

Dartbrook Mine - A Case Study

J Hayward¹

ABSTRACT

Any project carries a number of challenges and risks. Inappropriate design, poor project management, time, industrial disputation and capital over runs are all areas which can impact on a project cash flows and return on investment. In the resource Industry you have the added complexity and risk of geology which is difficult to predict and sometimes unforgiving. The Dartbrook Mine was designed and constructed as a high output longwall mine and has overcome a number of hurdles to produce over 2.3 million tonnes for the first year of operation. A number of problems were encountered during construction which resulted in the in-seam development being delayed for six months. Dartbrook people have demonstrated they can manage adversity and produce world class results. The mine has been through a very steep learning curve during 1997 and with this experience behind the mine is now producing at an annualised rate of 3.4 MTPA.

INTRODUCTION

Dartbrook Mine was designed and constructed as a new underground longwall coal mine with a planned capacity of around 3.5 million tonnes per year. The mine is located in the upper Hunter Valley 10 kilometres north of Muswellbrook NSW. Construction of the mine commenced in June 1993 and in-seam development commenced in October 1994 from the bottom of the 1200 metres 1 in 8 grade men and materials drift. The longwall was installed in September 1996 and when completed in mid October 1997 2.24 million tonnes had been mined by the longwall. Results from the first longwall block were exceptional considering the challenges of steep grade, new technology and managing abnormal quantities of gas.

MINE CONSTRUCTION - LESSONS LEARNT

The Shell Board approved the project in April 1993 and when construction commenced in June 1993 the project was already six months behind schedule. Project Managers were appointed to manage the construction of the mine. The contract was written for the Engineering, Procurement, Construction and Management (EPCM) of the project. The Dartbrook management team were employed before the project commenced which provided the opportunity for input into the mine design, contracts and equipment selection. Having a Project Manager also provided the opportunity for the management team to develop operating parameters for the mine, design systems, negotiate labour agreements and recruit people. However, Project Managers are expensive at 5% of the total Capital value of the Project. The Project Managers at Dartbrook were good at building offices, workshops and coal handling facilities but did not have the experience on underground construction work. We spent a lot of time arguing with our Project Managers and also employed contractors to "keep the Contractors honest". The end result was well engineered and constructed infrastructure with an good safety, Industrial and environmental record, but the project exceeded capital estimates by around 8% and underground development commenced 6 months behind schedule.

The experience gained indicated that an in house project team could reliably manage the construction for a new mine. There is sufficient expertise available in terms of experienced mining and engineering people now in consulting roles to assemble a well balanced team to design and construct a mine.

Mine Manager Dartbrook Mine

MINE DESIGN

The concept of a thick coal seams and the opportunity to develop 4 metre roadways sounds exciting and has a number of obvious advantages but also presents a number of challenges . Larger roadways assist in keeping ventilation pressures low and permit larger equipment to be transported and installed underground but presents difficulties in the installation of roadway supports and hanging the services at roof height .

Equipment to mine at 4.0 to 4.5 metres was not readily available "off the shelf" and Dartbrook has had to design and install some very innovative development, longwall and support equipment to meet the challenges of mining thick seams.

With a coal seam that has never been worked before we realised that we needed a comprehensive data base of information to be able to plan with high confidence levels. The mine plan was designed for the best recovery of the resource and orientation of mains and longwall blocks with due consideration given to geological features, grades and the management of gas, water and spontaneous combustion. The exploration program and mine design have been shown to be the best for Dartbrook with no major shocks after 3 years of operation. The coal seam is as good, or better than anticipated with only minor faulting and dykes. We always knew that gas and spontaneous combustion were issues that were unique in a 22 to 24 metres coal section and that we would have to come up with some unique solutions.

PEOPLE - RECRUITMENT, TRAINING AND EBA'S

The quality of people at Dartbrook has demonstrated the importance of the recruitment process. The process was time consuming, costly and involved a significant number of people .

Dartbrook personnel completed a seven week training program before entering the workplace. The value of this is bearing fruit, not only in terms of knowledge and skills but in the development of a unique safety and team oriented culture. This has led to a desire for training and qualifications, which has to be managed. The mine has been in operation for over three years and the energy and enthusiasm is still evident in the entire workforce.

During 1998 Dartbrook Mine will negotiate the third Enterprise Agreement with its workforce. The first EA was negotiated with the District Officials of the CFMEU and the majority of employees were recruited under this agreement. At the time the agreement contained some very innovative and ground breaking changes which have carried through to the Second EA which was settled for a three year term. The basis of the first EA was fixed salaries, all inclusive of allowances, overtime and production bonuses. In return employees were required to work rotating shifts of 8.5 hours duration five days per week and commit to work allocated overtime. The only changes to the second EA is a step change to level 4 and 6 of the Industry work model, greater use of contractors and the overtime component reduced to allow a separate payment for weekend overtime when worked. Of interest, the second EA included the option for all employees to salary sacrifice for a fully maintained company provided car. Approximately 60% of the workforce have availed themselves of this opportunity. It is worthy of note that the concept of production bonus payments has lost its appeal and Dartbrook people are pressing good performances because of personal pride in doing a good job and in their mine. Along with the rest of the Coal Industry we are paying our people higher salaries than other Industries however I believe time and technology will develop realistic labour cost. Industrial relations at Dartbrook remain to be very strong and robust.

Although Dartbrook has maintained excellent management / labour relationships over the three years of operation, I believe that it could be enhanced by talking direct with our people without District Union intervention on critical issues. We have built up a strong relationship with our people based on two way trust which could explore mutually agreed new opportunities outside the traditional union structure.

SAFETY

Another greenfields opportunity is the setting of high standards of safety which can be an integral part of the induction training program and be written into the mines operating procedures. From the design and construction stage, Dartbrook set very high safety standards with hazops, risk assessments, procedures and Risk Management Plans (RMP's) being

utilised as tools for the mine construction and operation. Only Contractors with good safety performances were considered for construction work on the site. Contractors have to go through a rigorous pre-qualification process to work at Dartbrook and Contractors with poor safety history are not considered for the tendering process.

External and internal safety audits are an ongoing activity at Dartbrook and maintain the safety focus. Extensive induction and training programs have assisted in setting a unique safety culture at Dartbrook.

Safety performance has been excellent for the first 2 years with LTIFR's less than 10. However 1997 was disastrous in terms of safety performance with 12 LTI's and one fatality. The fatal accident to a young contractor in January 1997 was a very sobering reminder that too much time cannot be spent on safety. The accident was a major shock to all employees who did not believe that such a tragedy could occur in a mine with such high standards and a strong safety culture.

Initially contractor safety performance during the first year of construction was very poor with an LTIFR of around 25. We have now formed long term partnerships with contracting organisations who have accepted the mines high safety standards. The two major Contractors have retained a regular experienced workforce and employed fulltime safety and training persons. The Unions initially did not like to see regular contractor organisations on site because of the fear of Contractors taking potential jobs away from permanent workers. After the accident everyone realised that you cannot have new and unknown contractors on site and good safety is having well trained and experienced people who you can trust to maintain the standards.

RESOURCE

After an extensive exploration program, the coal seam is almost as predicted with excellent mining conditions, low water make and some localised steep grades. On the downside we have experienced higher than predicted gas levels.

The Wynn seam is Permian in age and is a bituminous coal of thermal quality. It is low in rank and has little to no swelling characteristics necessary for coking coal. Coal quality is generally as predicted with low sulphur and low ash but has high levels of Calcium Oxide (CaO) in the ash content. The higher than expected CaO provided the impetus to review the need to bring forward the construction of the coal preparation plant from year 10 of the project. The recently commissioned coal preparation plant enables Dartbrook to compete in the premium Pacific Rim markets and also to recover an additional 500mm to 700mm of the coal seam which partially offsets the washery capital cost and helps the economics of the project to look more respectable.

Exploration

At Dartbrook early drilling by the Department of Mineral Resources (DMR) and other organisations identified the presence of abundant coal reserves. Further drilling detailed the potential open-cut reserves. Prior to the commitment to longwall mining at Dartbrook, some 4 bores intersected the Wynn Seam every square kilometre. The Wynn Seam does not outcrop anywhere, nor has it been mined previously. All information about the seam came from boreholes or remote sensing.

With Shell's decision to commit to mining in April 1993 it was decided that we needed more information on an area to cover the first four longwall blocks. A further exploration program involving 24 extra boreholes was undertaken during 1993/94 to improve the knowledge of the area. Drilling across the lease and exploration areas still continues in an effort to better identify the risks associated with mining. Currently, the mine has a coverage of 18 bores per square kilometre, composed of 94 open holes and 86 cored holes.

Stress

Initial stress determinations at Dartbrook in sedimentary strata above the coal seams realised a high degree of variation of horizontal stress. The Bayswater seam, which is the immediate roof of the Wynn seam was targeted for follow up stress work. This work highlighted the relatively benign stress environment enveloping the target Wynn seam. Ultimately, this meant that the effect of stress at Dartbrook was not a critical factor to be taken into account with the mine layout.

Stress measurements were undertaken both from exploration bores and underground. In general there is an active east west, maximum principal stress in the horizontal direction, averaging 110 degrees. However, in the environment of the Wynn seam envelop between overlying and underlying coal, the effect of the horizontal stress is minimised to such an extent that the vertical stress is predominant. The combined effects of the vertical and horizontal stresses have resulted in only minor guttering and rib crush occurring in gateroads. It appears that the vertical stress is nearly perpendicular to the seam itself which is dipping to the west.

Structural geology

To assist in determining the layout of a mine, the accurate identification of geological structures is critical. Depending on thickness, hardness and consistency. Igneous intrusions can have a devastating impact on mining as has been demonstrated at a number of longwall mines with dramatic consequences. Identification of these structures during the exploration stage, allows the opportunity to plan for them, rather than deal with them as an emergency situation.

Techniques such as surface and aeromagnetic surveys, have a proven track record of accurately locating structures. At Dartbrook several surface and aeromagnetic surveys found intrusive anomalies were orientated in a north-east direction. Further investigations involving costeaming, helped to identify these structures. Intersecting dykes near parallel to a longwall face could cause difficulties with extraction. Intrusions oriented at an oblique angle to the faceline will minimise longwall delays.

Dartbrook Mine has a nominal borehole spacing of 250m. Uncertainty surrounding possible faulting (at the time) resulted in limited input into the mine design. Clearly, faulting could cause difficulties with mining. However, the extensive coal overlying and underlying the mining horizon would minimise these difficulties. The issue becomes one of coal quality rather than structural constraint associated with mines with stone roof and floor.

Evaluation and examination of borecores identified the presence of extensive jointing at Dartbrook. Determination of orientation became a priority during exploration. The RaaX photography method accurately identified the orientation of the joints. The jointing is ubiquitous and trends relatively consistently at 110 degrees. Underground measurements in the first workings confirmed the exploration data. The orientation of the longwall blocks took the jointing into consideration. With the thick seam and the jointing in mind, design of the longwall supports incorporated face spags (flippers). The flippers support the top of the seam to reduce spalling, and protect the operators from injury.

Coal quality

The mainroad development is in a westerly direction along the length of the southern lease boundary. These roadways experience relatively higher ash levels and lower seam height to facilitate the longwall extracting the premium quality coal.

Roof and floor geology

In the current longwall mining area at Dartbrook, the typical roof comprises of about 14m of coal. While loading from the overlying sediments is unlikely, a 'risk averse' policy has selected longwall shields rated at 913 Tonne yield. The roof support density is 118 tonnes per square metre.

The mining floor comprises of 300mm of tuff which is quite competent with a compressive strength of between 14 and 28 Mpa. The Mine Technik Australia (MTA) longwall face supports at Dartbrook have a base lifting capacity to assist in keeping the face on the appropriate mining horizon. The Coal is very strong and both longwall one and two advanced around 15 to 20 metres past the installation roadway before the coal roof started to fail. No problems were experienced with wind blasts of gas inrushes on both longwall startups, although precautions were taken to minimise and manage these risks.

Gas

All coal seams in the Dartbrook mining lease contains a seam gas mixture of Methane (CH₄) and Carbon Dioxide (CO₂). In-situ gas contents range from 6.5 to 11 cubic metres per tonne in the Wynn seam. Gas contents for the upper seams are generally less. Carbon dioxide is the predominate gas with CO₂/CH₄ ratios ranging between 90:10 and 60:40.

Prior to the commitment to mine at Dartbrook, the gas data obtained from boreholes indicated the necessity for gas drainage. A variation between the surface exploration standard and the underground 'quick crush' technique gave a discrepancy of between 1 to 2m³/tonne. Absorption of CO₂ into the acidified brine caused this error. To make a more satisfactory comparison between the exploration and the underground data, the mine employs the quick crush technique in current exploration work.

Reservoir permeability, diffusivity, porosity and sorption isotherms have been determined by laboratory testing. In situ gas pressure has been directly measured. This work indicated that the coal has a fairly low permeability for its depth and is under-saturated with gas.

Gas reservoir modelling has been undertaken to determine gas emission rates upon development and longwall extraction of the Wynn seam. Development gas emission was modelled using the SIMED simulator from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) which uses a two phase 3D multi-component simulator. The indicated rib emission rates range from 20 L/s to 50 L/S per 100 metres and would be markedly influenced by seam permeability and gas content. Based on predictions for a 4 kilometre roadway, two heading gateroad with 8.6 cubic metres per tonne disorbable gas of 80% CO₂ and a permeability of 0.44 mD, a ventilation requirement of 55 cubic metres per second is required.

Longwall gas emission has been predicted using various empirical techniques. The modelling is limited due to most techniques being particular to methane gas. However, gas reservoir estimates indicate between 40 and 55 cubic metres of gas per tonne of coal to be mined, is contained in the immediate floor, working section and roof of the Wynn seam. It was estimated that without gas drainage on longwall one a ventilation requirement of 232 cubic metres per second across the longwall face would have been required to meet the statutory limit of 1.25% CO₂.

The actual seam gas content was 1 to 2 cubic metres per tonne higher than predicted from the borehole data, however the experience to date has demonstrated that the permeability is higher than expected and the gas drains relatively easy. In fact a little too easy as the cumulative rib emissions for a four kilometre gate road (in 2 klm and out 2 klms) culminated in general body readings at the outbye end of the returns of around 1 to 1.20% of CO₂.

Two weeks of development was lost due to gas levels running around the legal limit of .25 % CO₂. Extensive rib drilling was carried out to reduce the rib emissions.

Initial block drainage was trialed using directional drilling to drill 450 metre holes across the block parallel with the gateroads. When gateroads were advanced 450 metres cross holes were drilled across the block at initial spacing of 20 metres which reduced to 10 metres approaching the face installation roadway.

The cross holes were drilled in the seam section, downholes into the 4 metre section below the 300mm tuff floor band and up holes into the 12 to 14 metre coal roof section. Roof holes were determined to be of poor value with only 30 % capture after 6 months due to impermeable carbonaceous bands. Holes were branched off the up holes perpendicular to the stratification which only marginally improved the capture rate. All holes drilled were by directional drilling using a number of drill rigs including LM35, LM55, Boyles and Diamec 262 and Diamec 252. As at November 1997 approximately 300 kilometres of gas drainage holes have been drilled.

With the pre-drainage of the block modelling demonstrated that production would be limited to around 50,000 to 55,000 tonnes per week of production. The Department of Mineral Resources provided special dispensation to allow a special fenced off toxic return up to 3% carbon dioxide. This was later raised to 3.5% CO₂ as the mine production had plateaued at around 60,000 tonnes per week with an average of 20 hours per week of lost production due to high CO₂. As soon as the exemption was given to mine up to 3.5% CO₂ the longwall production levels increased to around 75,000 tonnes per week.

The ventilation system adopted for Longwall one was three intakes and one toxic return with two intakes on the maingate side and one intake up the blockside tailgate and a back return system. To ensure the back return remained open, initially two rows of 6 metre flexi bolts were installed. A number of 900mm auger holes were drilled through the tailgate chain pillars with minimal impact. The last 500 metres of the tailgate of Longwall 1 were supported with 900mm aerated concrete cans to maintain the back return. The cans were easily and safely set and maintained an excellent back return.

The longwall goaf was producing CO₂ and methane at the rate of 5 cubic metres per second and it was decided from the early modelling that post drainage of gas would be required if Dartbrook was ever to be able to meet the statutory limit of 1.25% CO₂. Vertical goaf wells were drilled 70 metres from the installation roadway and approximately 70 metres from the maingate side of the block and connected to a high pressure exhaust fan. Research found there was no experience with goaf wells extracting carbon dioxide. Goaf holes have worked well at a number of mines in Australia and the USA extracting methane but greater suction was required to overcome the buoyancy effect of CO₂. The holes eventually proved to be very successful particularly on the tailgate side of the block at 200 metre intervals exhausting at the rate of 1 to 1.5 cubic metres per second of CO₂ and methane per hole

With two pumps operating, up to 2 cubic metres per second of gas was exhausted which dropped the gas levels in the toxic return by around 0.3% CO₂. Longwall 2 has adopted a homotropical ventilation system which is a mirror image of Longwall 1. The Department of Mineral Resources (DMR) has given approval for longwall 2 based on additional post drainage facilities being adopted to reduce the 3% CO₂ limit in the toxic return to 1.25% by the completion of Longwall 2. As well as post drainage from vertical holes post drainage from seals behind the face line have proved successful. The Longwall 1 face was ventilated with 95 to 100 cubic metres per second which is 3 to 4 times the ventilation quantity on the average longwall face. Longwall 2 is currently ventilated with around 70 cubic metres per second

The four kilometre Hunter Tunnel construction experienced high methane emissions and water ingress associated with a synclinal structure. With the exception of two major dykes (2m and 9m) mining conditions in the tunnel were generally good. Water flows peaked at around 60 litres per second and produced uncomfortable physical working conditions. Water flows are now down to an easily manageable 12 to 14 litres per second. The gas content in seam was as predicted at around 4 to 5 cubic metres per tonne, however the fractured ground associated with the synclinal structure provided a conduit for the high gas emissions. The Hunter Tunnel was holed on the 3rd January 1996 and the 1800mm conveyor was commissioned during Easter 1996.

Spontaneous combustion

Sub bituminous thermal coals of the Hunter Valley have a history of spontaneous combustion events in both longwall and bord and pillar mining operations. In order to determine the propensity of the coal seams at Dartbrook to spontaneous combustion, a series of laboratory tests were undertaken and expert advice sought.

Based on the four tests

- Relative ignition temperature;
- R 70 index;
- Initial rate of heating; and
- Total temperature rise.

It was decided that coal seams in the Dartbrook lease had a medium to high propensity for spontaneous combustion and this would have to be a major factor in the mine design. The risk rating used indicated that the thickness of the seam and the amount of coal left in the goaf to be of particular importance.

The longwall ventilation system was designed as a relatively simple "U" type system with no goaf bleeders. It was also recognised that effective seals and an accurate and reliable monitoring system would be a pre-requisite for safe longwall mining. When one million tonnes of coal was mined from Longwall 1 approximately 3.5 million tonnes of coal remained

in the goaf. With the normal oxidation rate of coal we were running at 120 to 150 litres per minute CO make after 5 months of longwall mining. The Dartbrook conditions are very unique and cannot be compared to any conditions anywhere in Australia or overseas. Expert advice suggested that CO make could not be utilised as an accurate indicator of spontaneous combustion. The racking of CO levels and Grahams ratio (GR) and action response plans were incorporated in the Dartbrook Underground Environmental Management plan (DUEMP).

During April 1997 the CO levels were stable at around 400 ppm at the tailgate intersection of the installation roadway approximately 500 metres behind the faceline. On April the 15th the CO level rose from 450 ppm to 600ppm within 6 hours. At this time the Grahams ratio had risen to 0.62. All persons were withdrawn from the mine at 3.30 pm in accordance with the Spontaneous Combustion Management Plan (Action response plans) and a series of bag samples were taken and analysed by chromatography in Muswellbrook, Maitland and the Mine Rescue Mobile Laboratory to confirm results. The results indicated 80 to 100ppm of hydrogen from the tube bundle point at the edge of the installation roadway. At around 11.30 PM the CO at the installation roadway was 690 ppm CO with a GR of 0.72. Ventilation pressures were reduced across the longwall face by regulating the longwall return. The CO readings started to immediately decline and after 24 hours had settled back to normal. It was shown later than hydrogen was found in a number of vertical boreholes drilled from the surface for exploration and for hydrofrac trials. Helium gas was also discounted from the readings to show a true hydrogen reading. It was later suggested that hydrogen may be a seam gas given off at a lower oxidation temperature.

A similar incident occurred during June where people were again withdrawn from the mine. The cause was believed to be the absence of stoppings in the toxic return inbye the last ventilation cut-through inbye the tailgate. The DMR would not allow these seals to be installed by Mines Rescue teams under breathing apparatus at concentrations above the statutory working limits. After the second incident drop doors were erected in the toxic return every 200 metres which maintained the ventilation fringe shallow behind the longwall face line. No further problems have been encountered since.

Hydrology

Hydrology studies were undertaken to determine water make on development and from longwall goaf caving. Although these studies produced a wide range of results Dartbrook adopted a risk averse strategy to install sufficient pumping to withstand the worst case scenario. Despite the high quantities of water experienced during construction of the Hunter Tunnel, the current working area and longwall goaf is only producing around 1.5 litre per second. The only water created in the mine workings is typical nuisance water, which we create during the mining process.

TECHNOLOGY

Working at 3.9 metres height and longwalling at 4.5 metres presented some interesting challenges and to some extent was underestimated. Unfortunately you cannot procure standard equipment off the shelf to operate at this working height. The question was asked by many people, "why don't you mine at around 2.8 to 3 metres height to match the mining equipment available and ramp up from the gate roads for the longwall like the US mines do". We took the view that higher is better for ventilation efficiency, and to get larger pieces of equipment underground. We saw opportunities to design equipment and systems to mine and install services at this height and our people have designed and developed some very innovative solutions to problems. The 3.9 metre high roadways allowed conveyor belts to be installed against the roof, which allows for machines to move under the belts and makes belt cleaning less labour intensive. It also allowed for gas drainage drilling of the longwall block.

In the current working area of the lease the seam section comprises of three working sections, the Wynn upper A, B and C sections. The Bayswater B seam section also joins the top of the Wynn section and results in a combined coal section of 18 to 24 metres. Dartbrook typically mines 3.9 to 4.0m on development and mines up to 4.5 metres with the longwall to optimise coal quality. Working at heights greater than 3 metres presents a whole range of problems. How to install conveyors, pipes, cables, etc at roof height. A number of very innovative designs were developed to manage the tasks. A platform 1.5 metres of the ground was installed on the Voest Alpine ABM20's to provide a safe working area for operators and ease of installation of supports and ventilation mono-rails. Purpose designed platforms were manufactured for the

installation of pipes and the 1800mm main conveyors. A double crawler mounted tailpiece was designed with a conveyor installation platform to dispense with the development coal and install the 1500mm gate road conveyors. The 3.9 metre height in the development units allowed the opportunity to install a specially designed ventilation and cable management system.

DEVELOPMENT SYSTEMS

Dartbrook's operating structure is based on 5 days per week and 3 by 8.5 hour shifts per day. Initially, our plans were to have 2 production shifts per day and one service shift per day. The idea of the service shift was to not only complete the equipment maintenance orders, it also completed all the mining related activities such as belt extensions, DCB moves and installs 60 metres of supplies on the continuous miner ready for the production shift to have a press button start.

Equipment was designed to enable the conveyor and services to be extended by short increments on the service shift. Unfortunately the development equipment available on the market did not suit the operational aspects of the 2 production and 1 service per day concept as well as the 3.9 metre working height. The equipment size and complexity of the tasks did not provide the 10 quality shifts of production per week desired, so a cyclic system was introduced to allow maintenance activities to fit with the completion of a development cycle.

A new mine has the opportunity to install the latest technology available to the Industry. Dartbrook selected three Voest Alpine ABM 20 Continuous miners with four hydraulic roof bolters and two rib bolters. The ABM20's have an installed horsepower of 542 KW with a 270 KW cutter motor, 2 by 36 KW conveyor motors and 2 by 100 KW pump motors. The TRS canopy provides a footprint force of 2 by 200 KN. The ABM20 loads at the rate of 25 tonnes per minute. Roof support is via four by 4000 series semi-automatic Hydramatic Engineering roof bolters and rib support is provided by 2 by series 5000 hydraulic rib bolters. The support pattern is four 2.1 metre roof bolts at 1 metre centres with 6 bolts through gate road intersections and 4 to 6 rib bolts per metre of advance. Typical mining conditions are shown in Fig. 1

During the evaluation process for suitable development machines for Dartbrook, the Voest Alpine ABM20 Miners was seen as the only tried and proven machine with the capability of installing roof and rib support contiguous with the cutting activity.

Considerable redesign of the machine was undertaken with Voest Alpine to permit the machine to cut to 4.3 metres height and to install an on board sizer. Although the Wynn Seam at Dartbrook has relatively strong coal we did not want operators working between large single pass machines and 3.9 metre high ribs. A work platform was designed for the operators to stand 1.5 metres off the ground, be able to touch the roof and have all tools and supplies at their finger tips. The excavation of an overcast is shown in Fig. 2.

The platform was designed for operator convenience with a bolt box on either side of the machine located immediately behind the operator. Baskets were designed for chemicals, mono-rail fittings etc. Racks were fitted along the sides of the platform rails for spare drill steels and mono-rails. The ABM20 can carry sufficient supplies for 60 metres of roadway drivage. What was considered as one of the hardest and most hazardous jobs in a coal mine is the easiest job at Dartbrook.

Horizon control is managed by setting the working height on the Penpeck radio control system and referencing from the tuffaceous floor. Although the machine is very close to 90 tonne in weight it has low ground pressures and does not break up the floor on intersections. The ABM20's from day one have averaged approximately 5 metres per cutting hour and at times have achieved over 7 metres per hour.

Joy 15SC-32 shuttle cars were chosen basically because there were no other shuttle cars on the market and after mixed results with mobile conveyors at Capcoal in Central Queensland we opted for tried and proven coal clearance systems. Joy Manufacturing were contracted to supply shuttle cars that hold 15 tonnes of coal and after considerable modifications we now have a 15 tonne car which permit us to cycle two cars per metre of advance. The seat on the 15SC's were raised by 500mm which significantly improves the visibility of the driver.

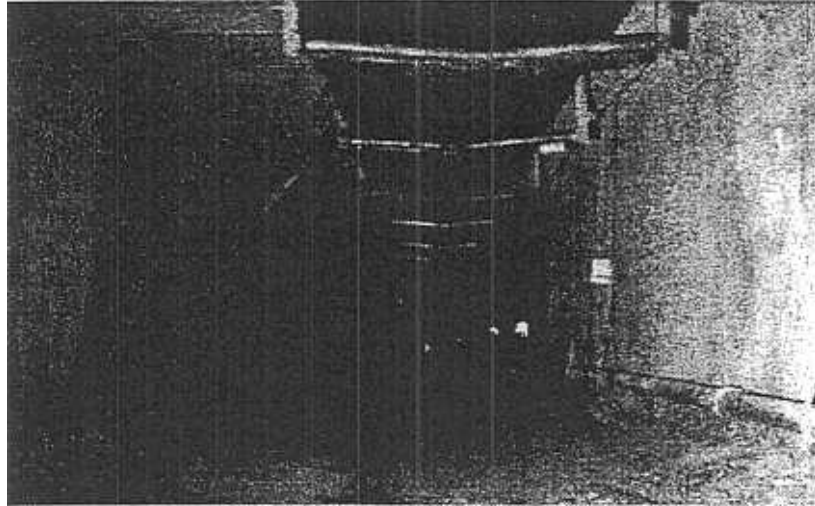


Fig. 1 – Typical mining conditions

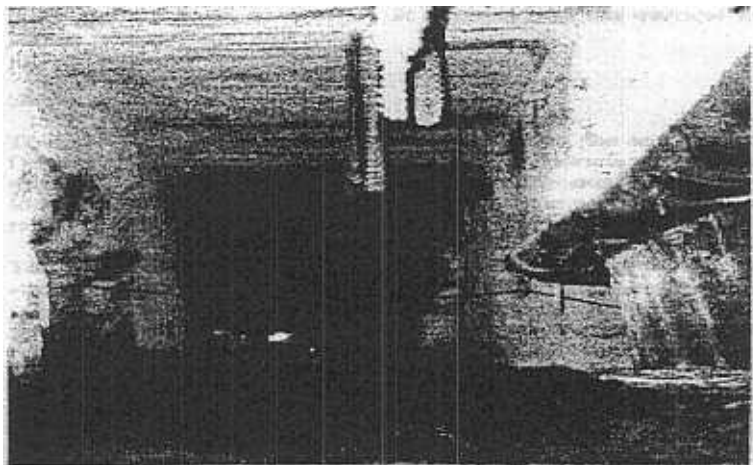


Fig. 2 -Eight (8) metre seam section excavated for overcast

With a new project and a “clean sheet of paper” a systems approach was used to design supply systems, ventilation and development systems. Materials handling is one of the most labour intensive activities and has the greatest potential for accidents in coal mines. Dartbrook designed a supply system of delivery from the manufacturer to the Continuous miner which involves the supplier loading and delivering boxes full of roof and rib bolts and trays that hold 60 straps. These are unloaded onto the ground or direct onto heavy duty trailers on the surface. Eimco EJC 130 LHD's tow the heavy duty trailer to the development panel where bolt boxes and strap trays are transferred to the ABM20 by a QDS hyab crane or by Eimco platforms. A panel support vehicle (PSV) was designed for this purpose and is currently away for modifications to install the bolt boxes onto the miner. The PSV is a crawler mounted machine with a flat deck and a hiab crane arrangement.

Face ventilation is provided by a 720mm diameter monorail mounted ventilation system which is attached to, and advanced by the ABM20 continuous miner and retreated by using a crawler mounted fan. The vent system also carries the

miner cable and 50mm water and compressed air hoses which has resulted in substantial time savings in cable and hose movements. The vent system is a combination of fibreglass and flexible ducting which runs on 1.5 metre lengths of round mono rail.

To enable the 1500 mm gate road conveyor to be installed at roof height and in short increments on the service shift a Development Tail End (DTE) was designed jointly by Dartbrook / ACE and MTA. It is double crawler mounted and has two MBS bolters mounted on the front above the tailpiece to install roof bolts for the belt structure. The unit has side shift and levelling facilities for belt alignment and the unit is aligned by lasers and perspex site boards mounted on the side of the machine. Two lifting platforms are on the outbye end of the unit to enable the belt structure to be installed at roof height. Initially a DCB mounted on a sled was towed behind the DTE with a reticulation cable in a basket behind it. We now have the DCB maintained back at the section transformer and a mono-rail mounted cable and ventilation management system, which advances and retreats with the miner. The ventilation fan is crawler mounted and is used to advance and retreat the system. An outbye compressed air driver moves the reticulation cables outbye the fan. A 30 metres structure pod is positioned behind the DCB sled under the belt ready for the belt extensions on the service shifts.

EXPERIENCE OF THE FIRST LONGWALL BLOCK

The Dartbrook longwall is currently mining the second longwall block. With 18 to 24 metres of coal we have a very large reservoir of gas which have been extensively drilled but experience on Longwall 1 showed that gas capture above the mining horizon was only around 30%. Within the goaf envelope there is a total of three seams with a combined gas content of around 50 cubic metres per tonne extracted. It is difficult to accurately model how much gas is liberated from the goaf but experience from Longwall 1 shows that around 5 litres per second of gas has to be managed by the ventilation system and post drainage from vertical goaf wells and from seals behind the longwall face.

The Wynn seam at Dartbrook is longwalled at between 4.0 and 4.3 metres in height. The first longwall block was 2.2 kilometres in length and Longwall 2 is 2.4 kilometres. The longwall's retreat to the rise with goaf water pumped by a borehole pump at the back of the blocks. Longwall 2 is ventilated by a simple "U" type homotropical ventilation system with no bleed system due to the risk of spontaneous combustion. The first longwall face was installed on a grade of 1 in 5 for 80 metres of the 200 metre face line. The steep grade was managed without problems. We took the view that steep grades will be experienced in several areas and we need to learn how to manage them from the first longwall. The initial faceline is shown in Fig. 3.

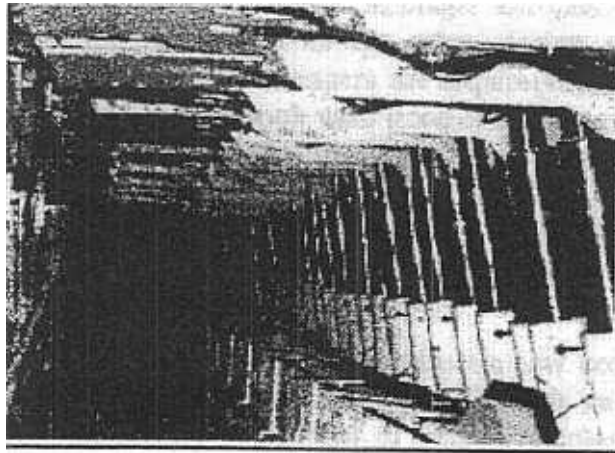


Fig. 3 - Longwall 1 faceline on startup

The longwall was supplied by Mine Technick Australia (MTA) and is 200 metres in length with sufficient horsepower to extend to 250 metres in the future. The Maingate equipment is installed on three self propelled crawler mounted trailers, which are retreated under the roof, mounted belt outbye of the Longwall Tail End (LTE). The LTE is a MTA/ ACE / Dartbrook designed unit which is skid mounted under the BSL and Crawler mounted on the outbye end and elevates the coal to roof mounted conveyors. The LTE has structure recovery platforms on either side at the outbye end where the

structure is recovered and installed in 30 metre structure pods ready for installation in the gate road panels. The specifications of the longwall equipment is shown in Appendix 1. Fig. 4 shows Dartbrook roof supports and AFC.

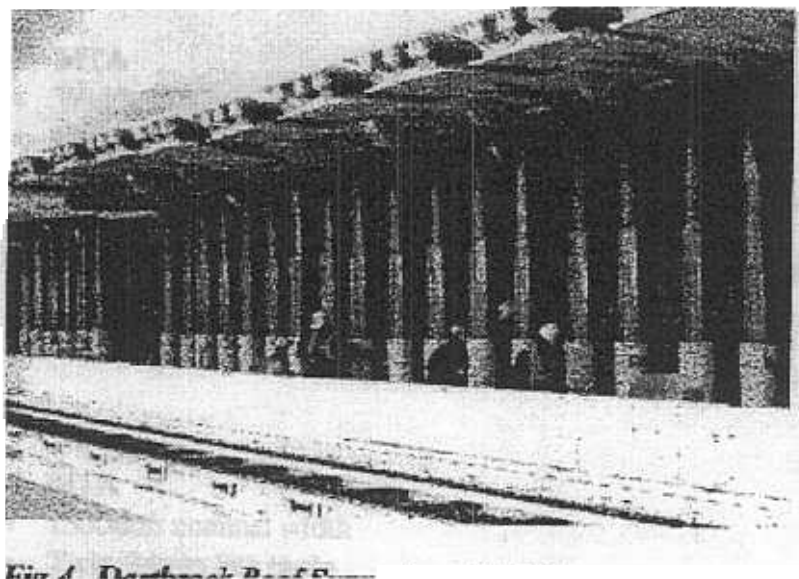


Fig. 4 - Dartbrook roof supports and AFC

Longwall changeover

The first longwall changeover was planned for 20 days and this was not achieved due to delays with the tailgate drive and crusher overhauls and a number of electrical problems. The longwall equipment move was actually completed in 15 days but we did not start cutting coal until 28 days after we started to bolt up the face. The Geogrid mesh, 14 metres in width was used in conjunction with one can and one timber crib per support during shield recovery. This process saved at least 4 days on the recovery and provided a safety barrier to prevent the goaf from flushing into the faceline during the recovery of shields.

CONVEYORS

For a high capacity longwall system the mine required a reliable high capacity coal clearance system. Like most modern underground mines in Australia and the USA, Dartbrook elected to not include a surge bin or bunker in the coal clearance system.

The main conveyor system is 1800mm in width operating at 4 metres per second speed. This gives a designed capacity of 4,200 tonnes per hour or a spill capacity of 5,300 tonnes per hour. The Hunter Tunnel conveyor hauls coal from the mining area to the west of the Hunter River 4 kilometres underground to the coal handling facilities on the eastern side of the New England Highway and main Northern Railway line. The first conveyor from the surface (HT01) is powered by a 2.2 MW drive and hauls coal up a 600 metre long 1 in 5 drift. The second in line conveyor (HT02) is 960 KW and roughly half way along has a 960 KW tripper drive. The drive units were designed by Dartbrook and manufactured by ACE Conveyors with the winches provided by Nepean Engineering. The gearboxes were supplied by Flender and CST drives by Dodge.

The maingate conveyors are also powered by the same drives as the mainraod conveyors (3 X 320KW power packs and CST drives. The gate road conveyors also have a tripper drive installed (960KW) to permit the haulage of longwall coal upgrade for 2.4 km. The maingate conveyors are 1500mm wide and have a designed capacity of 3200 tonnes per hour. After some compatibility problems with the CST software and minor winch programming problems the belts are settling down well. Coal on the surface is delivered to a 1100 tonne bin or can be diverted by a luffing boom to a 50,000 tonne

emergency stockpile. The coal from the bin is fed through sizers and Syntron feeders, through to stackout on to two 200,000 tonne stockpiles. Coal can also report direct to the 1000 tonnes per hour washery.

PLANT CONTROL SYSTEM

To understand and manage equipment and the mining environment a comprehensive and responsive control and monitoring system is a must. After evaluating a number of systems a decision was made to install the Windows based Citect Plant Control System. The system is working extremely well and is very "user friendly". Dartbrook has a control centre manned 7 days per week to monitor the Citect system and acknowledge and respond to alarms.

Underground monitoring-

- Maihak Tube Bundle gas monitoring system;
- AMR environmental telemetry system;
- Continuous miners;
- Conveyor belts;
- Fans;
- Power distribution 66/11 KV;
- Gas drainage plant;
- Longwall;
- Vertical goaf gas drainage pumps; and
- Dewatering pumps.

Surface monitoring

- Compressors;
- Water reticulation ;
- Sewerage plant and water treatment plant;
- Irrigation system
- Office security and fire alarms;
- East site coal handling plant;
- East site bins and conveyors;
- Stackers and reclaimers;
- Train loading bin and system;

- Weather station

The system is PC based with Allen Bradley Programmable Logic Controller (PLC) and Small Logic Controller (SLC) equipment to provide data on a regular basis, which is collected by the Citect software for display to the control room operators and a number of site offices including the mine managers office.

FUTURE PLANS

Dartbrook is currently undertaking exploration work to the west and north of the current mining lease to extend the reserve base. Dartbrook needs to produce in the vicinity of 3.5 million tonnes per annum to provide the shareholders with an acceptable return on capital employed. Gas drainage is a large cost impost on any mine but at Dartbrook it represented around \$6.00 per tonne in 1997 which has to be reduced for the mine to survive. Gas drainage is time dependent and we now have pre-drained for the next two longwall's beyond Longwall 2 and have reduced our gas drainage effort by one third. A lot was learnt on Longwall 1 which has allowed us to reduce the amount of pre-drainage with optimum drilling patterns and with the experience of successful goaf drainage holes. We believe that we now understand the parameters for effective pre and post gas drainage for longwall mining and understand the fundamentals to manage the risk of spontaneous combustion.

SUMMARY

Dartbrook Mine has not reached world class as yet but the basic elements are in place to provide a safe, efficient and profitable business.

The same level of enthusiasm and energy is still evident at Dartbrook that existed when the mine started 3 years ago. A high level of trust exists between all parties at Dartbrook and this helped through the early operational problems of learning to work at heights and the development of suitable equipment and systems to mine a thick coal seam full of gas and achieve high advance rates on development and planned tonnages of the longwall.

In summary the advice to any new Project Manager would be to allow sufficient time to gather and interpret an extensive data base of knowledge on the resource and to establish the best mine plan and cost structure. Invest money and time to employ the best people, train them well and have the best possible labour agreements in place. This is the best chance you will ever get to set the mine up on a stable foundation and take all the advantages presented by a greenfields opportunity.

APPENDIX 1

LONGWALL SPECIFICATIONS

MTA;

- Shearer Initiation;
- 116 X Two leg 913 tonne shields;
- 1.75 metres wide shields;
Range 2.2 metres to 4.8 metres;
- Face support mass 26.56 tonnes;
- Gate road support mass 27 tonnes;
- High strength steels 700 UTS;
- Support density 118 tonnes per sq metre;
- Full automation and data transmission to surface through Citect system;
- PM4 electro hydraulic support control units (SCU's);
- Leg pressure and push ram displacement transducers;
- Water sprays in canopy's; and
- Rear walkway in canopy down to 3.3 metres operating height

Shearer

- Long Airdox (Electra 1000);
- Cutting range 2.5 m to 4.5 m;
- Installed power 1332 KW, 3.3KV;
- Cutting drum diameters 1.9m to 2.5 m;
- 2 X 500 KW cutter motors;
- 2 X 56 KW DC haulage motors;
- 200 KW lump breaker;
- 20 KW hydraulic pump motor; and
- Hiab type crane on MG end.

Pumping system

- MTA;
- 3 X 275 l/min @ 350 bar Hauhinco hydraulic pump sets mounted on a crawler mounter trailer;
- 250 KW motors on each pump;
- 10,000 litre stainless steel tank with 1,500 litre mixing tank;
- High pressure shearer water pump mounted on crawler mounted trailer with tank.

AFC

- MTA
- Width 1150mm;
- Capacity 3200 tonnes per hour;
- Twin 42 mm Compac link chain;
- Automatic chain tensioning at Tailgate;
- 2 X 800 KW motors driving CST's at Maingate and Tailgate;
- Slow chain speed running; and
- Provision for fitting of pan tilt cylinders.

BSL

- MTA;
- 1500mm nominal width;
- Twin 34mm link chain;
- 350KW drive motor;
- Slow running device fitted; and
- Full length dust suppression system

Crusher

- MTA (Westfalia Becorit);
- 1800 mm width;
- High Inertia impact roller; and
- Size coal to minus 150mm.