2003

Hazard Management in Longwall Installations

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KEYNOTE ADDRESS

HAZARD MANAGEMENT IN LONGWALL INSTALLATIONS

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INTRODUCTION

From its beginnings in the mid 1960's, longwall mining has become the mainstay of the current underground coal mining industry in Australia. In addition and contrary to the variances in legislation applying to mines operating in Queensland and New South Wales, the underground coal reserves in both states exhibit the same hazards.

Words in mining legislation may differ from state to state, however the intent has a common theme - management of the safety and health hazards in the workplace.

All longwall mines share three basic features, they all involve the employment of people, they use similar types of machinery and extract coal from seams, which were deposited many millions of years ago. The purpose of this presentation is to briefly review some of the background matters surrounding the current mines and then identify a number of the hazards associated with each of these features. Finally, some comments are offered for the purpose of identifying some areas of opportunity to eliminate or better control hazards in the future.

Longwall mining should be the safest method of mining due to systematic process with high levels of engineering. The fact that injuries continue to occur is evidence that there is room to improve the level of risk control applied at a mine.

QUEENSLAND UNDERGROUND COAL MINES

BACKGROUND

The first longwall in Queensland started at German Creek Central mine in 1986. Since then more mines have opened up in the Bowen Basin in order to extract the rich coking coals

Queensland currently has twelve underground coal mines, ten of which operate longwall machinery, one is being developed to operate longwall machinery and the other was a longwall mine but is now only using continuous mining machinery. The longwall mines produce approximately 38 million tonnes of saleable coal, most of which is for the lucrative coking coal export market.

COAL RESOURCE

Generally the geological conditions are favourable to high extraction rates with thick seams at gradients generally below one in ten. Seam thickness varies from 1.8 metres up to 7 metres. The working heights varying between 1.8 metres and 4.8 metres.

The presence of faults, dykes, and seam rolls is not uncommon with mines in New South Wales although the presence of low angle faulting and shear zones appear to be more prevalent in Queensland.

Roof strata generally varies from a strong sandstone to a weak banded mudstone. None of the coal seams mined in Queensland have the strong conglomerate roof strata found in several mines around Newcastle.

Bowen Basin coal seams generally contain high levels of seam gas, the predominant gas being methane. It is not uncommon for mines to report figures ~~of~~ in excess of ten cubic metres of gas per tonne of coal. Methane gas outbursts have occurred at several mines during the past thirty years.

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Carbon Dioxide gas is present in some Queensland mines and high levels of hydrogen sulphide gas have been found in relatively isolated areas of a few mines.

Several coal seams are prone to spontaneous combustion and have been identified as the cause of most of the notable disasters in the recent history of underground mines in Queensland.

ENVIRONMENT

Heat stress is a matter of concern at several large underground mines. With a high ambient temperature in a tropical climate, the additional heat from large diesel engines and electric motors combine to test the limits of normal physical endurance.

Very few of the current mines in Queensland have significant problems with surface subsidence, and none have any residential areas to consider with. Subsidence of broad acre farms, country roads and electrical transmission towers constitute the main area of concern.

Several mines have extensive gas draining installations all of which vent the methane to the atmosphere with the exception of one mine which flares the gas. Gas drainage is done by either inseam drilling techniques or surface boreholes and goaf drainage from the surface.

WORKFORCE

The twelve operating underground coal mines in Queensland employ around 2500 mine workers plus contractors.

Most mines are located in the order of three hundred kilometres distance from the coastal areas. In the early stages of development in the Bowen Basin mines, small mining towns were developed to domicile the workforce and their families. Since then attitudes of society have changed and an increasing proportion of the workforce choose to locate their families in the coastal towns of Mackay and Rockhampton (Yeppoon). The mineworker then has to travel in order to leave the family in a location where there is access to higher education and more extensive medical services.

With both the direct and indirect employment opportunities in the mining towns being comparatively limited, the incentive to live on the coast is further enhanced.

Upon retirement, very few mineworkers choose to stay in the mining towns resulting in the community having very few senior members. As a result, a mine also looses much of its corporate memory resulting in many of the lessons of the past being re-learnt by adverse experiences.

Recognised training organisations are a major training resource used on the Queensland mines due to the distance that regional higher education centres are from the mining townships. To date the achievement of a consistent and satisfactory level of training and assessment standards has proven elusive.

HAZARDS IDENTIFIED AT MINES

All mines in Queensland are required to develop and implement a mine safety management system that addresses each of the safety and health hazards at the mine. Hazards with the potential to cause multiple fatalities are required to have Principle Hazard Management Plans.

The following hazards have been identified during either investigations of incidents or the conduct of mine emergency exercises:

Frictional ignition

Several events have been recorded during the past ten years. The events have occurred during both bi-directional and uni-directional operation of the shearer. Ignition is associated with sandstone roof or floor strata with a high quartz content, metamorphic intrusions with a high quartz content or hard pyritic nodules. Cutter pick management on the shearer drums and back flushing sprays have reduced the frequency of incidents but have not been totally successful. One mine is currently using the latest design in ventilated shearer drums in an effort to reduce the risk of ignition to as low as reasonably possible levels.

Strata failure

Weak roof strata, high coal ribs, joint planes parallel to the roadway, low angle shear zones and high and low stress areas continue to present uncontrolled risks to mine workers.

Injuries have ranged from fatalities to loss of movement in the limbs. Rib failure is the most common of the strata failure events and is often associated with less strata movement noise than roof movement events. Hydraulic powered face sprags fitted to the roof supports significantly reduce the risk level to persons conducting repairs and maintenance on the shearer, however their design is unable to prevent all uncontrolled coal falls along the working face.

Meshing of ribs in access roadways provides a high degree of security, however to date it has not been widely done on a consistent basis similar to roof strata support.

There appears to be a perception at all levels in the workforce that the risk from rib falls is lower than for roof falls and therefore the additional and immediate support is not warranted. This perception must change.

Gas outburst

Gas outbursts are not a common event in Queensland mines with only one being reported on a longwall face and one in a development heading during recent years.

In that instance, gas drainage had been conducted in the development heading but was ineffective due to the surrounding disturbed strata blocking the drainage holes.

With mines continuing to extract the deeper coal reserves, the risk of outbursts is increasing.

Spontaneous combustion

Spontaneous combustion is a hazard that is potentially present in most mines. Whilst statistically it might occur on an infrequent basis, it has been the cause of several mine disasters and the loss of a full longwall face at one of the mines. Several other mines have recorded high levels of carbon monoxide gas in the longwall goaf area, which has resulted in the withdrawal of the workforce from the mine.

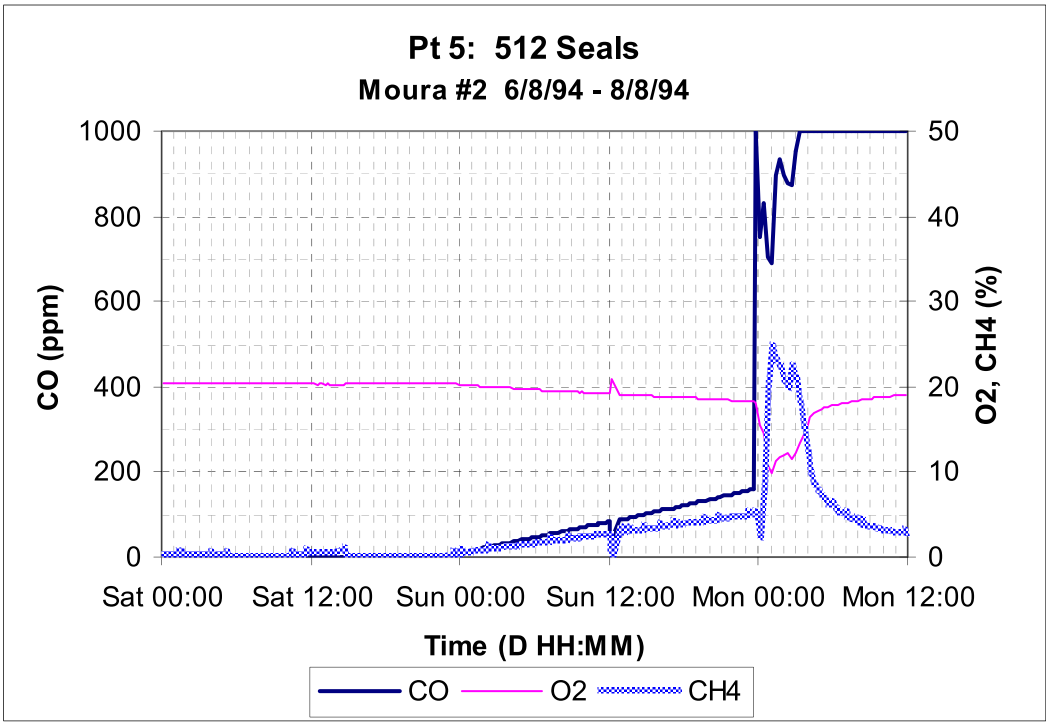
All mines conduct the standard R70 test, however experience at mines would suggest that the test should only be used as an indicator. It is imperative that every mine has a calibrated gas monitoring system and surveillance by competent persons in areas where evidence of spontaneous combustion may be found. Different seams have different characteristics that need to be identified. Text book indicators such as carbon monoxide make in litres per minute, are very dependent upon the seam characteristics, method of working and method of ventilation.

Spontaneous combustion is recorded as the cause of the disasters at Box Flat, Kianga and Moura No 2 which occurred in 1994, the latter incident had a profound effect on mining legislation in Queensland. It is of value to review the gas monitoring results of the 512 panel in Moura No 2 covering from when the panel was sealed until after the second explosion. (See Graph No1 and Graph No 2 in Figure 1).

Mining Engineering students will find the gas monitoring graphs of particular interest. These graphs were taken from the Simtars report into the 1994 Moura No 2 incident and is arguably the best gas monitoring record of any coal mine explosion in the history of coal mining in Australia. The graph demonstrates that technology can be an important aid to controlling hazards but cannot guarantee that there is no residual risk of significant proportions.

As can be seen from both graphs that the atmosphere, after the first explosion, has high levels of methane gas and low oxygen. The methane is believed to have come from old sealed areas where the seals had been demolished. The high levels of methane prevented mines rescue attempts and also played a major part in dropping the oxygen levels to levels where persons without self contained breathing apparatus could not escape. This data was vital in the developing the logic behind the new regulations for the strength of seals and the need for oxygen self-rescuers.

Graph No 1



Graph No 2

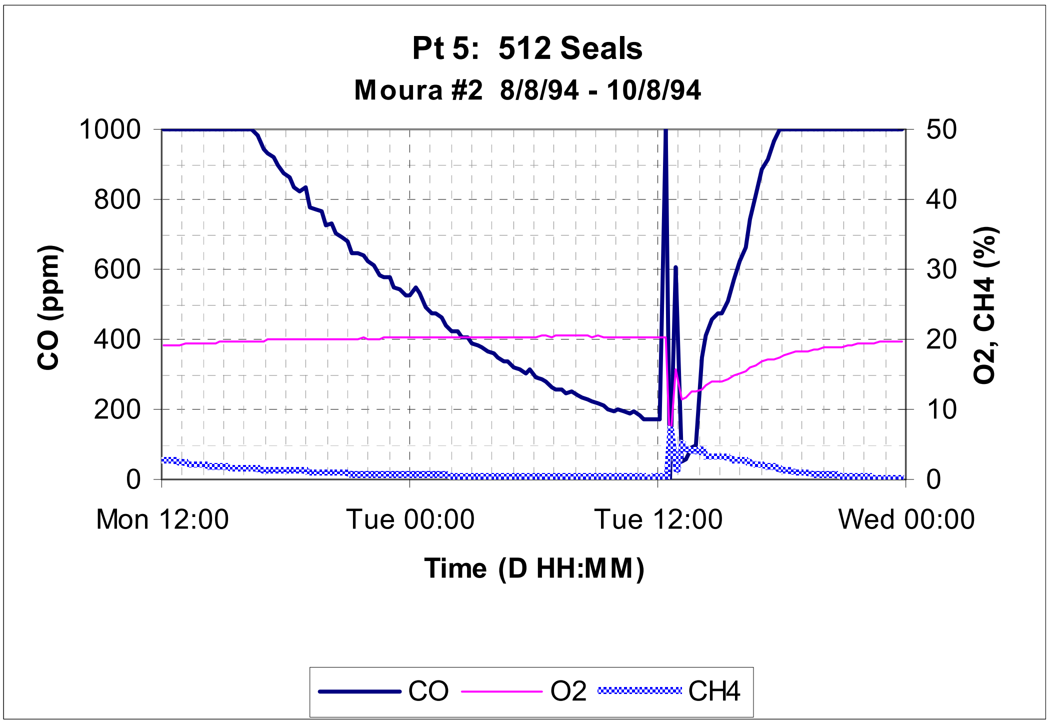


FIG. 1 - Graphs of gas monitoring at Moura No 2

The panel was being monitored using tube bundle gas monitoring equipment, which was calibrated during the 24-hour period after sealing. The trend graph clearly shows that the oxygen levels were decreasing at a consistent rate whilst at the same time methane and carbon monoxide were increasing at a consistent steady rate. The graph demonstrates that monitoring alone will not necessarily prove the existence of a spontaneous heating.

Stored energy

The risk of stored energy in the water emulsion hydraulics system is well known. Fortunately the occurrences of fine oil sprays injecting into mineworkers is rare but not unknown. Penetration of hydraulic fluids into the human body can have serious health consequences. It should not happen however controls remain a matter of training, close observation and maintenance management.

Respirable dust

Respirable dust was recognised as a health hazard by Agricola circa 1550. It took 400 years to develop systems that were effective in measuring and controlling the risk of pneumoconiosis in coal mines. Regulation controls are in place to limit the exposure of persons to less than 3 milligrams per cubic metre. Routine dust monitoring has identified that modern high output longwalls are finding it increasingly difficult to meet the regulatory standard, particularly when production levels in excess of 4000 tonnes per shift are mined. Reliance on personal protective equipment is not a satisfactory long-term solution and the matter is currently being targeted by the inspectorate.

Roadway dust

Modern shearers do create large volumes of respirable and roadway dust. Current regulations require the return airways within 200 metres of a longwall face to be maintained at 85 % incombustible dust levels. Achieving this level is very challenging for mine operators. Current practice still revolves around the use of stonedust during the production cycle. To date no longwall installations have utilised large capacity dust-scrubbing fans in the return airway or alternative dust inhibitors.

High voltage electrical power

The energy requirements to operate a modern longwall face continue to increase with substations now being installed up to 6.5 MVA. In order to transmit the required energy levels to the shearer and maintain a cable with manageable dimensions, the voltages have now risen to 3.3Kv. Issues of concern include:

- Fault levels and control apparatus have been found to exceed the available technology giving rise to open sparking events.
- Electrical maintenance is critical to the ongoing safety and the ability to service the control apparatus requires the employment of specially trained mine electrical personnel.
- Transient over voltages that cause flashovers in switchgear.
- Uncontrolled movement of remote controlled equipment.
- Capacity of flameproof enclosures to contain high power electrical arc faults.

Heat stress

Mining in areas where the ambient temperature of the surface contributes to the high underground temperatures means that the addition of diesel vehicles and wet roadways pushes the effective temperature to the limits allowed by regulation. Predictably, summer is the most problematic period.

One central Queensland coal mine has adopted metalliferous mining technology and has installed two large air-conditioning plants to cool the intake airways. The installations have a combined cooling capacity of 3.6 MW resulting in the underground temperature falling by and average of 3 C^{o} for an airflow of 196 cubic metres per second.

Air conditioning plants commonly use water evaporation to assist in the cooling process. Legionnaire's Disease has been identified as a possible hazard for staff working around the air-conditioning plant.

Where heat stress is a possible risk, the medical support systems at the mine need to be able to cope with heat illness. This includes training of first aid personnel at the mine and awareness of heat illness for mineworkers who need to be able to self-monitor for symptoms.

Musculoskeletal injury

Musculoskeletal injuries are the most common injury occurring in mines. Longwall installations have their own unique risks as well as those commonly found in mines such as wet boggy and uneven floors. There is a need for improved ergonomic design. Injuries have been recorded as a result of:

- heavy spare parts being manoeuvred in a confined spaces.
- walking along the face line operating machinery where the working height is limited by the chocks. Head and neck injuries are a high risk.

One of the newest longwall installations in Queensland extracts a 1.8 metre thick seam. The large chocks make access very difficult for persons who are unaccustomed to the working conditions. The mine has installed a special chair to assist workers stretch their back for some relief during the shift. Fitness conditioning of plant operators is a matter that requires careful monitoring.

The long term health effects of working in this type of environment for twelve-hour shifts is not known and will be a matter for future research.

Emergency rescue and escape

Queensland conducts an annual "Level 1" emergency exercise in which the mine is tested in its ability to respond to an emergency. The exercises are very realistic and tailored to possible events at the mine. Hazards identified by these exercises include:

- difficulty in extracting seriously injured persons along the chock line
- difficulty in accessing the return airway due to the end chocks being designed to eliminate goaf material rilling into the walkway area
- extreme difficulty in recovering injured persons from a longwall face should the intake airway be blocked by an impassable fall of roof and the only access is the return airway. Return airways are often several kilometres in length, a distance that a rescue team could not possibly carry an injured person
- roof falls in the intake airway have the potential to reduce airflow, increase the temperature and goaf gas contaminants in the airstream

Punch mining has potential to reduce some of the hazards and is being strongly considered a several sites. One mine, which operated a punch mine from an old open cut excavation recently advanced the face close to the high wall of the open cut, withdrew the underground workforce and removed the chocks by open cut methods.

Atmospheric gas contaminants

Contamination of the atmosphere in a longwall recovery face using large diesel machinery to move the equipment, has been found to be a problem because high levels of carbon dioxide and nitrous fumes can be present. Auxiliary ventilation and /or the use of large electrically powered prime movers are often used with success.

Noise

Hearing loss is a major compensation cost to the industry. Noise levels on longwalls commonly exceed 85 decibels and require the use of hearing protection.

Inrush

Problems experienced in this area have generally been associated with extracting panels under open cut voids which were filled with water. The events have been avoidable and fortunately no persons have been seriously injuries as a result of these events.

FUTURE

Longwall face installations continue to improve in design and productive capacity. Not all faces have each of the hazards identified above, however all working faces have many of the identified hazards present.
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There can be no argument that further research is required to assist mining engineers develop high order controls for the many hazards that exist in a mine environment. The controls will need the assistance of modern technology and infrastructure and should reduce the dependence upon persons and training.

All longwall faces have high levels of automation yet still have operators walking up and down the face with each shear. The High Wall Mining equipment used in open cut mines can be remotely operated without a person going underground. There is no technical reason why shearers and chocks cannot be reliably operated without the need for the operator to walk with the shearer on every shear.

The levels of dust and noise in the working environment demand that operators wear personal protective equipment whilst ever production activities take place. This is another reason to introduce remote control from a place of safety where noise and dust can be better controlled .

Machines need maintenance on a very regular basis, reliability factors need to be improved to levels where maintenance is only required every several hundreds of hours of operation.

Shearer drums create large amounts of potentially explosive dust. To reduce this there is a potential to use old technologies such as a plough, trepanner or other technology such as hydraulic picks that do not break the coal into such small pieces in the high velocity air currents ventilating the working faces.

Frictional ignitions of methane gas continue to occur. Pre-drainage of the gas has reduced the risk of a major explosion, but it has not eliminated the risk with high levels of methane gas often found in the goaf area. Although no ignitions of goaf gas has occurred in Australian mines, there was an ignition of methane gas in a longwall goaf of a South African coal mine in 1997.

"Necessity is the mother of invention" and what we need is some inventors to think outside the box and systematically develop high order controls for each of the hazards identified. Conferences such as these are the ideal venue to challenge the traditional thinking and improve tomorrow's mining industry.

It is past time that quantum improvements in our risk management procedures were made and high order controls were available for each and every hazard associated with longwall mining.

I wish you well in that quest and encourage everyone at this conference to share their collective knowledge and experience and work together toward a safe industry where occupational health is not at risk.