

SOME NEW DEVELOPMENTS IN MINE VENTILATION

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ABSTRACT

An overview will be given of some new developments in mine atmospheric monitoring and development of new simulation approaches. In particular three areas of new endeavour will be highlighted.

A new personal respirable dust monitor that gives realtime readings will be discussed. The unit is mounted within the miner's cap lamp and internally measures the true particle mass of dust collected on its filter. Samples are available for later mineralogical analysis and results do not exhibit the same sensitivity to water spray as optically based measurement approaches. The technique achieves microgram-level mass resolution even in the hostile mine environment and reports dust loading data on a continuous basis. The monitor is being adopted for statutory mine respirable dust determinations in the US and has particular application for determining high source locations and efficiency of engineering means of suppression and other approaches to handling the problem.

It has been recognised that the PDM's unique approach has application to allow real time atmospheric Diesel Particulate Matter (DPM) monitoring. The industry has no real time atmospheric DPM monitor at present. Recent surveys in NSW and Queensland continue to show significant numbers of miners continue to face full shift DPM exposures in excess of internationally accepted levels. Real time DPM monitoring will allow the industry to pin-point high exposure zones such as those encountered in coal longwall face moves, where a number of trucks, loaders, coal ram cars work or in areas of poor ventilation. Pinpointing of high DPM concentration zones will allow efficient modification of work practices to reduce underground miners exposure. The outcome of a currently funded ACARP project in this area will be discussed.

The use of the mine fire simulation computer program "Ventgraph" for modelling of fire scenarios in selected different mine layouts is discussed. Specifically an ACARP funded research project has been examining use and potential applications of mine atmosphere inertisation within the industry. The project has reviewed the variety of inertisation system available in Australia such as the GAG, Mine Shield, Tomlinson and Floxel approaches. Exercises will be discussed which involved "evaluation or auditing" of selected mines as to the ability to deliver inert gases to high priority underground fire locations in a number of mines.

INTRODUCTION

THE FUTURE

Mine ventilation is a critical aspect of all underground mines. Mining technological developments and mining environment challenges are necessitating new approaches. This paper examines three areas of new development.

Australian Metalliferous mines currently work in a vigorous and expanding sector. High prices and export demand are in the headlines. We are seeing increased production rates and emphasis on block caving, sub level caving and increasing numbers of open stopes in operations. There is still a ventilation need even with more remote loaders, tramming and possibly trucking. There appears to be a move away from large multi-purposes shafts with more and deeper declines. Belt transport is being used instead of shaft skips or decline trucking. The complexities of supplying high quantity and quality ventilation without major shaft infrastructure are a challenge.

There is an increasing number of smaller operations. These generally have a small plan section and progress to depth fast. Many face high heat load situations. They also face high diesel exhaust emissions at the same time. This combination is the big ventilation planning challenge.

The network in many modern mines changes daily as stopes break through. Maintaining an understanding of the ventilation network is a challenge. Improved use of real time monitoring and control may, in time, allow mines to optimise this situation.

The coal industry is also vigorous and expanding and driven by high prices and export demand. The push is unrelenting for increased production rates particularly from Longwall production. Faces quantities and velocities continue to increase in raised gas, dust and heat level environments.

Many of our mines face high seam gas levels in conjunction with high propensity to spontaneous combustion. There will continue to be better and more innovative approaches to gas drainage. Atmospheric inertisation was first introduced as a tool to fight fires. It is now accepted as a component of the production cycle in some mines.

Instrumentation developments are allowing improved realtime monitoring of ventilation parameters and particularly gases, respirable dust and airflow. Old worked out areas and goafs are becoming bigger. The issues they present are demanding thought and priority research. Understanding fires, simulation of fires and training the workforce will continue as a priority area.

Ventilation expenditure receives priority when it directly affects production. It is up to the ventilation practitioner to point out the real cost of the ventilation system to the overall mine capital and operating costs. Ventilation costs are not just fan electricity costs and ventilation control device budgets as some may see it. The layout of a mine is dictated by ventilation requirements. The provision of a pleasant and comfortable work environment returns

increased miner productivity.

Many of the new developments will be contributed to by research activities. The Australian Coal Association Research Program has been outstandingly successful in supporting focusing research efforts to productive industry benefit. The 5 cents per export tonne levy has been leveraged by additional co-sponsoring by operating companies, universities and others. Grants from this source carry prestige and it is hoped the real value of the program will continue. The Australian Minerals Industry Research Association has in the past funded some significant research in metalliferous ventilation projects. It is disappointing that this scheme no longer appears to be active in the ventilation research areas.

The Moura Number Two and Gretley mine disasters led to, or reinforced, a revolution in thinking in many areas of management of the industry. Regulations are less prescriptive and now demand risk assessment incorporating international best practice. There is a much grater emphasis on training at all levels.

Much of the industry is actually or effectively long distance commute (Fly In Fly Out). It is beyond the scope of this address to cover the issues of joint management, longer work shift hours and so on that this presents to the management of ventilation. There is more use of consultants than ever before, a situation than again presents many issues.

Vehicles for publication of ventilation innovation for dissemination to the wider industry community are becoming fewer. It is the specialist conferences that have become the main archival repository of our thinking and innovations for reference in the future.

The three areas of new development discussed within this paper have all been supported by Australian Coal Association Research Program grants, in recent years. They are stories in practical application and have received considerable additional industry financial support mine site testing and evaluation assistance.

MONITORING OF RESPIRABLE DUST

A new personal respirable dust monitor developed by the company Rupprecht and Patashnick (now Thermo Electron) in the US under a project funded by National Institute of Safety and Health (NIOSH) has generated promising results in underground coal mine testing performed in the US recently (Volkwein et al, 2004a and 2004b). Results from an Australian Coal Association Research Project (ACARP) funded study undertaken to evaluate this new real-time dust monitor for personal respirable dust evaluation particularly in engineering studies have been described by **Gillies and Wu, 2005, Gillies, 2005 and Gillies and Wu, 2006.**

This paper describes some results from mine studies that have been undertaken using the real-time personal dust monitor (PDM).

The technology that forms the heart of the PDM, the TEOM® system, is unique in its ability to collect suspended particles on a filter while simultaneously determining the accumulated mass. The monitor internally measures the true particle mass collected on its filter and results do not exhibit the same sensitivity to water spray as optically based measurement approaches.

The technique achieves microgram level mass resolution even in the hostile mine environment, and reports dust loading data on a continuous basis. Using the device, miners and mine operators have the ability to view both cumulative and projected end-of-shift mass concentration values, as well as a short-term 5, 15 or 30 minute running average. It is believed to be the first personal dust monitor instrument that reliably delivers a near-real-time reading.

The instrument has potential to be used as an engineering tool to evaluate the effectiveness of dust control strategies. Being a personal dust monitor, the instrument measures the airborne dust from the breathing zone region and so has many advantages over instruments that measure from a fixed-point location. It delivers a near-real-time reading and so can quickly highlight high dust situations and allow the situation to be corrected.

The underground workplace in both a continuous miner and longwall face environment has varying respirable dust conditions due to aspects such as ventilation conditions and air velocity, shearer activity and design, chock movement, AFC movement, manning position, face time of individual personnel, outbye conditions and dust levels in intake air and measurement instrument behaviour.

Many mines have observed a lack of repeatability in dust monitoring that is not easily explained. This study has evaluated the instrument as an engineering tool that can assess the effectiveness of a single change to improve dust levels in sufficiently short a time that other aspects have not changed.

The PDM is a respirable dust sampler and a gravimetric equivalent analysis instrument that is part of a belt-worn mine cap lamp battery. The main components of the device include a cap lamp and sample inlet located on the end of an umbilical cable, a belt-mounted enclosure containing the respirable dust cyclone, sampling, and mass measurement system, and a charging and communication module used to transmit data between the monitor and a PC while charging its lithium ion batteries for the next shift. Figure 1 illustrates the unit.

Tests were undertaken at a development face to monitor the dust exposure levels of various equipment operators. The PDM units can give 5, 15 and 30 minute rolling averages of dust concentration and for engineering evaluation purposes it is better to use shorter time rolling average dust concentration data as the quicker response to monitored changes shows more significant dust concentration variations.

As shown in Figure 2 PDM units were put on continuous miner (CM), bolter and shuttle car (SC) operators in tests commencing at 8:15 pm. The face crew was replaced at 9:10 pm by the second crew as the first crews were released for crib break. The results of the PDM tests are shown in Figure 2 as 15 minute average dust levels.

During the tests an unplanned event took place. The end cap of ventilation ducting in an inactive adjacent face of the development section was sucked in and caused reduction in the ventilation air quantity available to the face being monitored from $7.5\text{m}^3/\text{s}$ to $4.3\text{m}^3/\text{s}$. This caused a significant loss of suction head in the ventilation ducting at the face resulting in the dust-laden air at the face billowing back onto operators. All PDMs worn by the three operators have registered sharp rises in dust level. In fact this unplanned event was first

noticed by one of the operators who had checked the real time display on the PDM he was wearing at the time. The failure of the end cap piece in the inactive face was soon rectified and the normal ventilation flow re-established. Readings from all PDMs show the immediate reduction in duct concentration upon rectification.

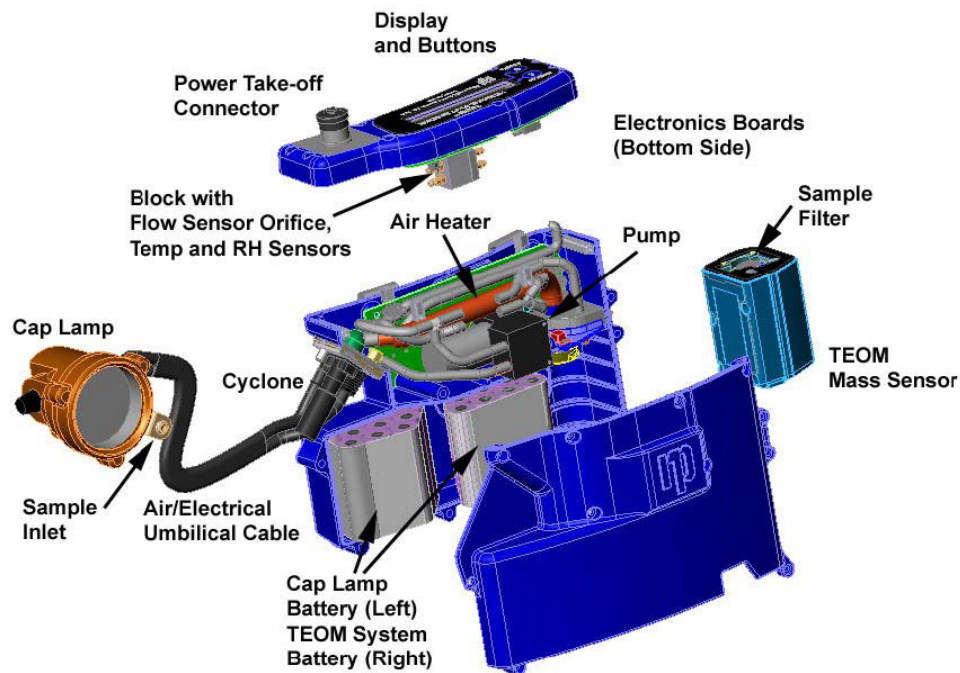


Figure 1 Major components of the PDM.

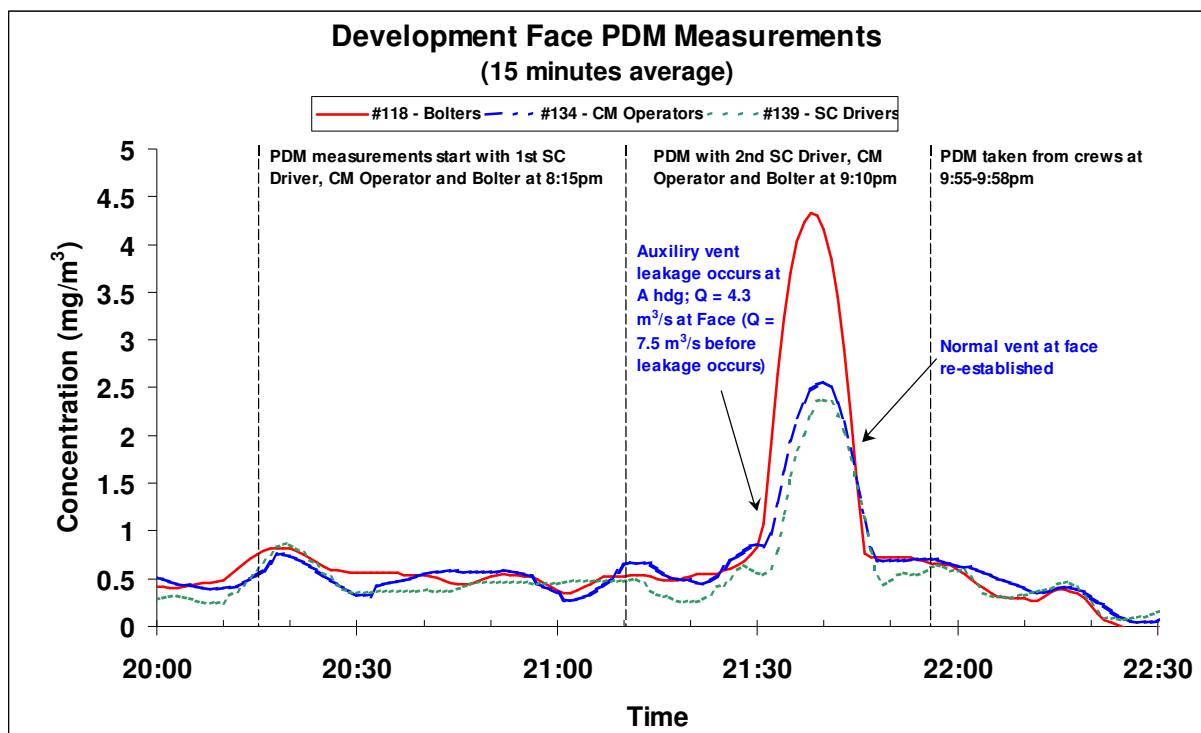


Figure 2 Development Face PDM results.

The longwall panel has a number of potential dust sources. A detailed survey can assist in evaluating the contribution of each component source, show the contribution from a number of major sources and the cumulative dust level faced by a miner at different points throughout the panel.

Tests were carried out as set down in Figure 3 to monitor the dust suppression efficiency of sprays in the BSL and at the belt transfer point where the longwall belt and the main trunk belt met. For the BSL test, one PDM was placed outbye of BSL, the second PDM was placed on top of the BSL inbye of the spray and the third PDM further inbye of the BSL at Chock 8. During the test, BSL sprays were on initially and then disconnected for about 30 minutes and then reconnected again. The results show that with the sprays off dust concentration levels downstream of the BSL were dramatically increased while the dust concentration level upstream of BSL remained constant with little variations.

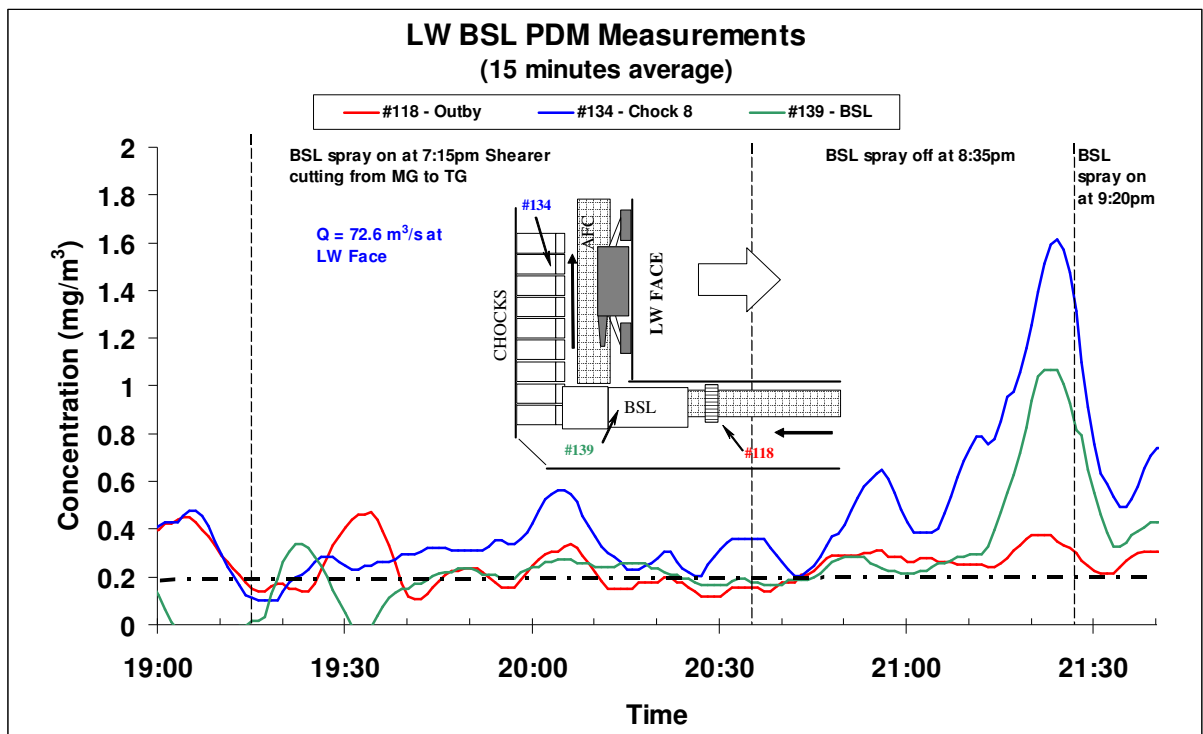


Figure 3 Dust make across a Longwall BSL PDM results.

It was found that the fluctuations in dust levels measured by the PDM upstream of the BSL correlated well with whether there is coal loaded on the conveyor belt or not. When there is no coal loaded on the belt the dust levels of intake air upstream of the BSL were measured at less than 0.2 mg/m³. It is possible to draw a horizontal line as shown in Figure 10 to indicate whether there is coal on the belt or not.

In undertaking Longwall studies it is important to maintain consistency with measurement conditions along the face activities. Figure 4 indicates studies undertaken over the majority of a shift with two PDM units. The shearer position data was downloaded from the mine

monitoring system. A cutting sequence took on average about slightly less than an hour. It can be seen in the figure that seven cutting cycles occurred across the 7 hour study time period with good regularity. One early period of 45 minutes of cutting was lost to belt structure removal.

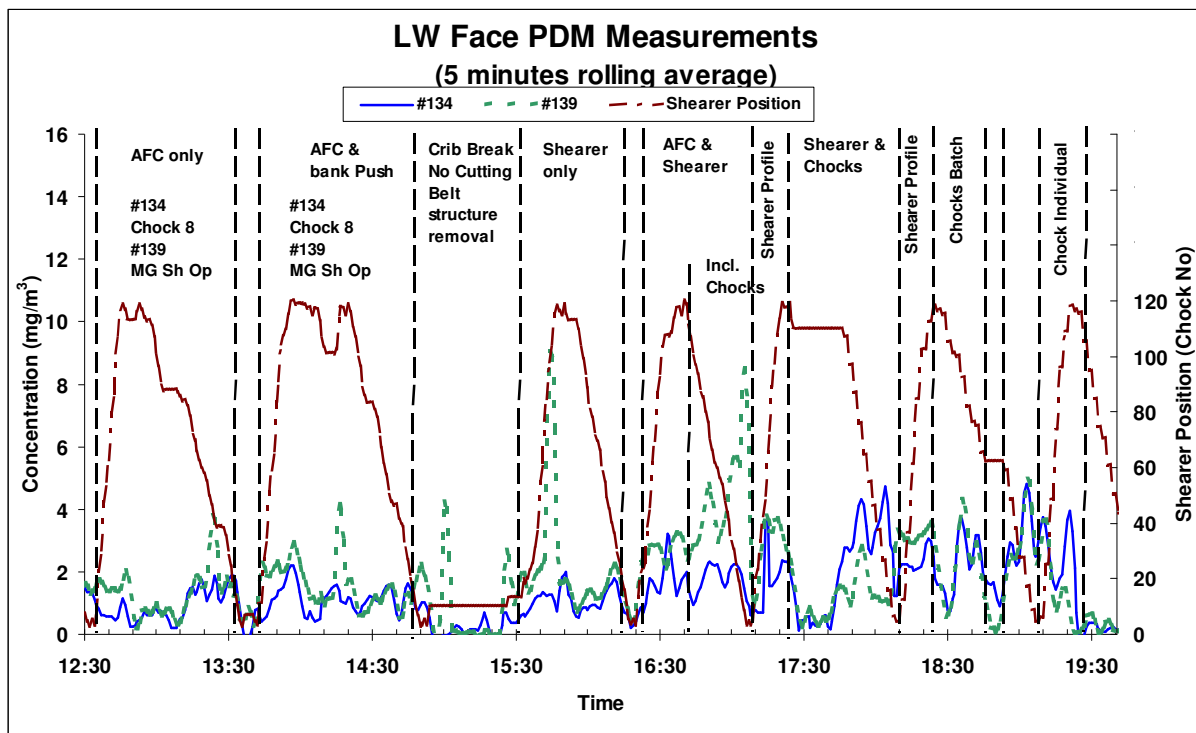


Figure 4 LW Face Dust Surveys Shearer Position and dust monitored points m Levels

Measurements were carried out at Longwall face positions monitoring the dust levels experienced by shearer and chock operators in a unidirectional mining cutting sequence. Results of these tests are shown in Figure 5 to 7 for various operator position combinations.

Figure 5 illustrates monitoring dust make across the length of a shearer when cutting. One PDM 134 was worn by a person who shadowed the MG shearer operators for a cutting cycle during unidirectional cutting. The other PDM 139 was worn shadowing the TG operator. The shearer position data was downloaded from the mine monitoring system and indicated that the shearer was cutting from MG to TG first and then cutting from TG back to MG during the test. The results showed the increase in dust exposure faced by the TG operator over the MG operator. The unusual anomalous “bump” in the PDM 139 result trace at about 15:45 is put down to a significant face-slabbing fall the significance of which was very obvious to those nearby.

Figure 6 illustrates dust exposure at the MG Shearer and TG Chock operator positions as the cutting sequences moves along the LW face. This shows under Unidi cutting that during the TG to MG cutting sequence operators are advancing chocks downstream of the shearer and so experience relatively high dust exposures. After snaking at the MG end chock operators following the shearer are upstream of the unit and so experience relatively lower dust

exposures. The results indicate that the MG shearer operator was subjected to relatively high dust level exposure when cutting from MG to TG. When cutting from TG to MG the dust level experienced by the MG shearer operator was much lower.

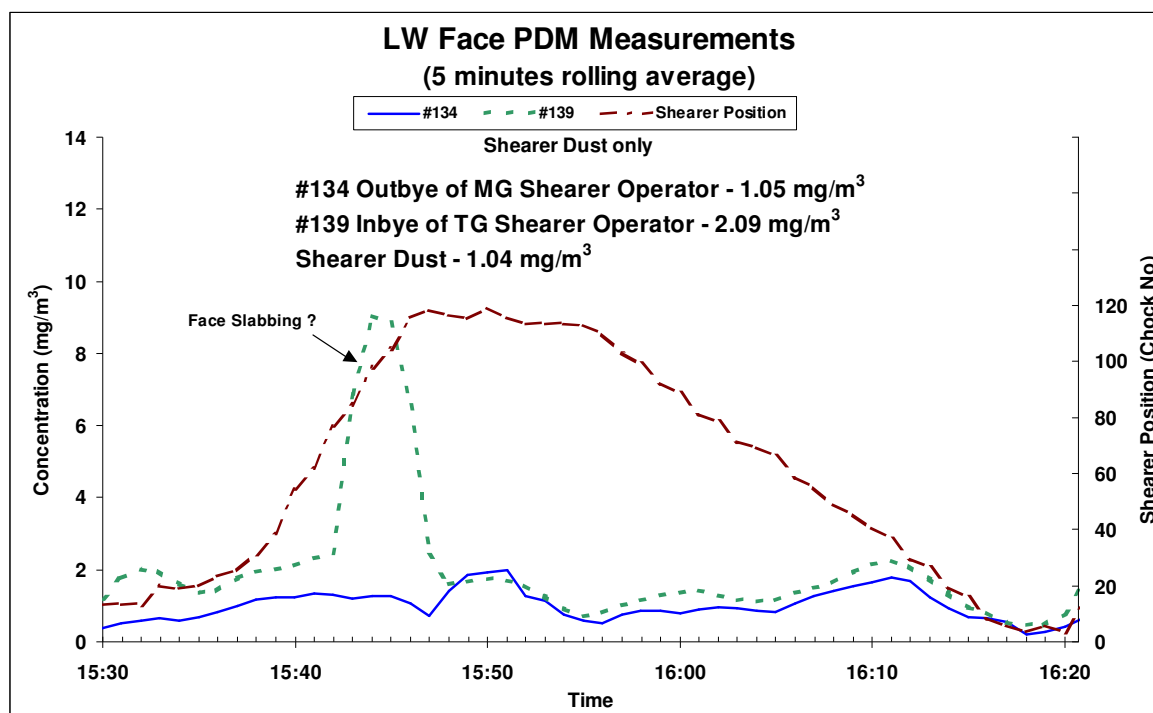


Figure 5 Relative dust make experienced by MG and TG shearer operators.

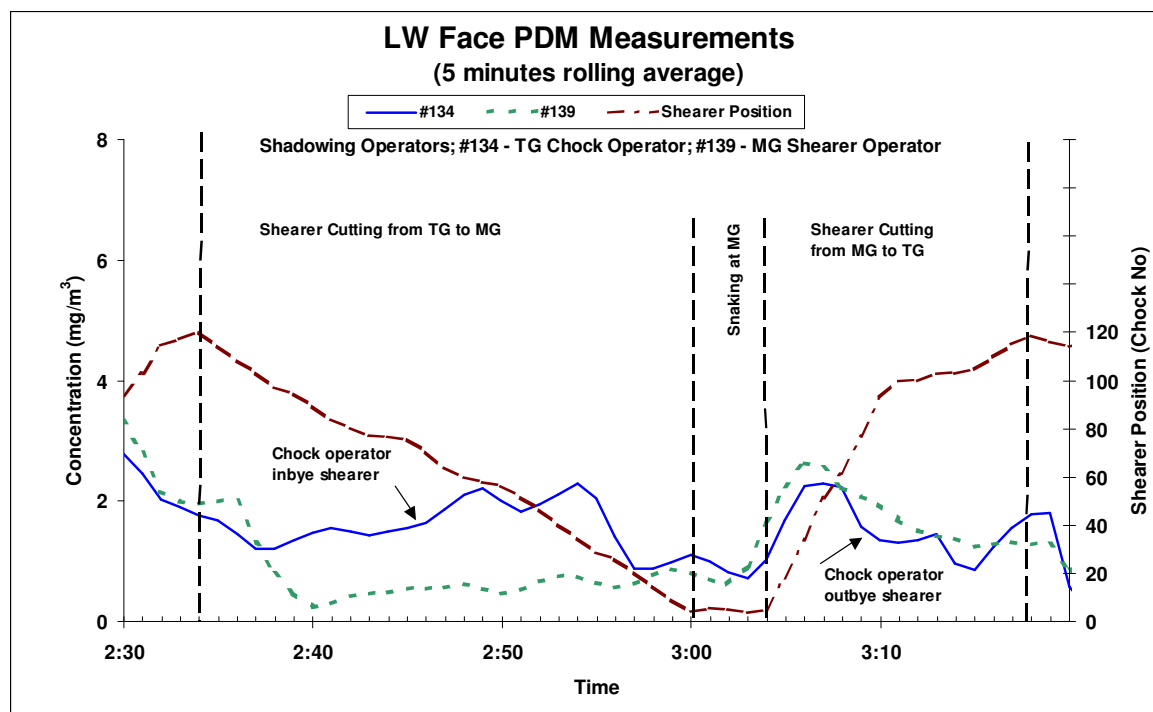


Figure 6 Relative dust make experienced by MG shearer and TG Chock operators.

Figure 7 examines variation of dust make with shearer advance rates. Two TG to MG cuts were examined; one taking over about 41 minutes for the cut and one only taking 24 minutes. It is clear that the at the same shearer position the dust exposure of average 1.72 mg/m^3 for the faster cut is greater than for the slower at mg/m^3 .

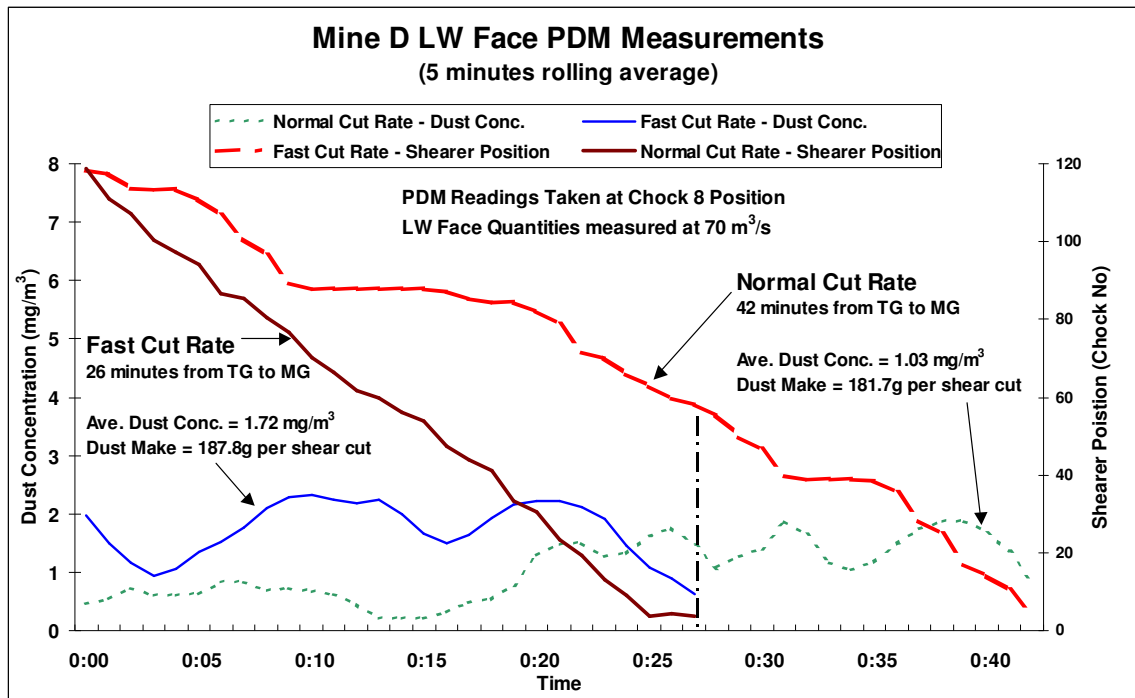


Figure 7 Variation of dust make with shearer advance rates

Based on the tests conducted, it is concluded that the PDM has demonstrated its potential use as an engineering tool to locate and assess various sources of dust during normal mining operations. The principles and concepts used to identify and fix some of the higher dust levels are generally common sense and would be easy for most miners to understand.

However, to make the most effective use of this information, training and experience in using this type of technology will be very important. Experience with the data from the unit will help miners gain confidence to use the information to maintain reduced or safe dust levels during mining.

MONITORING OF DIESEL PARTICULATE MATTER

Diesel Particulate Matter (DPM) issues are very high profile currently in both Australian coal and metal mines and both Australian states are moving to acknowledge and to broadly follow US 2001 final metal mine regulation limits of 0.2 mg/m^3 submicron particulate matter, 0.16 mg/m^3 total carbon particulate and 0.1 mg/m^3 elemental carbon particulate.

The real time DPM monitor is being developed on the base of the successful personal dust

monitor (PDM) recently developed by Thermo Electron Corporation and successfully evaluated for Australian conditions. The objectives of this proposed study are to finalise the design of a DPM unit, to undertake comprehensive and internationally recognised laboratory testing to evaluate the new design and to undertake an underground series of tests to establish the robustness and reliability of the new approach.

The proposed research project to ACARP is being undertaken in three work stages. Thermo Electron Corporation, the manufacturers of the PDM, have undertaken structural changes to the PDM to make it a DPM real time monitoring underground instrument, the D-PDM. The Pennsylvania Pittsburgh Research Laboratories of NIOSH (the group that originally contracted for the PDM development) has undertaken laboratory "calibration or verification" testing. They have an accredited diesel exhaust laboratory and international expertise in this area. A phase of Australian mine robustness and engineering testing is currently being undertaken to ensure the instrument can effectively assist mine management to handle this health issue. Tests will be undertaken at points of expected high atmospheric DPM such as during Longwall face moves, Development RAM car usage, Eimco usage, PJB usage, etc. in about five mines over about five testing weeks.

The outcome of the project will give the industry access to an enhanced tool for understanding the mine atmosphere in the presence of DPM.

The phase of Australian mine robustness and engineering testing commenced in September 2006 to ensure the instrument can, in a practical way, effectively assist mine management to handle this health issue. NIOSH scientists Jon Volkwein and Jim Noll came to Australia for two weeks to participate in the first mine test which undertaken in working sections with use of diesel powered Ram cars over four days. The results from these limited tests qualitatively indicated that D-PDM did respond to observed diesel activity in fairly low concentration ranges. 15 minute averaging periods appear to allow a balance between ability to recognise individual diesel source vehicle movements and measurement accuracy. Some readings were taken with instruments mounted on a vehicle with positive results.

A second series of mine tests was undertaken in December 2006. These exercises monitored various ventilation arrangements of longwall face move during chock transport to the installation roadway. Mine atmosphere DPM concentrations were in general higher than in earlier mine tests. These allowed greater accuracy in monitoring concentrations. Results were in most cases recorded as a rolling 10 minute average and so more clearly reflected activity changes. It was very easy to analyse results for arrival and departure of diesel machines at the face. Interpretation could be made on whether the machine travelled down gate roads either with a speed faster than the air velocity (and so with high exhaust concentrations trailing) or with a speed slower than the air velocity (and so with high exhaust concentrations in advance). Monitor results were compared with SKC impactor collection for determination of Elemental and Total carbon particulate shift average results taken in the mine at the same time by Coal Services personnel and close correlations were found.

Figure 8 shows Longwall ventilation arrangement for tests. The positions of the D-PDM monitors #106 and #108 are shown; #106 are in the face installation road and #108 in a cut through ventilating the face. On this test day loaded chock carriers travel in from MG and out

through TG. About 50 m³/s ventilation was measured in the MG and about 35 m³/s in the TG. Four chock carriers were available and a total of 10 chocks were moved but only 9 installed.

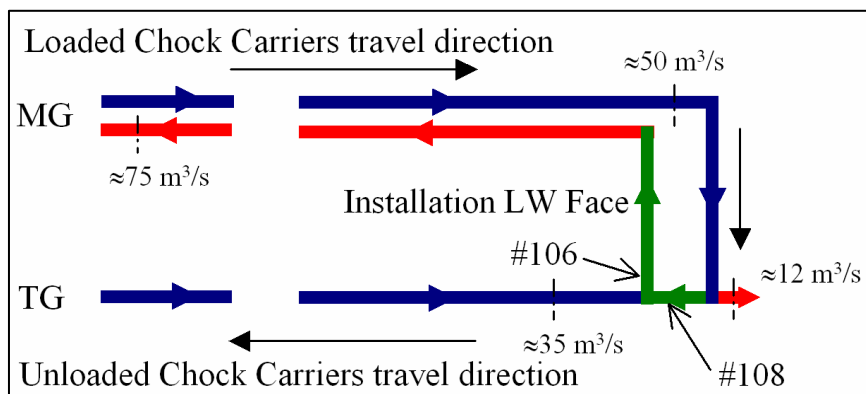


Figure 8 Longwall ventilation arrangement for tests - chock carriers travel in on MG and out on TG.

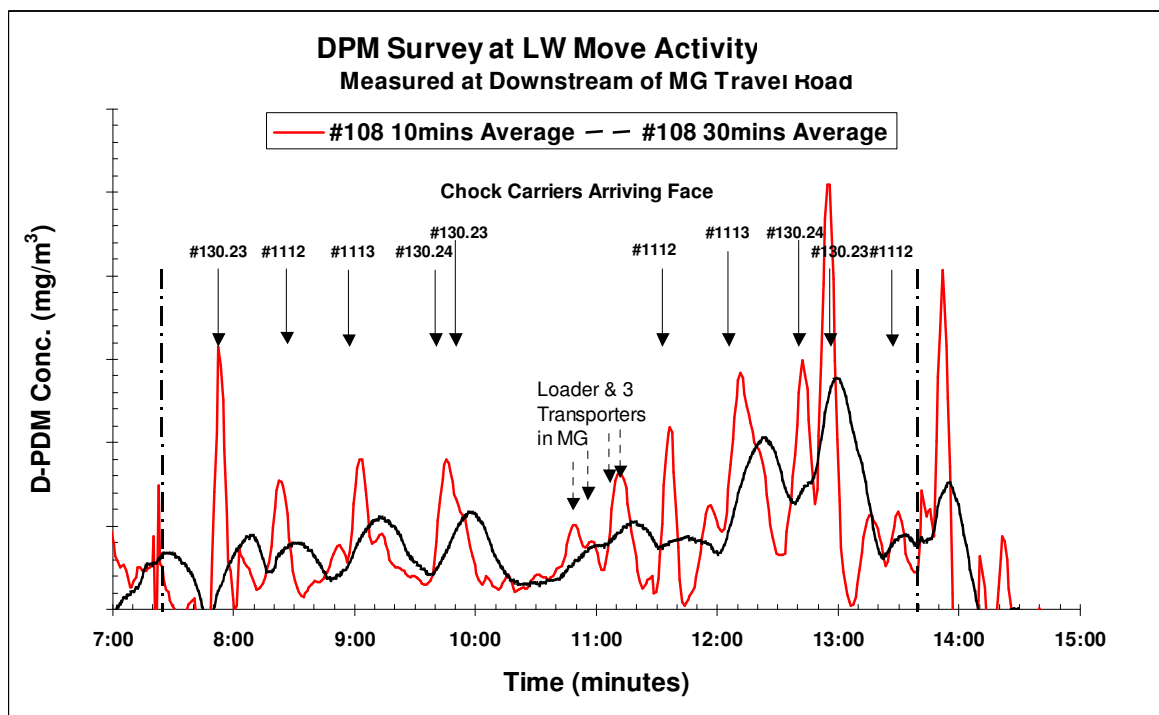


Figure 9 Observations on results at monitor 108 fixed location.

Results from monitor #108 as shown in Figure 9 clearly demonstrated the ability of the D-PDM units to detect variations of DPM levels in the atmosphere as the Chock carriers travel in from MG and out from TG of the LW face. High submicron DPM readings were recorded due to the large number (10) of chocks that were transported during the shift. Levels of DPM recorded in the second half of the shift were higher. The condition of the back road had become so poor that some chock carriers were reported to be having difficulty travelling through.

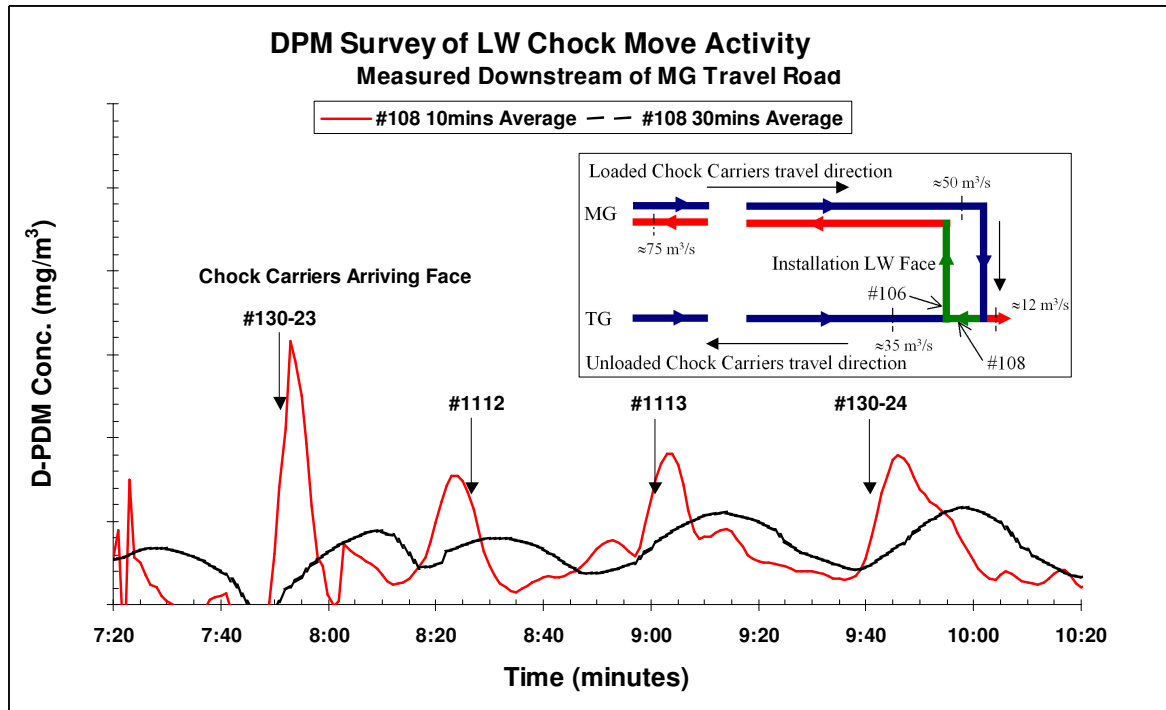


Figure 10 Observations on results over a three hour period at monitor 108 fixed location.

Figure 10 examined one three hour period with particular interest in recording of D-PDM readings as compared to Heading air velocity chock carrier vehicle speed. Close examination of results from #108 monitoring the DPM downstream of the MG and back road showed that when the chock carriers travel in from the MG in three cases they arrived at the TG end of the face in advance of the peak level of the DPM cloud. This indicated that the carriers were generally travelling at higher average speed than air velocity. However Carrier #1112 arrived slightly later indicating slower machine travel speed than air. The time difference and also the peak concentration will depend on the air velocity and chock carriers' travel speeds. In theory if the chock carrier travels at the same speed as air velocity the peak concentration will be extremely high and the carrier will arrive at the same time as the concentration peak.

FIRE SIMULATION

Fire simulation software has the great advantage that underground mine fire scenarios can be analysed and visualized. Modern software provides a dynamic representation of a fire's progress in real time and utilizes a colour-graphic visualization of the spread of combustion products, O₂ and temperature throughout the ventilation system. During the simulation session the user can interact with the ventilation system (eg. hang brattice or check curtains, breach stoppings, introduce inert gases and change fan characteristics). These changes can be simulated quickly allowing for the testing of various fire control and suppression strategies.

The study is examining the effects of fires and introduced inertisation on mine ventilation systems using Polish fire simulation software "Ventgraph". Various case studies based on the

modelling of fire scenarios with introduced inertisation in a number of different Australian longwall mine layouts have been examined.

Inertisation has been accepted to have an important place in Australian mining emergency preparedness. The two jet engine exhaust GAG units purchased from Poland by the Queensland government in the late 1990s for the Queensland Mines Rescue Service have been tested and developed and mines made ready for their use in emergency and training exercises. Their use in real and trial mine fire incidents has underlined the need for more information on their application. The NSW Mine Shield (liquefied nitrogen) apparatus dates to the 1980s and has been actively used a number of times particular in goaf heating incidents.. The Tomlinson (diesel exhaust) boiler has been purchased by a number of mines and is regularly used as a routine production tool to reduce the time in which a newly sealed goaf has an atmosphere “within the explosive range” and for goaf spontaneous combustion heatings (**Stephan and Blanch, 2000**). Nitrogen Pressure Swing Adsorption (Floxal) units are available and in use both for reducing time in which goafs are “within the explosive range” and for goaf spontaneous combustion heatings. Each of these facilities puts out very different flow rates of inert gases. Each is designed for a different application although there is some overlap in potential applications. Table 1 examines some typical characteristics of the outlet flow of examples of these four units.

Table 1 Characteristics of the outlet flow of the GAG, Mine Shield, Tomlinson and Floxal inertisation units.

	Flue Gas ¹ Generator (Tomlinson Boiler)	Mineshield ² Liquid Nitrogen System	GAG unit ³	Membrane ⁴ System (AMSA Floxal Unit)
Inert Output Range, m ³ /s	0.5	0.2 – 4.0	14 – 25	0.12 – 0.7
Default Quantity, m ³ /s	0.5	2.0	20	0.5
Delivery Temperature, °C	54	Atmospheric	85	20
Oxygen, %	2	0	0.5	3
Nitrogen, %	81.5	100	80 – 85	97
Carbon Dioxide, %	15.3	-	13 – 16	-
Carbon Monoxide, ppm	0	-	3	-
Water Vapour, %	1.2	-	some	-
Water droplets			significant	

Underground mine fires lead to complex interrelationships with airflow in the mine ventilation system. Addition of the gas stream from an inertisation unit adds another level of complexity to the underground atmosphere behaviour. Important questions are raised such as should the main mine fans be turned off so as not to dilute the inert gas or will this action cause, in

¹ Tomlinson Boilers, 2004

² Mine Shield, 2002/03

³ GAG, 1997

⁴ Sajimon, J. 2005 and AMSA Floxal Unit, 2006

conjunction with buoyancy effects, airflow reversal and the drawing of combustion products or seam gases across a fire leading to an explosion?

The GAG and Mine Ventilation Systems

Simulations using the fire simulation software “Ventgraph” can be undertaken to gain better understanding of how inertisation units or systems interact with the complex ventilation behaviour underground during a substantial fire or hating. Aspects worthy of examination include:

- Location of the introduction point for inert gases for high priority fire positions; eg. portal docking position, special boreholes;
- Size (diameter) of borehole or pipe range required to deliver inert gases and back pressure issues;
- Time required for inertisation output to interact with and extinguish a fire;
- Effects of seam gas on fire behaviour with inertisation present;
- Changes which can be safely made to the ventilation system during inertisation including switching off some or all fans;
- Need for remote controlled doors to channel inert gases to the fire location;
- Complications caused by underground booster fans; and
- Spontaneous combustion issues.

EFFECTIVE DOCKING POSITIONING OF INERTISATION UNITS

Positioning of the inertisation units is a major determinant of potential success for most efficient suppression of a specific fire. Traditionally in Queensland docking points have been placed on intake ventilation headings (either travel roads or conveyor belt roads). Some mines have prepared docking points on boreholes of about 1.0 to 2.0m diameter placed at the back of longwall panels.

The advantages that can be gained from use of various inertisation docking positions depends on a number of considerations including the location of the fire, the relative distance from the inertisation docking portal location and the attributes and complexity of the mine ventilation network. Operation of a GAG unit requires preplanning in terms of infrastructure requirements for a GAG surface portal docking station and access for operating personnel, fuel, water and other operating requirements.

Some of these aspects are examined in an example based on a model modern mine layout as shown in Figure 11.

The fire scenario developed is as follows:

- Two diesel vehicle collision caused fire in Mains at about 24-25ct B Hdg.
- Driver stunned and observing but not fighting fire initially.
- The fire has ignited 400 litres of fuel equivalent.
- Seam CH₄ gas sources of 2 x 0.26 m³/s along LW face; Mains and Panel development faces of 0.36 m³/s each.
- GAG Initiated at 29 ct Intake Shaft Docking Station.

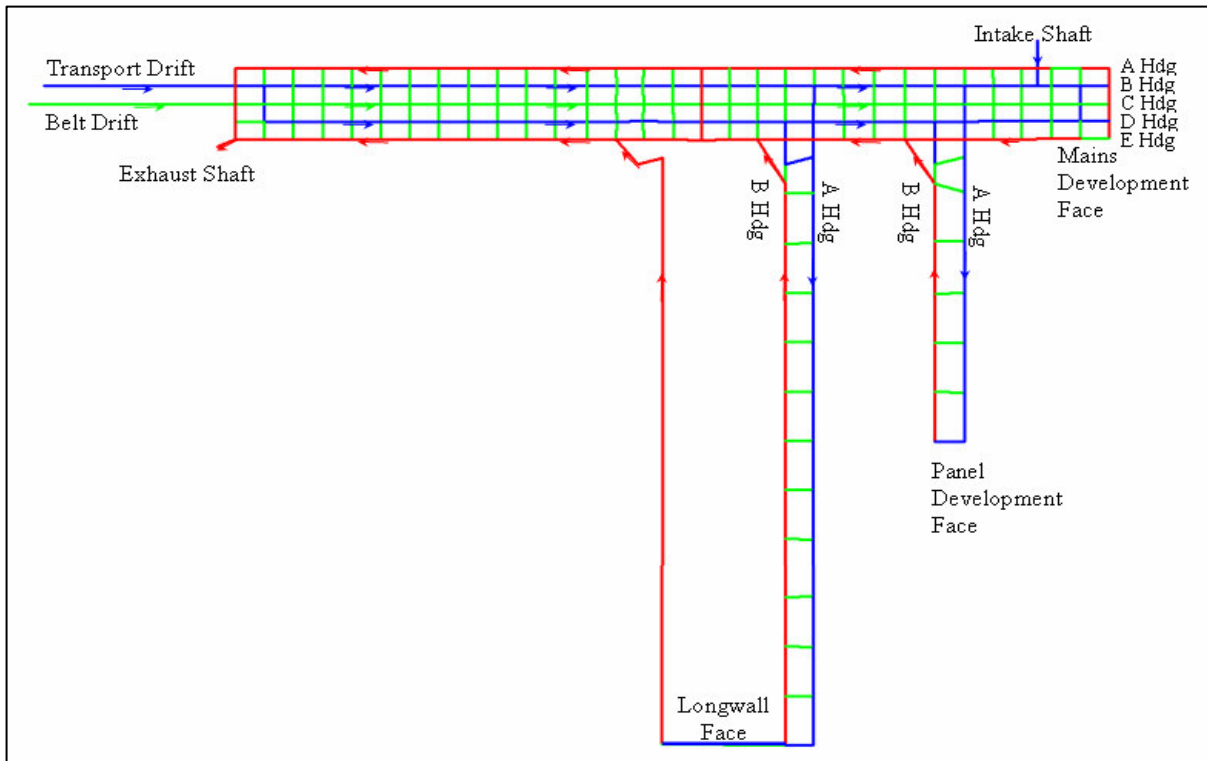


Figure 11 Simplified modern Longwall mine layout.

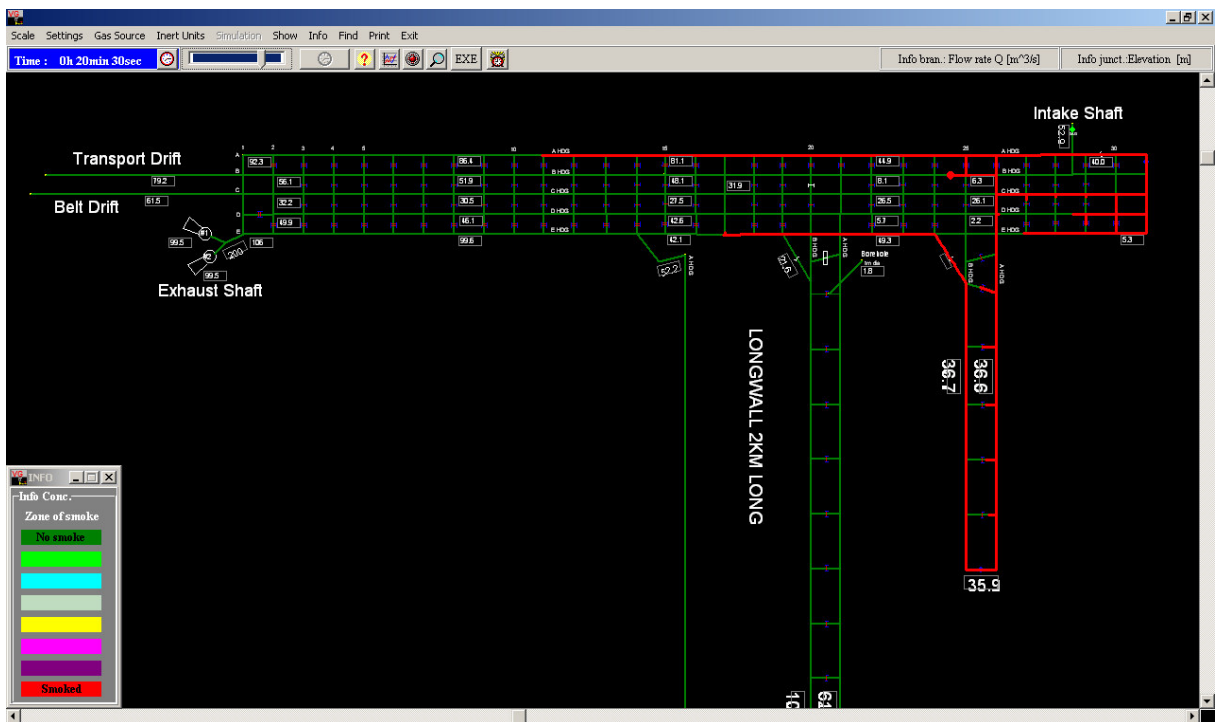


Figure 12 Smoke distribution at 20 minutes.

Figure 12 shows smoke distribution after 20 minutes. Smoke reaches both Panel and Mains

Development faces after about 10 minutes. It has not entered the Longwall panel at this point in time.

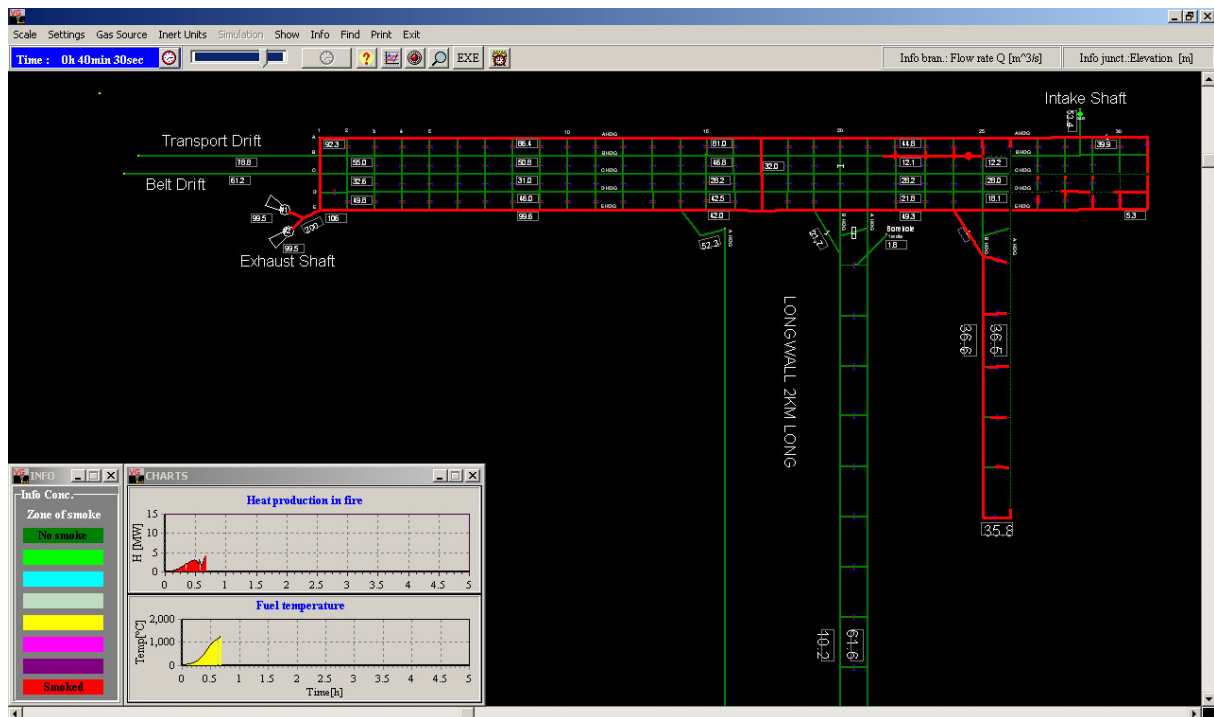


Figure 13 Smoke distribution at 40 minutes; note air reversal across fire at about 37 minutes.

Air reversal occurs across the fire site at about 37 minutes from start of fire (chimney effect of heated air on a dipping Roadway). Smoke laden air and fire fumes start to affect some Mains roadways and Longwall panel section. Smoke laden air and fire fumes are drawn out of the Panel Development. Change in Mains Development behaviour of smoke laden air and fumes occur. Air distribution is rebalanced throughout the mine.

The consequences of the air reversal are Longwall crew have fire fumes enter their Section. Development section crew find fire fumes first are sucked from their Panel and then a little later return. Similar change to Mains Development air flow occurs. At 50 minutes after the fire commences Longwall crews at the face are affected by smoke and fire fumes and start evacuation if not already doing so.

A GAG unit is prepared for use at 4 hours after fire start. A decision is needed whether to dock the unit at the Decline Intake portal or the Vertical intake shaft. For this exercise the GAG is docked at the vertical intake shaft. In this position and with ventilation reversal having already occurred GAG inert gases are drawn across the fire. Inertisation would only occur after all people evacuated from mine. GAG inert exhaust is drawn into the Longwall Section and both Development Sections. As inert gases are drawn across the fire they stabilise the fire and reduce its intensity and temperature.

Simulation has demonstrated that the correct docking point is the Vertical intake shaft to draw

inert gases across the fire. Inert gases would not have reached the established fire if docking occurred at the Decline Intake Portal. Inert gases in time stabilise the fire.

As a conclusion to the simulated fire exercise has shown that smoke reaches both development faces within about 10 minutes. CO levels rise rapidly and so personnel movement out of the panel into clear intake air in the Mains should be as fast as possible. Air across the fire heats up and reverses at about 37 minutes. Reversal causes mine airflow balance to be changed. Fire fumes now enter Longwall Section and travel to face. Fire fumes still may affect Development headings. Escape routes need to take reversal of airflow into account. Miners should, if safe, fight fires as soon as possible to avoid reversal, to stabilise atmosphere and assist the men to escape. Inertisation can stabilise the fire but selection of the correct Portal to dock the GAG unit is critical. Evacuation exercises allow crews to become familiar with the self escape equipment and procedures and increase understanding of an escape in potentially non clear and difficult conditions.

CONCLUSIONS

There was a prediction that we would have moved further towards the provision of a pleasant and comfortable work environment or put another way a mining environment based on quality of life. Howard Hartman acknowledged this was on the wish list. In the last five years there have been a substantial number of both coal and metalliferous mines installing some form of refrigeration. There continues to be a high awareness of dust with new emphasis or developments in dilution and scrubbers. Newly emerging real time monitors will assist here. Some monitoring of blasting fumes is occurring. Better approaches to switching on local fans following blasts are in use. Monitoring of other gases is occurring. There is still some way to go here. Improvements in productivity that result from raising of mine atmosphere quality are the most likely to receive financial priority.