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A Review of Current Australian Longwall Ventilation Practice

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ABSTRACT

A study has been undertaken into the mine ventilation systems currently in use within Australian modern longwall extraction mines. The paper reviews current systems and discusses evolving changes being adopted to address the more complex problems.

To remain viable mines are constantly emphasising cost reduction resulting in longer panels, wider faces, greater extraction heights, increased production rates and decreased personnel. In addition mine workings are moving deeper. Exacting ventilation control issues such as increased total and respirable dust, greater seam gas content at lower insitu permeabilities, spontaneous combustion and heat management become critically important.

This review forms the basis for understanding these current ventilation issues. It analyses a comprehensive database of Australian longwall ventilation practice. This understanding is important so existing knowledge can be built on to assist with future operations.

The review was completed by visiting and surveying 16 large longwall mining operations in Australia. The selection of longwall mines was based on encompassing most pits with pronounced ventilation challenges while focusing on larger operations facing issues related to higher production. Details are given of ventilation techniques used including number of gateroads developed, longwall ventilation patterns, use of monitoring systems, methods for sealing goafs, seal and stopping practices, pressure balancing of goafs and ventilation structures.

INTRODUCTION

The purpose of this paper is to establish the state-of-the-art of Australian underground longwall mining ventilation practices. Within Australia the two states where almost all underground coal mining activities take place are Queensland (Qld) and New South Wales (NSW). The mining history, geology and regulations vary between these two states. This current study demonstrated significant change from a similar review by Schaller and Savidis (1983) almost two decades ago.

The core of this review is based on visiting and surveying 16 large longwall mining operations in Australia. In total there were 34 operating longwalls in Australia in 1999 producing approximately 66.7 Mtpa, 11 of which operated within the Qld Bowen Basin and the remaining 23 were within the Western, Southern, Hunter and Newcastle regions of the NSW Sydney Basin. All of these collieries operated a single retreat longwall except for one colliery that operated two retreat longwalls with a one week dual operation or overlap to ensure continuity of production.

INDUSTRY SURVEY

Survey Format

The survey was divided into a number of major sections including colliery statistics, physical mine environment, main ventilation environment, development ventilation, longwall ventilation, ventilation network analysis, ventilation monitoring and future considerations. The physical mine environment section dealt with the physical parameters of the mine including seam cross section, roadway dimensions and physical layout of the pit. The main ventilation environment dealt with main fan installations, issues affecting ventilation and related incidents and location of the critical or open split. The development ventilation dealt with ventilation layout in development and most importantly considerations for breaking through in development. The longwall ventilation dealt with extraction method and equipment, ventilation method and sealing practices behind the active longwall face. Ventilation network analysis and monitoring dealt with the level of monitoring of ventilation parameters within the pit and how computerised network analysis was being utilised. Future considerations allowed issues expected to affect future production and ventilation of the pit to be noted.

Summary

Of the 16 mines visited 14 longwalls were ventilated using a variation of the traditional U ventilation approach. The two exceptions were using a Z ventilation method and a variation on the Z ventilation method. The typical longwall block dimensions were in the order of 2000m long with 250m face lengths. The face quantities varied from 25m^3/s up to approximately 100m^3/s with face velocities up to 4m/s. The seam conditions varied greatly with a variation in working section thicknesses from 1.8 to 5.5m within seam thicknesses from 1.8m to 24m. The gas content of these seams varies in content from 0.1m^3/t up to 22m^3/t in-situ with concentrations of methane and carbon dioxide, the two main seam gases present in Australian seams, each varying from 0 to 100%.

Gas drainage was used in pits with gas contents high enough to cause development and/or longwall ventilation issues. In most cases a method of in-seam horizontal pre-drainage was used ahead of the mining activities to reduce in-situ gas contents. In two mines visited a system of in-seam horizontal and inclined post-drainage was used. This system was designed to capture gas liberated in underlying seams during and after longwall retreat. Two of the mines visited used a method of goaf drainage using vertical wells from the surface placed under suction pressure.

Production from these longwalls varies from about 1Mtpa up to 5.5Mtpa for the newer "thick seam" mines. All collieries had a combination of shaft and/or drift access for personnel, materials and ventilation. The production method on the face was predominantly uni directional cutting due to gas and/or explosive or respirable concentrations of dust.

Currently all Australian longwall collieries have two heading maingate development. Panel headings are designed without a yielding pillar to maintain a boundary between two adjacent goafs. Some collieries are planning to lengthen their longwall blocks and are considering alternative methods for ventilating gateroad development including three heading development in line with North American practice. The development method is predominantly in "place miners", however "place changing" operations currently operate in a few collieries.

Sealing practice varied between the two states based on new Qld regulations requiring rated ventilation structures. However, NSW practice was to some degree falling in line with Qld regulations and evolving practices.

Monitoring of gases within collieries was provided by tube bundle and/or telemetry systems. Typically carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4) and oxygen (O_2) were monitored using these systems. Those collieries with ventilation issues involving gas typically had a gas chromatograph to assist with the analysis of bag samples for other indicator gases. Network analysis was in most cases facilitated through the use of a mine ventilation computer network simulation program. The operation of these computer models was generally supported by consultants that had assisted in the creation of up to date models.

LONGWALL VENTILATION CASE STUDIES

Typical Aspects of Australian Longwall Mining

The typical layout of an Australian longwall mine is shown in Figure 1. In terms of ventilation nomenclature intake roadways are shown as solid, single arrow roadways where as return roadways are shown as dashed, double arrow roadways. In this case a raisebore exists behind the current goaf and is shown as a circle with an intake roadway connecting to the longwall face roadway.

Australian longwalls at present use only two roadway maingate development and have typically between five and seven Mains' roadways. In development, A Heading (as shown in Figure 1) is an intake roadway with B Heading the return roadway through which the panel conveyor runs. In the Mains, B, C, and D Headings are typically intake with flanking return roadways, A and E Headings. When all longwalls are being extracted on one side of the Mains only, D and E Headings may be used as return roadways with A, B and C Headings as intake roadways. The conveyor runs in the intake headings typically in C Heading. In Qld this roadway is segregated from either one or both of the other intake roadways. In NSW segregation is generally not undertaken. The previous goaf's are sealed from both the tailgate of the current longwall and where the previous maingate/tailgate join the Mains. The current goaf is progressively sealed as the longwall retreats.

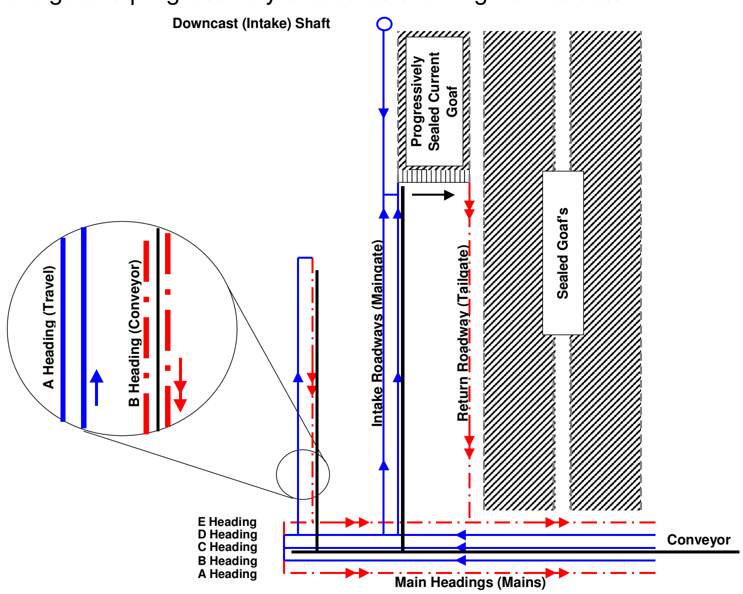

Figure 1. Typical Layout Aspects of Australian Longwall Mining

Case Study A

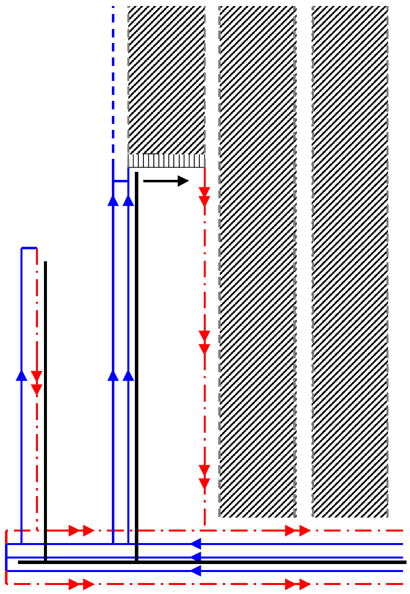

Figure 2. Case Study A

Case Study A, shown in Figure 2, is an example of a traditional U ventilation approach. This is the most commonly used longwall ventilation base model in Australia. This method minimises the induced ventilation pressure difference over both the current goaf and goaf's minimising the need to pressure balance.

As the longwall retreats a rated seal or some form of ventilation structure is installed in the cut throughs behind the longwall. For this reason seal sites must be accessible for inspections, installation and maintenance. In this ventilation method auxiliary ducting ventilation allows access to the A Heading roadway in the Maingate.

Case Study B

Case Study B, shown in Figure 3, is a variation on the traditional U ventilation approach where the panel belt road (B Heading) is operated in a homotropal mode. This mode of operation has been used for reasons including toxic seam gas management, heat management and for dust management with consideration for the open split location. The management of this homotropal split location can represent an operational issue.

Again in this example auxiliary ducting ventilation allows access to the A Heading roadway in the Maingate.

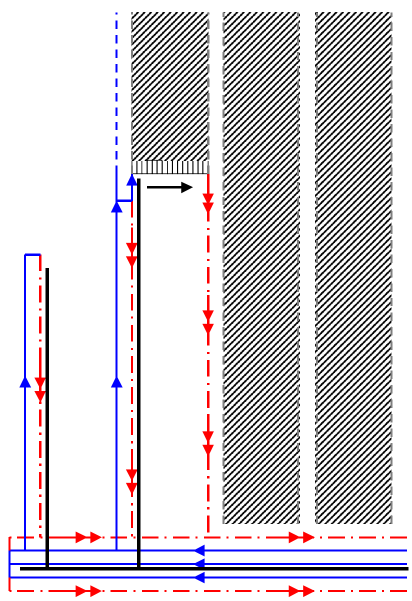

Figure 3. Case Study B

Case Study C

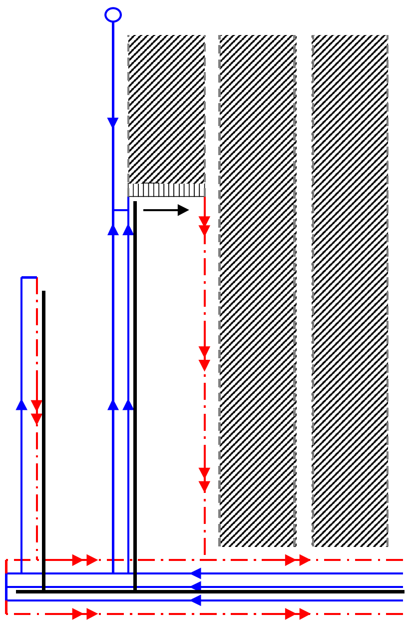

Figure 4. Case Study C

Case Study C, shown in Figure 4, is a variation on the traditional U ventilation approach where a small diameter raise (typically 1 m diameter) has been bored behind the current longwall. In this case study the raisebore is being operated in a downcasting mode.

This raisebore will facilitate a small drop in the overall mine resistance and an increase in airflow on the longwall face. This method allows for access to the next longwall's tailgate roadway.

This airflow however may be contaminated by gas as the goaf breathes out. This contamination may be considerable when installing some of the last panel seals.

Case Study D

Case Study D, shown in Figure 5, is another variation on the U ventilation approach with a small diameter raisebore (typically 1 m diameter) behind the current longwall operating in an upcasting mode. This method requires the installation of a fan on the raisebore, which increases the operating issues of multiple fan installations.

This method removes potential contamination from the seal installation site but can reduce the available quantity of air on the longwall face.

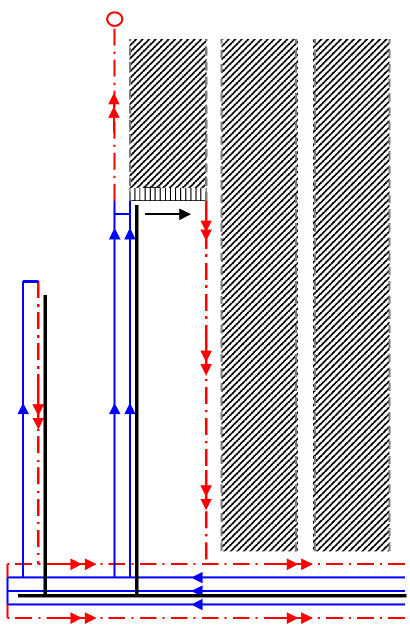

Figure 5. Case Study D

Case Study E

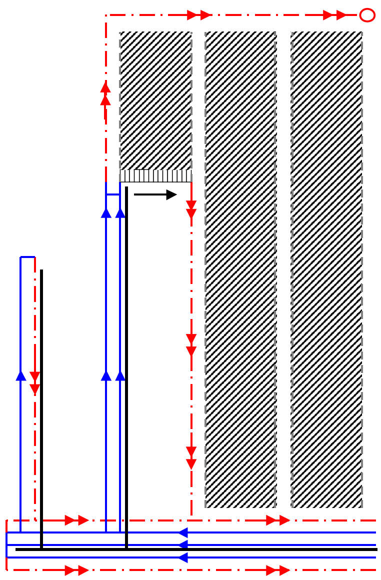

Figure 6. Case Study E

Case Study E, shown in Figure 6, is similar to the previous example where air is returned along the next longwall's tailgate roadway. Air is exhausted via a small diameter shaft (typically 2 m diameter) along a back return roadway.

Providing the advantages of contaminant removal this method has the potential to provide an increase in air quantity in the pit. Again another fan installation is required for the additional shaft location. Due to the existence of the back return roadway a pressure difference can be induced across the old goaf's. Leakage from this pressure difference can be an issue for the operation of the fan and exacerbating the potential for spontaneous combustion.

Case Study F

Case Study F, shown in Figure 7, is based on the Z longwall ventilation approach. This method brings intake air up the tailgate (beside a sealed goaf) and across the longwall face. Air then exhausts behind the longwall through the goaf. This method allows air to be coursed through the two caved roadways (maingate and tailgate) and through the next longwall's tailgate roadway. All air is exhausted via a set of Submain bleeders behind the longwall panel. This method allows for increased airflow and is used to dilute excessive quantities of gas in a seam with little or no potential for spontaneous combustion. A mixing chamber (restricted access/barricaded zone) is utilised to allow high concentration goaf gas to dilute behind the current goaf.

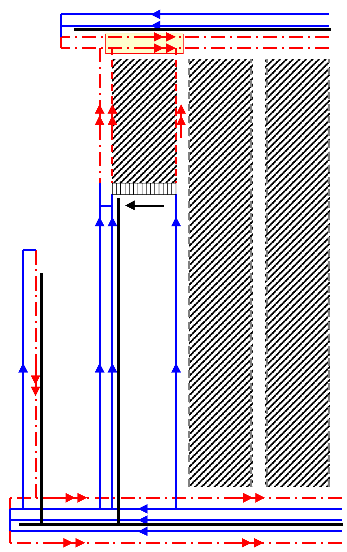

Figure 7. Case Study F

Case Study G

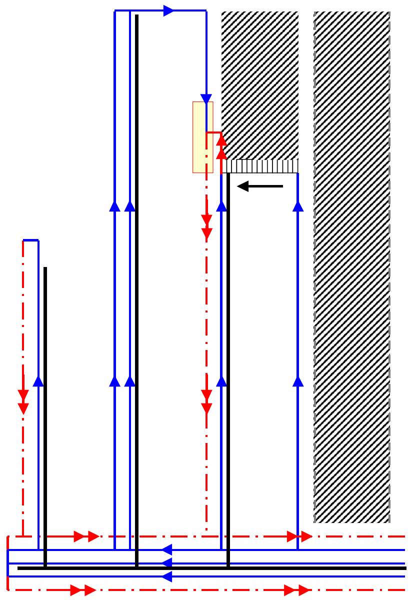

Figure 8. Case Study G

Case Study G, shown in Figure 8, is a hybrid ventilation method utilising aspects of both U and Z ventilation approaches. Intake air is coursed towards the longwall face along the tailgate roadway and panel belt roadway. Intake air is also sourced from the next completely developed longwall panel and brought against the sealed current goaf. Air returns from the longwall face through the goaf to the last open cut through behind the face. At this point return air mixes with intake air from the next panel and is returned through a single roadway to the Mains. This single roadway is barricaded, has restricted access and can be considered a “sewer” roadway.

In this method the mixing chamber concept is utilised in the location where return air from the longwall face is mixed with the intake airflow from the next longwall panel. Due to the reorientation of the sewer roadway, development can be reversed from the traditional to minimise seal preparation and stopping destruction.

LONGWALL VENTILATION ISSUES

Maingate Development

The development of maingate entries using two headings is the standard method of development within Australian collieries. However, due to concerns over development face gas, dust and heat issues three heading development is being considered as collieries move further underground extracting reserves at greater depth.

Choice of development method is another issue that continues to be addressed from a productivity standpoint. "In place" mining methods are used commonly with a few examples of "place changing" being used. The use of the "place changing" method is based on apparent gains in productivity. Irrespective of whether there is actually an increase in productivity the mining cycle is based on providing enough "places" for mining activities to occur. This results in a greater number of cut throughs. The larger number of cut throughs has two ventilation implications. The first is during the development phase where leakage through stoppings becomes a critical aspect of the development panel ventilation. The second issue appears as the longwall is retreating, seals are erected behind the active face in the open cut throughs to prevent oxygen migration into the goaf and goaf gas migration into the ventilation airflow. The increased number of seals to be erected presents both an increase in cost and more leakage paths between the general body of air and the goaf atmosphere.

Bleeder Ventilation

Within Australia there is currently limited use of true bleeder ventilation due to the propensity of Australian coal to spontaneous combustion. Of the 16 mines visited only two mines employed a variation of bleeder ventilation to ventilate the current and previous goaf's due to excessive gas accumulations.

Raisebore Utilisation

The issue of ventilating future tailgate entries and other blind entries has been addressed in a number of ways. The most apparent solution is to maintain development at least a full longwall panel ahead of the operating longwall. This way intake air can be directed though the next panel entries, across the installation face and down the future tailgate entry to be returned possibly across the working longwall face. This method provides access to the installed seals behind the current longwall face for inspection and maintenance. However, this additional development does not usually exist due to factors including economic and productivity focus.

To provide ventilated access to the current goaf seals some collieries are boring raises behind the longwall panels and used in a downcasting mode for intake to the longwall face or upcasting mode providing return capabilities. These raises can be utilised for other purposes during longwall installation (eg; concrete drophole) or during emergency scenarios as another means of access to the working seam and/or surface.

CONCLUSION

From the case studies discussed it can be seen that there are several underlying themes that are common within Australian longwall mines. At the same time, however, there are also some extreme variations of ventilation approaches utilised to facilitate management of severe ventilation issues. Each of the 34 operating longwalls in Australia manages a combination of issues including spontaneous combustion, total and respirable dust, heat and explosible and toxic gases. The increasing depth of operations exacerbates most of these issues.

The utilisation of two headings in maingate development is common across all operations. This limits the number of different longwall ventilation methods possible and hence most operations use a variation of the traditional U ventilation approach. This method is also utilised to assist with the minimisation of pressure differential induced across the current and previous goaf's for spontaneous combustion reasons. A limited number of operations use a variation of the Z ventilation approach but only to facilitate the ventilation management of extreme quantities of gas in a seam with little or no potential for spontaneous combustion.

The use of raisebores and small diameter shafts is becoming more common assisting with reducing mine resistances in some instances and allowing the ventilation of blind headings subject to gas inundation and development breakthroughs.

ACKNOWLEDGMENT

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