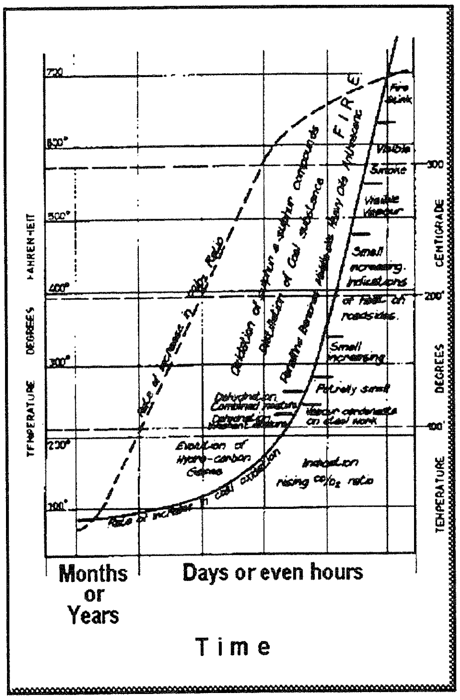

Figure 2

Past history would strongly suggest that present practice has failed to detect abnormal increases in the oxidation process until it is too late. Experience in the Bowen Basis would strongly suggest that the progress of a spontaneous combustion event may be as shown in Figure 2.

There is ample evidence in the events listed above, which would strongly suggest that the oxidisation process has developed undetected until a critical point in the temperature curve was reached and then the progress of the heating was extremely rapid.

Evidence to support this belief is very limited, however an interpretation of mine monitor results for the Moura No 2 1985 event, caused the author to adopt a carbon monoxide make Trigger Point of 7 litres per minute, at Cook Colliery in 1989.

What is clear from past events is that there is no apparent consistency in:

- Inspection and testing methods and techniques
- The methods used to interpret the results of monitoring and analysis
- The quality and type of information collected.

It is therefore very difficult to compare the data collected from one event to another and identify any one ratio or other indicator which has consistently provided an early warning of the heating.

One common denominator in the failure to detect the early stages of accelerated oxidation, is the sampling process and this more than any other has been largely neglected in most of the research done to date.

Do we really believe that all of the deputies and other statutory officials charged with the responsibilities of care, have failed to carry out their duties in a thorough manner, or that they are guilty of neglect, carelessness or complacency.

Most of these people do a thorough job and more importantly they do the job in the manner in which they were trained.

All of us who have held such positions, have been trained and in many instances required by law, to test for flammable and noxious gas in the "General Body" and many thousands of determinations are made every day in the General Body and the atmosphere is declared safe.

Experiments at Cook Colliery indicate that the General Body is not always the most suitable location to detect abnormal gas makes. A detailed examination with a smoke tube adjacent to a goaf edge has identified a number of distinct air flows.

These air streams contained various levels of gas, were of different temperature and density and could be clearly identified until they joined the main air current where they are diluted many times and could not be detected.

Given the history of undesired events in the past, we are not satisfied that our current approach to sampling, testing and monitoring, delivers the quality information necessary to ensure safety. Firstly, we need to understand the behaviour of the atmosphere in a goaf prior to, during and after sealing and develop standard sampling, testing and monitoring protocols which will deliver quality information.

PANEL SEALING MANAGEMENT PLAN

The Moura No 2 Inquiry found that the sealing of an area in a gassy mine should never be considered a routine or trivial event and it identified a need for a management plan for the entire sealing operation. There are many references to seals and sealing operations in readily available literature, however there are no standard procedures or guidelines based on a detailed risk/hazard analysis and consistent with Quality Assurance Standards.

In the first instance, we need to develop a Safety Management Plan which will provide:

- A template for the identification of the generic potential hazards associated with the sealing process
- Barriers and controls which will minimise the risk associated with those potential hazards
- Safe Work Procedures which will facilitate management, control and audit functions
- A high level of confidence that an area may be sealed without exposing the mine and the workforce to unknown risks.

CONCLUSION

With your assistance, this project the Sealing, Monitoring and Low Flow Inertisation of a Goaf, will provide quality information and Safety Management Systems which will:

- Satisfy the basic principles of Duty of Care
- Be cost effective
- Limit business interruption
- Above all protect life

We accept and we ask you, the stakeholders in our industry, to accept that there is a need for a fundamental change in our approach and attitude to the sealing, monitoring and elimination of the potential explosion hazard associated with sealed areas.

We believe that there must be a better way, we are committed to finding the solution to this challenge, however without your commitment, this project will fail.

REFERENCES

SIMTARS 1995 Gas Awareness Course Notes

JONES, Howard, Spontaneous Combustion in Underground Coal Mines.