NEWLANDS UNDERGROUND SPONTANEOUS COMBUSTION MONITORING AND MANAGEMENT

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Newlands Coal

INTRODUCTION

Newlands Underground is a recently commissioned longwall mine extracting steaming coal from the Upper Newlands seam a member of the Rangal coal measures. The seam is of Permian age (around 200million years old) and is classed as Bituminous – High volatile and has the following characteristics.

Inherent Moisture Content: 2.7%

Carbon Content: 57.5%

Volatile Content: 25.8%

Energy Value: 28.46MJ/kg

Use: Steam raising

The seam varies in thickness from 6 to 7 metres consisting of 6 plies A through F. A ply being located on the floor, F in the roof, mining takes place in plies A to E pyrite and chalcopyrite are present in some areas of the upper plies in a finely disseminated state.

The predominant seam gas in the upper Newlands seam has been identified as methane in concentrations of above 95% small amounts of Carbon dioxide 0.5%, Hydrogen, Hydrogen Sulphide and Ethane (less than 5ppm) have also been identified.

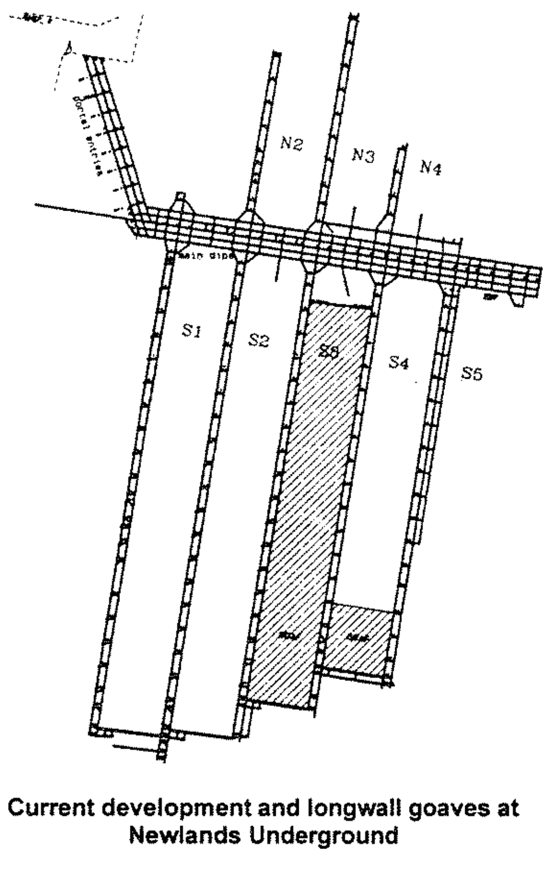
MINING

Longwall equipment consists of one hundred and forty seven, twenty six tonne chocks supporting a face of 250m the shearer cuts at a height of 4.2m, development roadways are cut at a width and height of 5.2 and 3.6 metres respectively. Longwall mining depths are currently in the vicinity of 150 to 170 metres with up to 2.5 metres of subsidence observed on the surface.

The mine is ventilated via a 5.2 metre diameter upcast shaft, on the surface two axial flow fans draw 260 cubic metres of air at a collar pressure of 850pascals giving a maximum pressure differential across the line of pillars at the shaft bottom of 700Pascals.

Panel ventilation is achieved using 18 cubic metre auxiliary fans. Returns flanking the main dips deliver this air to the shaft via overcasts.

Longwall ventilation is a simple U system with 50 cubic metres per second on the face and 15 to 20 cubic metres continuing inbye past the goaf seals and returning across the next longwall face. The pressure drop across the face has been measured at 60 Pascals from maingate to tailgate. This low pressure loss is possible mainly due to the large cutting height and relative good face conditions. Measurements of wet and dry bulb temperatures from the tailgate goaf stream and other parts of the mine show humidity levels of close to 100% at 30° Celsius in the hotter months winter has seen this level reduce to around 80% at 27°

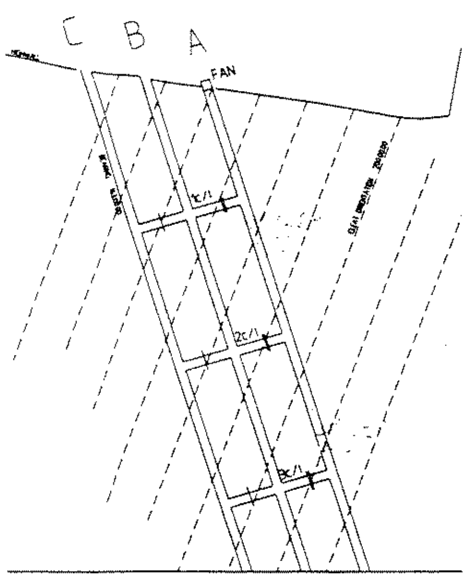


Current development and longwall goaves at Newlands Underground

GENERAL

Early tests on the Upper Newlands seam classified it as having a 'moderate to high propensity' for spontaneous combustion and a higher than average reactivity. With the occurrence of several small heatings near the portal entries occurring in April/May of 1998 prior to longwall mining commencement Newlands now classes the seam as having a high propensity. These heating events came about due to the following factors

1. A sustained pressure differential of 400Pa across coal pillars that contained a large amount of open fractures
2. Air migration through the afore mentioned fractures.
3. High ventilation quantities concealing any products of the heating from monitoring devices located outbye.



Location of heatings showing portal entries, cleat direction and old fan location

Upon finding the first heating several actions were taken these actions and their consequences were the initial prompts towards compiling a more comprehensive management and inspection system to the one in use at the time.

In short the heatings were contained upon there discovery by utilising water injection for the initial stabilisation of coal temperatures and to give time for a plan of action to be formulated and the required personnel and equipment to be sourced to treat the problem.

The resulting actions included injection of both silicate resin and strata seal products. Injection varied in depth and direction in relation to the cleat direction for maximum results. The injection process and the immediate results obtained illustrated the need for other areas of the mine that would be subject to high pressure differentials to be looked at closely and treated.

In addition information gathered by deputies of temperature monitoring of roof and rib surfaces along with in seam measurements showed that a surface temperature of 30 to 35 degrees was an indicator of higher heat below the surface. Found to be up to 300 degrees in some cases. This 30 degree trigger was to become a valuable tool for the identification of further hot spots. Atmospheric monitoring, including minigas readings and bag samples also illustrated the need for a more formalised system to be put in place including temperature monitoring and atmospheric analysis. Incorporating the afore mentioned into a regular monitoring and inspection regime would not only minimise the likelihood of a spontaneous combustion event developing undetected but also build a background database for future reference.

MAIN CONTROLS

Procedures

Procedures have been developed at Newlands Underground to record specific information and control activities relating to spontaneous combustion from ventilation and environmental monitoring through to Deputies inspections and reporting systems. These have been designed specifically for the purpose of having detailed records, simulations and reports of all events effecting the likelihood of spontaneous combustion. Should any abnormal activity occur conclusions could be drawn and effective action be taken ensuring the safety of men, equipment and the future of the mine. The main controls developed and implemented under the manager's scheme included the following.

- Ventilation Control Device Construction Permits and Inspections regimes
- Spontaneous combustion status notice board
- Environmental Monitoring
- Coal surface temperature scans using probeye infra red camera

- Inertisation

VENTILATION CONTROL DEVICE PERMIT PROCEDURE

The Ventilation Control Device Permit Procedure applies to all seals, stoppings, regulators, overcasts, doors or appliances that will have a life of greater than twelve months or a pressure differential of greater than 300pa placed across them, seals being the only exception which automatically come under the permit process. The permit procedure was developed to maintain the ventilation control device standard.

The permit procedure is designed to be both a scope of work for the device's construction as well as containing detailed information on site geology, site preparation and the intended purpose of the device. The permit consists of two sections the first containing geological, ventilation and mining assessments of both the device to be built and the site conditions. The assessments of the inherent geological conditions present at the work site that may contribute to a spontaneous combustion event includes normally cleat direction and rib competency, the presence of faults or broken ground and pyrites. These structures are illustrated on a site plan that is included in the permit. Any recommendations as to the device construction or location within the site and any additional support requirements are outlined and the mine geologist then signs this assessment.

This is followed with a description by the Ventilation Officer as to the expected ventilating pressures across the device and the over pressure requirements ie35, 138 or 345Pa he may add any construction requirements he deems necessary and signs off of this section.

Finally an estimate of the geotechnical and mining stresses that will be placed on the structure in the future is made ie abutment loading and signed by a senior mining official. These three parts together make up the first section of the permit and will dictate the type and location of the device and any necessary rib or roof support to be installed.

The second section involves the contractor building the device, with both a Newlands and a contractor's representative signing off on the following stages of construction

1. Location of the device within the site
2. Completion of site preparation
3. Completion of device construction

Completed structures are subject to leakage tests and checks as to the compliance with all the criteria set out in section one of the permit before they have attached to them a verification plate, inspection board and site specific identification number. The site inspection board shows the device and the surrounding ribs and roof in both plan view and front elevation for inspection purposes. Once the device has been constructed to satisfaction of Newlands Underground and signed off the permit is then signed by the mine Manager and filed, should any problems occur in the future at the site a detailed record of its construction and the surrounding geological conditions is on hand.

INSPECTION OF VENTILATION CONTROL DEVICES

The core of the Newlands Inspection regime and TARP system is the process by which changes in the observed norm are highlighted and followed up. This is implemented through a specific sequence of events.

Combined with the Ventilation Control Device Permit procedure is a weekly inspection system of all ventilation control devices that are subject to a 300 Pascal pressure differential and all accessible seals. This inspection consists of a visual inspection for cracks in both the surrounding strata or the structure itself and leakage tests utilising smoke tubes, the surrounding ribs and roof are also inspected using an infra red thermometer for areas of increased temperature. Any changes are reported by exception. A spontaneous combustion status board is located in the muster area this board displays any TARP's currently enabled and the actions being taken and by whom. The board serves two purposes:-

- It notifies all personnel that a TARP has been activated
- It illustrates that controls and actions have been put in place to manage the situation on a shift by shift basis.

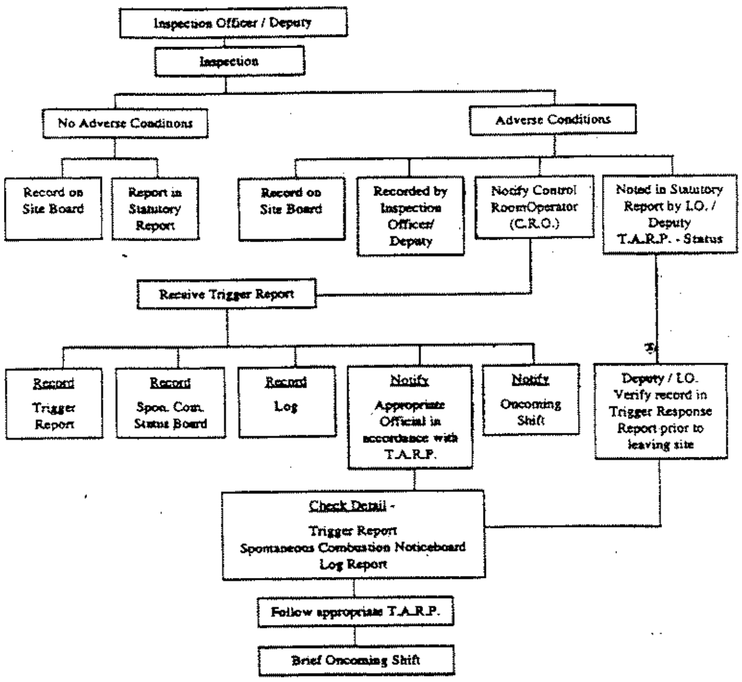
Example of Trigger event and follow up

Starting with the deputy or inspection officer noticing a change during an inspection this information is recorded by the deputy and noted on the inspection board located on the device along with relevant dates and times. This information is then passed on to the surface control room and from here the trigger is logged and then recorded on the spontaneous combustion status board located in the muster area, any officials required by the TARP to be informed are then notified. The reporting deputy on returning to the surface then completes a form identical to the inspection board located on the device itself and then signs the status board. Until he is relieved by the oncoming deputy/ undermanager he is responsible for the inspection and or monitoring required by the TARP. When he is relieved he briefs the oncoming official of the situation and signs over his responsibilities to that oncoming person through use of the spontaneous combustion status board and the trigger event log form. This person then continues with any actions required under the TARP or directions from the review committee.

At any one time the status board and the trigger log will show who initiated the response and who is currently responsible for any actions required under the TARP.

Following on the initiation of a TARP, committee meetings (including the Mine Manager, Ventilation Officer and Production/ Technical Superintendents) are held to review any current TARPs depending on the type and level of response activated these may take place every day. Minutes are taken and decisions made based on the information collected. This information and the required actions is then passed on to the control room and the deputies involved in the TARP. Only the review committee can remove a TARP from the spontaneous combustion status board and review and investigation.

Sequence of events for tarp initiation



MINE MONITORING

Two TARP's for spontaneous combustion in a longwall goaf are used at Newlands Underground and deal with (a) An 'Active' goaf and (b) A sealed goaf. The TARPs rely almost completely on trends developed from the atmospheric monitoring of the tailgate return for an active goaf or monitoring from behind seals in a sealed goaf. So it is here that any early signs of an abnormality in the goaf either active or sealed is first detected via the Newlands tube bundle system and gas chromatograph. In the event of a failure of the tube bundle system a further TARP directs the actions to be taken to monitor all areas of the mine via bag sample and chromatograph analysis.

The tube bundle system utilising infra red analysers to detect Carbon monoxide, Carbon Dioxide, Methane and Oxygen to high levels of accuracy through twenty monitoring sites underground. All panel returns are monitored along with the longwall goaves both active and sealed on a continuous rotation. Coupled with the Safegas analytical software, plots of Cowards triangle and Ellicots diagram along with Carbon monoxide make and Graham's ratio can be plotted for any sample location at any time. Trends of all the four gases can be plotted from the system incorporating a trace of any barometric fluctuations over large time frames.

A Quad gas chromatograph located in the surface control room is used to detect any of the higher hydrocarbons from the longwall goaf stream and general body as well as performing any parity checks on the infra red system or hand held gas detection devices. The chromatograph has also been utilised to analyse the products of combustion from the upper Newlands seam coal giving an insight into the make up of what produced when the Upper Newlands seam coal combusts.

LONGWALL MONITORING

Extensive monitoring of both the active and sealed goaves at Newlands Underground has been undertaken in order to gain a full insight into the goaf behaviour especially the activity immediately behind the working face. We will also monitor what happens immediately in front of the face in the previous goaf.

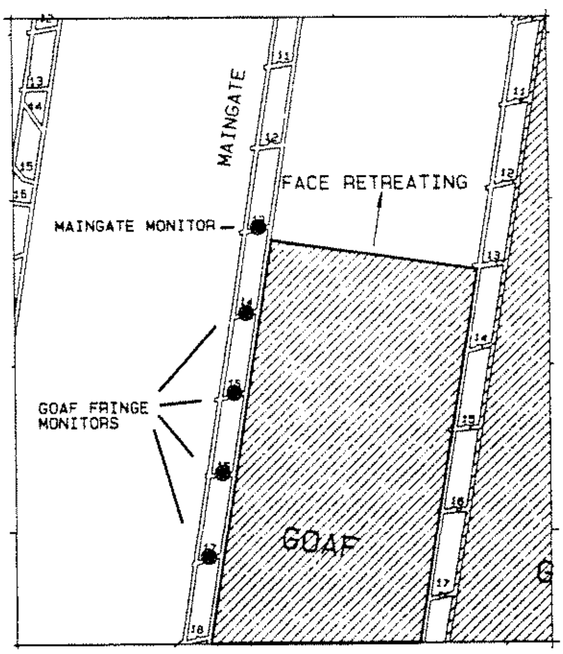
With no prior knowledge as to the behaviour of a longwall goaf at Newlands Underground a level one TARP trigger of seven litres a minute of Carbon Monoxide make from the longwall return was set based on information from other operational longwall mines in the Bowen Basin. This low trigger level was used as a set point at which any increase would be deemed as an indicator of an abnormality.

With a ventilating face quantity of between 40 to 50 cubic metres per second a seven litre per minute carbon monoxide make equates to a carbon monoxide level of just over 2.0 parts per million. Knowing this an accurate means of detection to these low levels was essential and achievable through the infra red analysers and chromatograph. A means of eliminating carbon monoxide make attributable to diesel equipment was necessary to avoid false alarms in times of high diesel activity eg longwall moves. To correctly identify the true longwall goaf gas make tube bundle monitoring points were arranged as follows.

Monitoring configuration on the Longwall maingate

To achieve effective monitoring of the air entering the longwall face and to be able to account for any abnormal readings due to contamination by diesel activity, a monitor was placed as close as possible to the maingate drive or in the closest outbye cut through. Monitoring points are put in place in the cut throughs inbye of the face area for four pillars (400 metres). This configuration was developed through knowledge gained in the monitoring of the first shortened longwall block where the area of goaf behind the face that had not moved into the fuel rich inert zone was observed to be within four hundred metres.

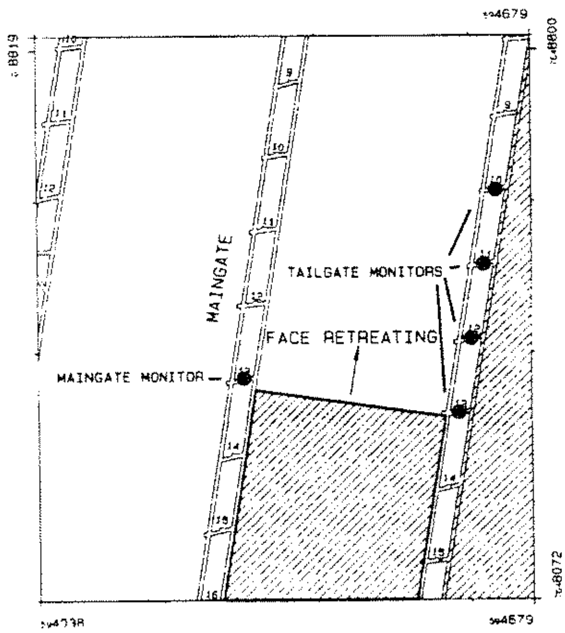
These monitoring points are leap frogged up to the next available cut through as the face retreats the tube bundle system records the change in the atmosphere behind the seals from fresh air through to a fuel rich inert mixture. One final monitor is in place inbye of the working face on the maingate side to monitor the composition of the airflow passing the longwall seals should one of the inbye seals leak any goaf gas escaping into the roadway (on a low barometer) should be detected at this point.



Position of maingate monitors in active goaf

Monitoring configuration on the Longwall tailgate

On the tailgate side monitoring via the tube bundle system will also take place in the sealed goaf adjacent to the block being extracted. The monitoring here will detect any changes in the sealed atmosphere due to a seal or chain pillar failure in the goaf that would possibly create an air path along the goaf fringe and conditions promoting spontaneous combustion. The area to be monitored will once again be four pillars in front of the retreating face. Finally in the tailgate a monitoring point is situated outbye in the return and records the total panel return air composition. It was found that monitoring points that were located further inbye towards the tailgate recorded fluctuating readings unsuitable for trending due to the insufficient mixing of the goaf gases over a short distance.



Position of tailgate monitors in sealed goaf

Bag sampling takes place at both the tailgate goaf stream and adjacent to the tube bundle monitoring site located outbye in the tailgate. From here samples are analysed both through infra red and chromatographic techniques. A cross check is made by an external consultant for auditing of trends and analysis.

The use of high accuracy equipment such as the Quad gas chromatograph has enabled Newlands to identify previously undetectable concentrations of gases. In the case of both Hydrogen and Ethane these gases have been detected in the raw seam gas in low concentrations. With this in mind the TARP's have been modified to reflect the fact that hydrogen and ethane will occur naturally in the tailgate goaf stream and are not necessarily a cause for immediate alarm. Sustained upward trending Hydrogen concentrations will on the other hand trigger a response.

INERTISATION

With the spontaneous combustion incidents already experienced prior to longwall mining and with the knowledge that up to 2.0m of coal from E and F ply would remain in the goaf after longwall retreat, a means of dealing with spontaneous combustion event in the goaf was needed. The method most importantly had to be readily available and operate with a minimum of infrastructure.

A pro-active approach was taken for the final sealing of Longwall block S4. A Tomlinson inert gas generator was utilised to deliver inert gas into the goaf prior to and immediately after final sealing commenced. The introduction of the inert gas performed two functions,

1. By pressurising the goaf the emission of methane from the surrounding strata and the goaf itself is retarded

2. The inert gas (comprising of 2.5% oxygen) diluted the percentage of oxygen present in the goaf, to below 12% within 24 hours and prevented the sealed area from going through the explosive range at the monitoring sites.

With this important tool in place, production was able to continue during the sealing and inertisation process. With this result and other successful trials Newlands Management has made a commitment to utilise the inert gas generator for all future longwall sealing activities and infrastructure to facilitate this is already in place.

Due to the small goaf size and the amount of monitoring points contained on both maingate and tailgate sides a large amount of data was obtained and was utilised in the planning and configuration of monitoring points in the current longwall block.

GENERAL OPERATION

The inert gas generator is situated on the surface with diesel fuel, power and water on site. The unit burns the diesel and delivers the product gas to the required locations underground via a cased borehole linked to a

150mm underground pipe range. This range can be linked into the existing 150mm compressed air range and service any part of the existing mine development.

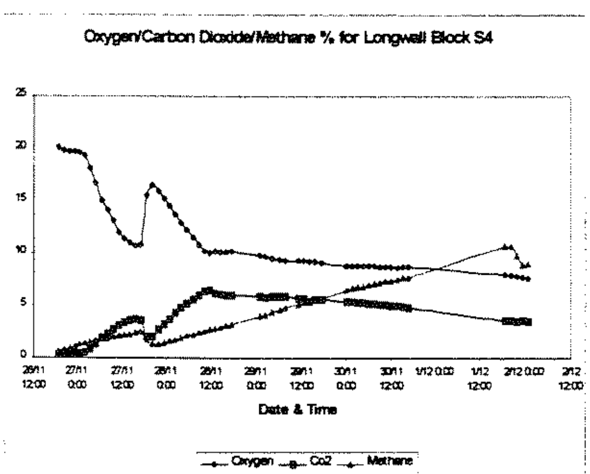
Newlands has recognised the potential for active spontaneous combustion to develop in goaf areas. Our spontaneous combustion management plan provides for the ability to deliver inert gas to any particular longwall seal. Each goaf seal is fitted with a 150mm pipe expressly for the purpose of receiving gas from the inert gas generator for final sealing, or, should a problem be identified at any other time. Monitoring points in the goaf seal's track the progress of the inert gas and on site pressure gauges measure the injection pressure being generated in the goaf. Pressures of over 500 Pascals were measured on the first inertisation.

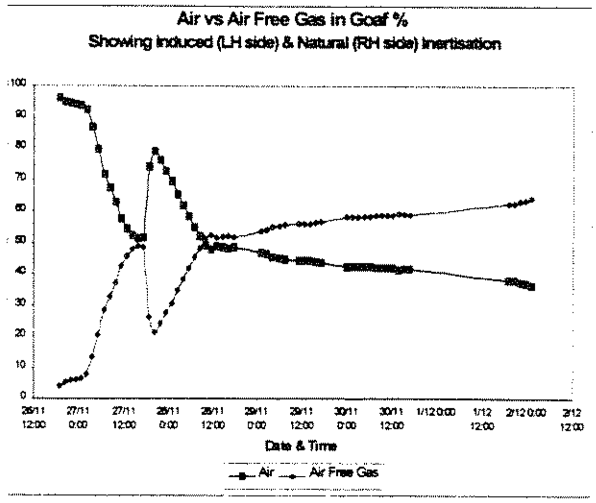
The generator produces typically the following gas:

- Oxygen 2.5%
- Carbon monoxide <15ppm
- Carbon dioxide 12.0%
- Nitrogen 85%%

The inert gas, after it is cooled, leaves the unit at around 20°C above ambient air temperature. On board sensors monitor the oxygen level of the gas being delivered instantaneously the range is also coupled to the tube bundle system for direct reporting to the control room. Shown below are the recorded effects of the boiler on the S4 goaf. The first shows the effects of the boiler on the major gases, oxygen, methane and carbon dioxide. The second plot is presented as air versus air free gas ie methane, carbon dioxide and nitrogen not attributable to the original air content.

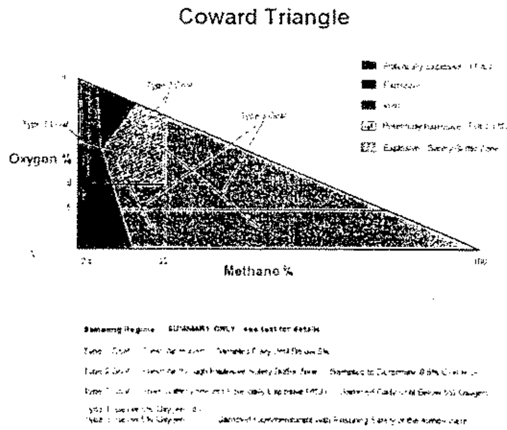
S4 goaf inertisation plots





The results of the S4 inertisation illustrate the effectiveness of the unit in bringing the goaf into a type 3 category in three and a half days.

Coward triangle showing goaf categorisations as per the standard for monitoring of sealed areas



In summary as with all procedures and monitoring techniques developed for spontaneous combustion every mine is different and conditions change within mines from panel to panel. Newlands Underground is by no means different, in built into the Newlands system are bench mark reviews and audits of all the major monitoring and procedural tools. In the previous twelve months all hazard management plans related to spontaneous combustion have been reviewed to simplify the document and include any improvements deemed appropriate. These reviews include underground employees, supervisors and outside consultants all of who deal with these tools on a day to day basis and whose input is essential if the process is to improve.

The documents and procedures must not only be able to achieve the major objectives but be workable documents on all levels. Through the input of all parties in its development and its relative success the workforce gains confidence in the fact that controls and equipment are in place to detect and deal with any abnormalities that may arise.