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Improving productivity and viability of underground coal mining

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IMPROVING PRODUCTIVITY
AND VIABILITY OF UNDERGROUND
COAL MINING

A thesis submitted in the fulfilment of the requirements
for the award of a degree of
Master of Engineering (Honours)

by
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ABSTRACT

The Coal Mining Industry has evolved from the days of Land mining into a highly mechanised process becoming Australia’s largest export industry and the major source of fuel in the generation of power required for both industrial and domestic use.

As in all commodity markets the Coal Mining Industry will only remain viable whilst the product can be competitive with alternate fuel sources such as Hydro-Electric, Solar and Nuclear Power. In order to meet the above objective it is important to maintain products superior in quality or cheaper to other sources such as Asia, South Africa, Europe and North America.

Over the last two decades highly productive longwall units have been developed to provide bulk tonnes from operations, however, other important support services have largely been ignored. Exploration techniques required to understand the resource prior to mining are inadequate. Safety performance is not competitive with other industries. Development and auxiliary equipment are largely incapable of providing timely exposure of coal and support to longwall equipment. Marketing and transport infrastructure is costly. Maintenance is generally carried out to meet legislative requirements. Industrial relations and human resources management issues have often been referred to independent arbitrators for settlement.

This thesis systematically addresses the major components involved in improving the productivity and viability of the underground coal mining industry. Whilst each individual component may have an incremental effect on the industry, but collectively they may have a major effect on competitiveness.

Chapter 1 summarises the current exploration techniques available to understand a resource and predict mining conditions prior to commitment to major expenditure. It also describes some of the impediments to running areas for legislative reasons.

Chapter 2 describes the marketing and transportation opportunities available within the mining operation.
Chapter 3 demonstrates the cost to the industry of poor safety performance and the opportunities for cost saving where industry attempts to eliminate disabling injuries.

Chapter 4 analyses the reasons for industrial disruption in the Mining Industry and the cost of this industrial disruption both directly and because of poor work performance.

Chapter 5 describes mainly the development machinery presently available to the industry and that machinery being introduced in order to gain the “quantum leap” in development performance, thus, leading to greater utilisation of longwall equipment.

Chapter 6 describes changing philosophy to maintain mine machinery by better condition monitoring techniques whilst sharing improvements with equipment suppliers.

Chapter 7 details conclusions and recommends further research.

In order to achieve the optimum improvement in productivity and viability of underground coal mining in Australia, this thesis demonstrates the interdependencies of exploration, marketing, safety, human resources, machinery and maintenance.
CHAPTER 1

EXPLORATION AND LAND USE FOR IMPROVING PRODUCTIVITY AND VIABILITY OF UNDERGROUND COAL MINING

1. Introduction

Exploration techniques presently available have recently been inaccurate in predicting how successfully the resource can be mined once entries have been formed to the seam and ultimately when extraction has commenced. This is demonstrated by the initial poor production performance at Tower Colliery where an undetected 20 m down throw fault was struck 100 m from the main downcast shaft in 1980. A 12 high 11 gas regime at Dartbrook Colliery impeding development for the first longwall block, poor roof conditions on development at Springvale Colliery (Duncan and Larcombe, 1996) and subsequent gate failures on longwall extraction and almost impossible longwall retreat conditions at North Goonyella Colliery. Whilst Gordonstone has now reached acceptable production levels, the initial drivages were two years behind target, and subsequently longwall production targets were not met.

Once initial exploration has been undertaken large coal reserves have been sterilised due to legislative constraints around surface structures. Recently South Bulli Colliery has mined a high quality reserve under Cataract reservoir; this coal was previously sterilised by legislation.

1.2 Exploration

The primary aim of coal exploration programs is to locate a deposit and subsequently take samples so that the quality of the product can be tested. These tests determine seam thickness and marketability (Phillip and Haynes, 1990). In some circumstances the stress regime may be anticipated by determining joint patterns from the coal sample. This predication techniques has however proven to be unreliable.
Exploration involves geological techniques such as traverses, mapping and sampling and geophysical techniques.

It is possible in aerial photography to recognise and plot possible areas of geological disturbance mainly to predict major faults and dykes. Once these features have been plotted, boreholes from the surface can be planned to confirm the approximate extent of these anomalies.

Unfortunately these geological anomalies do not always cause displacement to the surface in the case of the faults and dykes may commence underground and find weaknesses in surrounding strata only to form into sill areas below surface terrain.

Small faults of less than two metres are difficult to detect even using bore hole information, however, they cause extremely difficult mining conditions when the seam is being extracted, particularly by the longwall method.

Geophysical methods of exploration using gravity, seismic, magnetic and electrical methods are commonly used as integral parts of exploration. The gravity survey can be used to determine the existence of volcanic intrusions within an area. It basically relies on a variation in density between different strata. Where a coal seam is intersected by a geological feature the mass contribution changes and interpretations are presented using a Bouguer anomaly map. This method of exploration is extremely expensive.

Magnetic methods are also used to determine the existence of areas containing igneous intrusions such as sills dykes and plugs. These magnetic surveys can be carried out using helicopters and aeroplanes. They rely on detecting changes in the earth’s magnetic field. Iron and other metallic objects can be magnetised producing a magnetic field around it. Igneous rocks especially, basalt contain more magnetic minerals and are susceptible to stronger magnetic fields. Some shear or fault planes may be identified where iron rich oxides are deposited along the fracture planes and are detected using magnetic methods (Hutton, 1995).
The Electric method relies on the fact that all rocks and surface materials conduct electricity, even if only slightly. Geological changes may therefore be determined by measuring the difference in the conductivity of the coal compared to any structure intersecting the seam.

Seismic surveys have been undertaken in the oil industry for identifying anticlines and faults. These methods are now widely used in the coal industry. This method shows layering and structure as well as an indication of rock properties. It relies on the conductivity of sound waves through different strata.

1.3 Land Use

Whilst there is a close association between coal mining and land development, conflicts have still arisen. The development and growth of eastern cities such as Wollongong and Newcastle were originally due to the proximity of coal as an energy source. However, the number of potential sites available for construction of mining operations is being reduced and the amount of coal that can be extracted is being restricted. Although New South Wales has very large resources of coal, about half of this resource is affected by other land uses. It is estimated that approximately 30% of NSW coal resources, which are economically mineable, have been sterilised. The conflicts are due to urban development, conservation areas, agricultural land, transport and communication corridors and public utilities, such as railways, bridges, roads and water storage reservoirs.

1.3.1 Effect of Subsidence

One of the affects of coal mining on the surface is subsidence which may be caused by underground mining. Subsidence can affect the stability and integrity of natural and man-made features on the surface. Overall production and productivity may be affected where coal mining is limited in order to protect these features. In some cases continuing mining is not economically viable due to the restrictions to protect surface
features. Open cut mining also affects agricultural land, surrounding towns and natural features.

Mining operations may be jeopardised when resources are not considered when decisions relating to land use are made. Pressure from the public may also influence government decisions on land. A working party of the Coal Resources Development Committee (Anon., 1994a) suggests that environmental constraints as well as land uses may, if not already, affect the extraction of coal resources. Such constraints include natural features, heritage sites and groundwater resources.

As urban development expands, more coal is sterilised particularly throughout New South Wales. Areas particularly affected are Newcastle coalfields which contain the two relatively large populated cities of Newcastle (133,000 people) and Lake Macquarie (158,000 people). Expansion is likely to occur in the area of Wyong-Gosford due to its proximity to Sydney. Mining operations in the Newcastle region are faced with restrictions because mining takes place at relatively shallow depths. These restrictions limit the amount of coal that can be extracted to ensure subsidence does not cause damage to above lying features. The Southern coalfields are also affected, however, mining is at greater depths.

Subsidence may cause damage to the foundations of buildings, however, mining operations can accurately monitor subsidence and maintain it at a required level. The extent of subsidence depends on the depth of seam, thickness of seam, number of seams and behaviour of strata above seams.

The inaccurate implementation of control measures in a longwall mining operation below Lake Macquarie allowed subsidence to be visible causing public pressure for governments to impose strict legislation on mining operations.

Without multiple land use, large reserves of coal will be sterilised. This is the situation in the fast growing areas of Wyong-Gosford and Macarthur region west of Sydney where further urban expansion is planned. Transport infrastructure must also be
provided in order to deliver the coal to either the port for export or to domestic consumers.

Inhabitants of rural towns can be affected from mining operations when the operation is relatively close to the town. Towns and neighbouring farms around Muswellbrook and Singleton are areas where mining is in close proximity to the town. Not only is there the potential for unpleasant visual aspects but uncontrolled noise and dust may also cause problems when adequate screening is not implemented. Very comprehensive procedures are required before mining is permitted. Thus, mining operations may not be financially viable in these areas.

1.3.2 Visual Impact of Subsidence on Cliffs

In the Western coalfield of New South Wales, mining under cliffs has previously caused subsidence and now careful planning and monitoring must be undertaken to ensure that no further damage is done to these cliffs. There may be the potential for sterilisation in this region if further damage occurs.

Approximately 22% of economic coal resources lie beneath National Parks. This coal is presently sterilised because of potential subsidence or through limiting land access to provide the infrastructure to mine these areas.

1.3.3 National Parks

Conservation areas consist of National Parks, Wilderness areas, Nature reserves and State Recreation Areas. These areas provide preserved environments so the flora and fauna remain in their natural state. They are dedicated to providing the public with areas for enjoying the natural unspoiled surroundings, for education and recreation. Some of the areas may also include historic sites such as buildings or monuments.
1.3.4 State Recreational Areas

Mining can only be carried out in State Recreation Areas with the permission from the Minister for the Environment. At present there is one mining operation extracting coal within the Illawarra State Recreation Area but this is an isolated case. There are concerns that the National Parks and Wildlife Service, who are responsible for the management of State Recreation Areas, may impose such restrictions on coal mining so as to make any operation uneconomic.

There is also the potential for further sterilisation of coal resources in proposed national parks and state recreation areas. Unless the classification of areas for national parks and state recreation areas involves the consideration of mineral content in an informed decision over the choice of protected areas, further coal resources will be sterilised.

1.3.5 Mining under stored bodies of water

There are coal resources overlain by stored bodies of water but mining in these areas has been restricted to first workings only.

In the Southern coalfield the Cordeaux, Cataract, Avon and Nepean Dams store water for the surrounding area. Despite the cover between underground mining operations and the dams, which exceeds 250 metres, there are major limits on the extraction of coal. The Water Board has implemented these limits to minimise subsidence that may occur during operations.

1.3.6 Mining under railways

Until recently, the State Rail Authority would not allow mining to occur under railways but evidence supplied from Europe has shown that mining can occur under such infrastructure with no damage to railway lines, roads, bridges and transmission lines. Mining has been allowed to occur under the Northern Railway at Teralba and the
railway lines have not been affected. Teralba Colliery implemented precautionary measures to ensure subsidence would not affect the railway however, a large cost impact was placed on the company.

The State Rail Authority in NSW has now established guidelines for mining under railways and this will allow the extraction of coal resources that would have previously been sterilised.

1.4 CASE STUDY - Mining Under Cataract Reservoir At South Bulli Colliery

In 1988 it was decided to formulate a plan to mine an area of coal under Cataract Reservoir previously sterilised by legislation permitting any extraction of coal under the reservoirs which provide water to both the Illawarra and Sydney urban areas.

The reason for these areas being sterilised was that in the event of catastrophic failure of the strata being undermined the water supply to these areas would be severely affected.

By 1991 a mine plan was developed using a conservative approach to panel geometry basically extracting longwall blocks of 90 metres in width and leaving chain pillars of 100 metres by 60 metres to support the strata below the reservoir. (Figure 1.1)

In late 1991 a submission was presented to the Dams Safety Committee, the Department of Minerals and Energy and the Water Board for approval. This approval
was subsequently given by the Minister for Mining and Agriculture in New South Wales subject to the following conditions;

a. Underground seam mapping was to be carried out to extrapolate known geological features which may impact on the stability of the strata below the reservoir.

b. An in seam seismic survey using boreholes within the seam to identify any structures that may lie within the seam but had not been revealed by previous extraction from areas around the reservoir.

c. A detailed surface subsidence grid to accurately measure subsidence around the perimeter of the reservoir.

d. Mine water monitoring to measure the water inflow into the mine was carried out by means of water balance studies of underground operations. This was carried out by measuring the quantity of water provided for dust suppression and drinking and measuring the quantity of water pumped out of the mine during normal operations. Any increase to this imbalance may indicate fracturing of the strata to the reservoir.

e. In-situ strain measurements carried out using strain gauges capable of measuring strain in 0.1 mm per metre the equipment being used for this measurement is similar to that used to monitor the San Andreas fault in the United States.
f. Ground water monitoring using piezometers to measure variations in water pressures contained within the strata above the areas to be extracted.

g. Pillar loading and deformation using gauges to determine whether the chain pillar remaining after longwall extraction has deformed as a result of extraction.

1.5 Mining Under Cataract Reservoir At South Bulli Colliery - Monitoring Results

After completion of the first six longwall blocks subsidence has been measured as 262 mm maximum. Maximum, calculated tensile strain is 0.87 mm per metre, whilst in-situ strain is 0.01 mm per metre.

Stress increases to 5mm per metre at the centre of the pillar. Additionally at least 70% of the pillar has remained unaffected by extraction.

1.6 Conclusion

The ultimate success of each new or operating coal mine is dependent upon an exploration systems carried out prior to mining. This exploration can be constrained by the inability to fully model the effects of mining with underground machinery.

Stress regimes and caving characteristics when extraction takes place are not accurately predictable during initial exploration.
With up to 30% of coal deposits lying beneath National Parks or other areas restricted by the legislation the case study mining under the Cataract Reservoir demonstrates that extraction of these reserves is possible causing minimal disruption to surface structures.

Mining under Cataract Reservoir will be used as a benchmark throughout the industry to open up new reserves of potentially highly successful economically sound mining operations.
CHAPTER 2
THE IMPACT OF MARKETING
FOR IMPROVING PRODUCTIVITY AND
VIABILITY OF UNDERGROUND COAL MINING

2.1 Introduction
Coal production in Australia has been steadily increasing over the past 35 years and coal has become Australia’s largest export commodity. The majority of the production is exported and as a result, Australia is now the world’s largest coal exporter. Australia has achieved this position because of the relatively small population and unlike other major producers of coal, exports a large proportion of production due to minor requirements for domestic purposes.

The coal production that is retained for domestic purposes is primarily used for coal-fired power stations throughout New South Wales and Queensland and the steel industry which requires coking coal. Coal that supplies New South Wales needs is obtained from the New South Wales coal industry and similarly the Queensland coal industry meets industry requirements in Queensland.

2.2 Internal Factors
Within NSW there are several consumers of coal. The major consumers being power stations and steel works which demand the largest share of the coal produced in NSW. Table 2.1 displays the domestic consumption of NSW coal and Table 2.2 shows proportionate usage of coal in NSW in 1994.

| Table 2.1 Distribution of NSW coal (in million tonnes) (Source: Anon. 1995a) |
|-------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Coke Works                    | 0.286   | 0.316   | 0.320   | 0.329   | 0.290   |
| Cement                        | 0.450   | 9.411   | 0.357   | 0.377   | 0.376   |
| Railways/gas                  | 0.29    | 0.1     | 0.1     | 0.1     | 0.1     |
| Other                         | 0.664   | 0.569   | 0.522   | 0.443   | 0.430   |
| TOTAL                         | 24.360  | 27.858  | 27.915  | 28.105  | 28.631  |
2.2.1 Power Generation

Electricity generation is the largest domestic consumer of coal within NSW. Coal-fired power stations are responsible for generating 90% of electricity in NSW, of this 90%, Pacific Power (ELCOM) operates approximately 95% of NSW electricity generating capacity with coal-fired power stations. They operate six coal-fired power stations and have three sources of coal supply for power generation. These are underground coal mines operated by companies owned by Pacific Power, Ravensworth Mine which is under long-term contract and other privately owned companies under long-term contracts.

2.2.2 Steel Industry

NSW coal production is also the source of coking coal supplies for the Australian steel industry. Within this industry, the primary consumer of coal is BHP, who is the major producer of steel in Australia. Coal required for BHP steelworks is supplied from its own underground mines in NSW and other mines within NSW's coalfields. It is expected that BHP's demand for coking coal will remain constant over the coming years or may even decline by the year 2000.

2.2.3 Miscellaneous Coal Users

There are several other domestic consumers of NSW coal but these amount to a small proportion of total consumption within the state. They include the cement, food processing, brewing, sugar refining and chemical industries.

There is a similar situation in the domestic use of coal in Queensland as with NSW. In Queensland, electricity generation by coal powered stations is the major domestic consumer of coal production.
2.2.4 Domestic Coal Consumption in Queensland

Austra Electricity generates 98% of Queensland electricity from coal fired steam turbines under its operation. It is the major domestic coal consumer in Queensland, using approximately 18% of total coal produced in 1994. Unlike the NSW situation, Austra does not own any mines and depends on tendering from privately owned mines for its supply of coal. However this process may not continue in the future.

Queensland produces both high quality coking coals and low sulphur thermal coals. The power stations have been designed to burn low quality coal and acid rain is not a risk due to the low sulphur content of the coal. Table 2.3 outlines the coal consumption of Queensland power stations.

Australian coal producers need to be remain competitive in the coming years to retain the power companies as the major domestic consumer of coal. Although energy
consumption in Australia is expected to grow by 1.7% (Errington and Rudenno, 1995) till the year 2010, there is increasing pressure to reduce the cost of energy generation and environmental pressure to reduce the amount of green house gases emitted in energy generation. Coal has high levels of carbon dioxide emissions and will face increasing competition from gas in electricity generation due to lower green house emissions.

The Australian Bureau of Agriculture and Resource Economics forecast, that in general, the demand for coal by domestic customers will remain constant over the next 10-15 years. There will be opportunities for underground coal mines to provide more coal which will be achieved through growth in productivity.

The amount of supply of coal to domestic consumers may be effected by new policies set to reform the competitiveness of the electricity and gas markets and thus enhance the national economy. The Australian government has set in place new policies relating to the electricity and gas markets due to the implementation of microeconomics reforms throughout Australia in recent times. These policies are set to reform the market by establishing ‘more open trade and prices so that they reflect the cost of supply.’ (Errington and Rudenno, 1995). The Hilmer Report is a set of policies that have been accepted to achieve this reform.

There is potential for increased production of coal for use in electricity generation interstate if the deregulation of the eastern energy market is achieved. The National Grid Management Counsel was set up by the Commonwealth Government and governments of the eastern states in 1991 to try to establish this interstate grid as part of the Hilmer reforms. NSW coal producers may be in the position of supplying additional electricity interstate and benefit greatly due to the surplus generation capacity that its power stations are capable of.
Although Australia's energy consumption is expected to rise in the coming years, there will be no more coal-fired power stations built for the next decade. Productivity will be important to coal producers in order to achieve maximum profits in the domestic market against competing mining operations. The Mt Piper coal powered station was commissioned in 1993 and it will be the last major station to be built until the year 2005. It is expected that Mt Piper and the Loy Yang B station in Victoria, that operates on brown coal, will be able to supply increased capacity if need be. If however the need for additional power is required, it is expected that these needs will be met by increasing the efficiency of already existing power stations.

Despite the fact that no further power stations will be built it is still expected that the demand for thermal coal for power stations in the Newcastle, Hunter and Western Coalfields will increase annually by 25 Mt by the year 2000. (Anon., 1995a). There are also several mining operations investigating the potential of 'coal seam methane resources and extractive technologies for the future recovery and utilisation of methane for power generation and gas reticulation.' (Anon., 1995a).

If this is economically viable and practical, then it would ensure that the underground mining industry would remain viable.

With increased competition in the market and between producers, it is likely that the preferred fuel for electricity generation will be gas over coal. It is more suitable for cogeneration and emits less green house gases than coal. However, even though it is expected that gas will be the main beneficiary of the Hilmer reforms, the demand for coal in the long term is promising if the development of steaming coal operations for domestic use are implemented before gas becomes less expensive in the next five to ten years. Productivity will be crucial in achieving this. For coal to remain competitive, there is also increasing pressure to improve the performance and acceptability to the community of coal driven systems.
2.3 External Factors

There are export opportunities for Australian coal but industry needs to remain productive to acquire and retain these markets. This is despite the claim that customers have tried to create an over supply and thus reduce the export opportunities. Australia is ranked as the largest exporter of coal and in 1994 exported 130 million tonnes to 36 countries (see Figure 2.1). In 1995 New South Wales coal was exported to 29 countries throughout the world (Flint, 1995).

![Figure 2.1 Destination of NSW Thermal Coal Exports (Source: Flint, 1995)](image1)

![Figure 2.2 Destination of NSW Coking Coal Exports (Source: Flint, 1995)](image2)
In total Australia holds 30% of the world market. Of that, about one third of the seaborne coal in steaming coal (see Figure 2.2 and Figure 2.3) and one half of the seaborne trade in metallurgical coal. (Anon., 1994) Figure 2.3 shows Australia’s share of coal in comparison to the world.

Figure 2.3 Australia’s Share of Seaborne Exports by Type (Source: Dunlop, 1994)

The majority of Australian exports go to Japan, Korea and Taiwan. Australia holds a commanding share of the Japanese coal market and is the main export market for Australian coal. This is one of the critical coal markets due to the premium prices that the Japanese pay for coal. The Japanese pay the highest prices to ensure they are able to choose the quality of coal that is most suited to their needs, for guarantee and priority of supply and diversification.

There is very fierce competition among exporters to supply Japan. Japan has very little resources and is dependent on imports of coal to meet its industrial and energy needs, primarily in the steel and electricity industry. From past experiences with the OPEC oil shocks, Japan has learnt the importance of ensuring a reliable supply of resource. As they are so reliant on imports, their objective is minimise cost in the long term without compromise to quality or quantity. Minimising costs means that Australia will have to
improve productivity to maintain the key role it currently holds in this market and any hope for increased market share.

Korea, Taiwan and Hong Kong are also important customers and amount to a substantial amount of Australia exports after Japan. The European countries of the Netherlands, United Kingdom and Belgium-Luxembourg are also significant customers of thermal coal exports from Australia.

There is the possibility that Germany may start importing coking coal. This may present the opportunity for Australia to supply them. Germany is the largest steel industry in the European Commission and is currently under the Hüttenvertrag, which requires that they use domestic coal sources. However, this is causing economic difficulties and the steel industry is looking to end the contract before the specified time of the year 2000. The recent import of coking coal from BHP indicates that in the long term Germany may import substantial amounts of coal.

![World Imported Coal Demand](https://example.com/figure2.4.png)

Figure 2.4 World Imported Coal Demand (Source: Dunlop, 1994)

There is additional export potential for Australian underground mines due to a forecasted strong demand for imported coal up to the year 2000. In a study by Barlow Jonker, (Dunlop, 1994) it is estimated that the world import demand will be at 510 million tonnes by the year 2000. (refer to Figure 2.4) and Australia has the potential to rise to 225 Mt export capacity in 2000. (Refer Figure 2.5) This is compared to the 1990 value of 107 Mt. (Refer to Table 2.4).
However, the coal market is driven by supply and not demand and it is expected that supply will continue to outdo demand. Therefore, Australia coal mines need to be competitive.

![Diagram showing World Imported Coal Demand](image)

Figure 2.5 Australian Coal Export Capacity (Source: Dunlop, 1995)

A report by Errington & Rudenno indicates that there is a strong demand for Australian coals at the present. (Errington and Rudenno, 1995) In their monitoring of Australian stockpiles, a short supply of coal was evident. There is a strong coal market outlook with new export opportunities and an apparent shortage of supply. However, they expect that it will weaken in the next three to four years due to various factors.

<table>
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<th>Table 2.4 World's Largest Producers of Coal 1994</th>
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<td><strong>Country</strong></td>
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<td>China</td>
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<td>Australia</td>
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In the coking coal market, there continues to be a strong demand for Australian coking coals. This is due to the increase in production of world steel and pig iron of which coking coals are used to produce. This increase has come from both the Asian and European steel industries with India also playing a part. The Indian pig iron
production is progressing at a very fast rate, and with their construction of a new 10mtpa integrated steel mill, it is optimistic that they will be looking to Australia for long term coking coal contracts. This is also supported by the forecast that steel and pig iron production will remain strong.

An increase in productivity in underground coal mines would maximise the return on coking coal exports. However, the Competitor Analysis of Australian Coal Producer Report forecast indicates that production will remain flat despite efforts to increase production (Errington and Rudenno, 1995).

The Australian Bureau of Agriculture and Resource Economics also forecast that demand for coking coal will remain flat. The coking coal market is remaining stable due to improved efficiency in blast furnace steel technology in both the European and Japanese community. However there will be significant growth in the thermal coal market over the next 10-15 years due to strong Asian growth and their need for thermal coal for electricity generation. This is supported by the ABARE that predicts a growth in the thermal market due to strong commitment to coal fired power generation in Asia. There is potential for India, Pakistan and the Philippines to also become export customers of Australian thermal coal.

Investment in NSW coal mines from export customers has helped secure the export market. Customers have invested in Australian coal to maintain a secure supply of quality coal. These investments are not likely to encounter problems as the Government encourages overseas investment into coal mines. This has the potential to maintain overseas markets.

There are marketing opportunities for Australian coal producers to increase their supply of coking coals. If productivity can be maximised, then there will be higher returns on profit. But they do need to capture the market first and retain it when it weakens.
Productivity will be of great importance and the underground coal mines will only be viable if this is achieved.

2.4 Competitiveness

Although Australian coal exports have been steadily increasing, market share has been decreasing due to increasing competition. Australian coal needs to be more competitive and more flexible than competitors due to the fact that Australia does not have a large domestic market to rely on when the demand in the international market is not strong. The Australian economy relies heavily on the placement of coal and thus it is imperative that it retain ahead of its competitors.

Despite advantages such as proximity to market, high quality coal and a major share of the critical coal markets, Australian has lost ground in the World Competitiveness stakes (Errington and Rudenno, 1995) due to government charges on rail freight which in turn have inhibited productivity growth and the increase of new low cost exporters entering the market due to diversification of coal from leading importers such as Japan. This is among other factors including decreasing coal price, labour reforms and competition from other energy sources.

Australia has attained the position of largest exporter (refer Figure 2.6) due to various advantages over other countries including proximity to the Asian market and location of coal resources close to the coast and transport systems. However to remain competitive, productivity gains need to be better than the competitors and there needs to be substantial returns to mines as Australia can no longer just rely on these advantages. Despite the fact that Australia is not the largest producer of coal, it still holds the largest world export share due to small domestic requirements.
Australia has developed a commanding position of the critical coal markets such as Japan. Australia’s share of the Japanese coking coal market has been gradually increasing over the years. However Japan is diversifying supply away from Australia in order to spread consumers risk. This may see new exporters enter the market as they see the opportunity to gain a share of this very important market by exporting their coal resources.

Although the forecast for the export coal market varies between groups, there is a general view that the demand for imported coal will be strong up until 2000 but it is expected that supply will outdo demand (Anon., 1994c).

Not only has diversification away from Australia supply been undertaken by Japan but South Korea and Taiwan are also doing so and both of these countries are important importers in the thermal coal market. This diversification has led to new exporters entering the market and increasing competition.

The new exporters that have recently entered the market due to these opportunities include Colombia, Venezuela, Indonesia and China. This has been possible because of
the fairly large dispersion of coal resources around the world and the relatively low cost structure required by producers. It can also be expected that more will enter the market. As the demand in the thermal coal market is likely to increase, it is expected that there will be increased competition from lesser developed countries.

Indonesia represents the most significant threat as a competitor to Australia in the thermal coal market. Most of Indonesia’s coal resources are found on the island of Kalimantan where they are mined in an open-cut method. Factors leading to its increased competitor threat to Australia include a coal that is of high quality, low fuel costs, low labour rates, close to ports and very low overburden removal costs. The only major problem they are experiencing is lack of transport infrastructure but this is being overcome by overseas investment. The very low cost at which Indonesia is capable of producing coal may cause the price of coal to decrease and therefore Australian underground coal mines will have to be productive to retain the market.

In the thermal coal market, Australia is likely to remain the main exporter to the Asian market. This is due to the proximity of the Australia compared to other countries to the market. Australia has a freight advantage over the other countries and also offers a high quality coal with low sulphur and ash. Continued reliability of coal supply should ensure market share. However Indonesia is becoming a competitor to Australia due to similar advantages such as freight costs, low mining cost and low ash coal.

There is also the recent threat from China and Russia with the opening up of their economies. Both these countries have large reserves of coal and other fuels that have until now not been utilised. How these countries decide to use and market these fuels may well influence the energy market and affect other exporters. The major competitors to Australia in the coking coal market are the United States and Canada. The competition in this market is not quite so strong and Australia is likely to be the major exporter to the Asian market due to the cost advantage that it holds. Unlike the
thermal coal market where competition is coming from lesser developed countries, the coking coal market has mature industrialised countries. Competition may be increasing though with Canada and the United States producing coal from mines with similar cost structures to those in Australia. In particular in North America, they are working towards greater productivity gains.

Australia needs to have competitive cost structures which in turn require high productivity to continue to be competitive as other countries are meeting Australian prices and threatening to gain increased export market share due to their low cost structures. This includes Indonesia and China. Australia does have freight advantages over many competitors but due to the charges imposed on producers, are losing ground on what should be advantageous.

2.5 Transport

Productivity is effected by operating costs and coal mines have found it increasingly difficult to reduce these costs. One of the primary reasons being the lack of efficient transport infrastructure due to government control and charges. As many underground mines are situated some distance from port, they are burdened with rail freight charges to deliver the coal to the port for export. Rail freight and state charges are quite high and this is a distinct disadvantage for Australian producers against other competing countries (see Table 2.5). The average price of A$17/t required from mining operations to deliver coal to the port and load it on the boat is significantly higher than the estimated price of A$2.75/t that Indonesia is faced with.

In Queensland, the rail freight charges vary between mines. The costs vary between $11/t and $17/t and these prices were negotiated in the past and contracts established between the mine operation and the government. The variation in charges between mines has produced some very discriminatory situations (Errington and Rudenno, 1995)
Whilst it would be very beneficial in the long term for the government to reduce rail freight, the Queensland Government is trying to delay the introduction of competitive rail haulage, established in the National Competition Policy, for the next 5 years. This would put Australian underground coal mines at a distinct disadvantage, making it increasing hard to increase productivity and would in essence be giving competing countries a head start. However, in the Hunter Valley, the Premier of NSW announced in November 1994 that the State Rail Authority would open up their lines to competition from non-government bodies. This increase in competition could mean savings of up to 200 million dollars for the coal industry on coal haulage.

In NSW the rail freight is lower than in Queensland and it is estimated to be at about US$0.08/t per kilometre. To put this into perspective, for mines in the Hunter Valley this is about $11/t and for mines further towards the west, prices are negotiated to give a maximum price of $14/t.

However the freight prices in Australia have been shown to be as much as ‘30 to 40 per cent and more above comparable US rates’ (Anon, 1993a). For the same coal haulage, Australian rail freight is more than the United States and is on average 22 per cent higher on similar haul lengths (Anon., 1993a). Comparing delivered costs of coal from Australian coal mines to other key competitors has shown that the cost to Asian markets is 20-40% higher. (Anon., 1995b)

| Table 2.5 Rail Freight Rates Comparison 1990 (Source: Anon., 1990a) |
|---------------------------|-------------------|--------------|
| Country | 1990 Freight rate per tonne km (US cents) | Distance to Port (km) |
| Australia | 5.18 | 120 |
| NSW | 3.93 | 230 |
| QLD | 2.28 | 500 |
| South Africa | 1.57 | 1060 |
| Canada | 2.75 | 600 |
| USA | 1.10 | 1000-2000 |
The Government have recently responded to a study they initiated in 1994 into the black coal industry in Australia. This study, the Taylor study, (Anon., 1995b) recommends changes in rail transport policy to enable Australia to improve international competitiveness. The Government supports these recommendations and realises that their implementation is a critical factor in international competitiveness. It states that both New South Wales and Queensland are working towards these recommendations which are detailed below:

Rec16. “The Study considers there are three basic principles which should apply to the operation and pricing of rail freight services:

(i) charging should be on a commercial basis (allowing for a reasonable return on railway assets and transparent (that is, the components of charges should be clearly identified);
(ii) railways should benchmark the productivity and efficiency of their operations against world’s best practice and continually strive for productivity and efficiency gains;
(iii) separately, Governments should set mineral royalties at a level sufficient to ensure a fair return to the community and make the royalties explicit rather than including them in one other charge, such as rail freights

Both Qld and NSW Governments should move their railways to such a regime a soon as possible, thereby providing the coal with efficient services and transparent, commercial charges. (Anon., 1995b)”

In New South Wales there are two ports which are used for exporting coal - Port Waratah and Kooragange port loaders at Newcastle and Port Kembla coal loader just
south of Wollongong. The capacity of these ports is a combined total of 62 mtpa with the potential to increase capacity. A gradual expansion of the Newcastle coal loaders facilities and the approval of expansion of the Port Kembla coal loader facilities will see an increase in export coal capacity and reducing ship turnaround time. In Queensland there are five port facilities which are used to export coal overseas. These are Abbot Point, Brisbane, Dalrymple Bay, Gladstone and Hay Point.

Similar recommendations by the Taylor study are given for port facilities which centre around corporatisation and commercialisation of coal port operations in order to contribute to Australia’s international competitiveness. Relevant recommendations are:

Rec21. The principles which should apply in the operation of coal loading ports are the same as those outlined above for rail: charges should be on a commercial basis (containing no super-profit or royalty component) and there should be continuous improvement in productivity and efficiency. In addition, the principles of corporatisation should apply to government owned ports.

Rec22. A pricing formula for port charges should be applied which provides an incentive for continuing productivity gains and their adequate sharing with customers. Pricing should be independently monitored.

Rec23. The process of corporatisation of State owned ports should continue as expeditiously as possible. Corporatised bodies should be required to operate on a truly commercial basis.

Rec24. Governments should clearly identify, and separately fund community service obligations being met by ports. (Anon., 1995b).
Australian underground coal mines are at a competitive disadvantage with high rail freight and profitability is adversely effected and it is harder for producers to increase productivity in times where it is imperative in an ever increasing competitive market.

2.6 Conclusions

Whilst the Australian Coal Industry has a large reserve base and the infrastructure to export coal, it will become under increasing pressure from other products both in the export and domestic market. Large gas reserves off the North West Cape of Australia will become increasingly available to the Eastern seaboard of Australia over the next 5 to 10 years.

On the export market, Australia will come under further pressure from new competitors such as Columbia, Venezuela, Indonesia and China. In order to remain viable all costs including rail freight, and other transport charges including port loading will need to be reduced in real terms.
CHAPTER 3

THE EFFECT OF SAFETY PERFORMANCE FOR IMPROVING PRODUCTIVITY AND VIABILITY OF UNDERGROUND COAL MINING

3.1 Introduction

Whilst improvement in safety performance is a requirement by both society and employees, employers have an obligation to provide employees with a safe place of work under the Occupational Health and Safety Act (Anon., 1983). Even though these obligations are fulfilled, safety is good business. This can be demonstrated by reduced insurance premiums, cost of replacement labour, and cost in productive time of not having the people at work.

3.2 NSW Safety Performance

NSW safety performance has been steadily improving over the last four years as measured by Lost Time Injury Frequency Rate (L.T.I.F.R). (Refer to Figure 3.1)

\[
L.T.I.F.R = \frac{\text{Number of Lost Time Injuries}}{\text{Million Man Hours Worked}}
\]

Figure 3.1 NSW LTI Frequency Rate from 1984-94 (Source: Anon., 1995a)
Whilst this safety performance has improved (refer Figure 3.2) companies have also seen a reduction in insurance premiums.

Table 3.1 Mine "A" Insurance Premiums and Claims

<table>
<thead>
<tr>
<th>Year</th>
<th>Premium</th>
<th>Cost of Claims</th>
<th>ETPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-91</td>
<td>$2.358m</td>
<td>$0.913m</td>
<td>222</td>
</tr>
<tr>
<td>1991-92</td>
<td>$1.244m</td>
<td>$2.905m*</td>
<td>160</td>
</tr>
<tr>
<td>1992-93</td>
<td>$1.393m</td>
<td>$0.901m</td>
<td>98</td>
</tr>
<tr>
<td>1993-94</td>
<td>$0.953m</td>
<td>$1.301m**</td>
<td>36</td>
</tr>
<tr>
<td>1994-95</td>
<td>$1.183m</td>
<td>$0.650m</td>
<td>27</td>
</tr>
</tbody>
</table>

* Affected by 3 fatalities  ** Claims affected by retrenchment

It should be noted that cost of claims shown in Table 3.1 for Mine "A" was severely affected by 3 fatalities in 1991 which resulted in the increased premium from $1.244m to $1.393m from 1991-1992. This increase of $149,000 represented an imposition of $0.15c per saleable tonne during that period.

During 1992, Mine "A" was forced to shed 215 men by retrenchment and resultant claims for past injuries were processed during 1993 thus the increase of $400,000 in the cost of claims for that year (or $0.40c/tonne).

It may be noted that the indirect costs are also decreased; for example the cost of replacement labour can be calculated and the savings in labour cost estimated. (Refer Table 3.2)
Table 3.2 Number LTI’s

<table>
<thead>
<tr>
<th>Years</th>
<th>No. of LTI’s</th>
<th>Severity</th>
<th>Days Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>209</td>
<td>6.0</td>
<td>1254</td>
</tr>
<tr>
<td>1991</td>
<td>169</td>
<td>5.6</td>
<td>946</td>
</tr>
<tr>
<td>1992</td>
<td>102</td>
<td>6.5</td>
<td>663</td>
</tr>
<tr>
<td>1993</td>
<td>48</td>
<td>7.1</td>
<td>341</td>
</tr>
<tr>
<td>1994</td>
<td>25</td>
<td>4.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Cost Wages: Average daily base rate for Machineman. Before on costs, $519.00 per week. Average Daily Rate $103.80. Total Cost of LTI is depicted in Figure 3.3

Figure 3.3 Cost of LTI’s

Table 3.3 Mine “B”: (NSW South Coast) Safety Performance

<table>
<thead>
<tr>
<th>Premium % of Wages</th>
<th>NSW Southern Cost of Claims</th>
<th>LTIFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 - 1991</td>
<td>$0.432m</td>
<td>229</td>
</tr>
<tr>
<td>1991 - 1992</td>
<td>$0.844m</td>
<td>263</td>
</tr>
<tr>
<td>1992 - 1993</td>
<td>$0.745m</td>
<td>193</td>
</tr>
<tr>
<td>1993 - 1994</td>
<td>$1.110m</td>
<td>190</td>
</tr>
<tr>
<td>1994 - 1995</td>
<td>N/A</td>
<td>70</td>
</tr>
</tbody>
</table>

In a survey carried out of three mines in New South Wales reductions in premiums or cost of claims as a result of improved Safety performance is depicted in Tables 3.3, 3.4 and 3.5.
In the global sense Premiums in Queensland have risen by $4.80m from 1990 - 1994 although safety performance has improved from LTIFR 168 to 74 over the same period.

During this period production from underground mines increased from 8.65 million tonnes to 13.1 million and employment from 1712 to 2020.

3.3 STRATEGY FOR CHANGE

3.3.1 History

In 1989 the major shareholders found it unacceptable that this mine was injuring in excess of 200 people per year and that improvements must be made. Management accepted that people would get injured whilst at work and the general perception was
that coal mining was dangerous and employees expected to get hurt. Many of these injuries went uninvestigated and recurred with regular monotony. There was no follow up to see if indeed the injury was genuine. The following steps were undertaken to arrest the situation.

3.3.2 Rewards

In March 1990 it was decided that a Safety Incentive Scheme would be introduced. The scheme would reward those people who did not get injured and support the local School of Autism in the form of a $2000 donation for each drop of 10 LTIFR (Lost Time Injury Frequency Rate). The reward for employees was two fold.

a. Each month that an employee was uninjured his name was put into to raffle for a $3000 holiday. This was drawn monthly.

b. After three months those people who have remained uninjured would be eligible for a major draw of a $10,000 overseas holiday. This incentive scheme had immediate effect. The LTIFR dropped from 260 to 160. (Refer Figure 3.4)
In conjunction with the safety incentive for employees the Autistic Children were housed in a company house and the workforce performed voluntary tasks to assist the Autistic Association.

3.3.3 Accident Investigations

During 1990 all supervisors were put through a course in accident investigation. The course consisted of 6 modules each of 3 hours. Front-line supervisors were led through the process of accident from the time of the incident to the time the employee arrived at work. All contributing factors were identified where possible. This task was arduous, considering that there were 209 Lost Time Injuries during 1990 and in excess of 1500 reports (refer Table 3.7) or 30 per week to be prepared and analysed. Managing this process was almost impossible and the improvements made by the incentive scheme dropped the load from 209 - 169 LTI or 5000 reports per year.

Table 3.7 Accident Investigation Form

<table>
<thead>
<tr>
<th>Shift/Area Supervisor's Preliminary Report</th>
<th>All Accidents / Incidents Preliminary Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What was the accident/incident?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Where did the accident/incident occur?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>When did the accident/incident occur?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Who was injured?</td>
<td></td>
</tr>
<tr>
<td>Name: ............................................</td>
<td></td>
</tr>
<tr>
<td>Occupation: ...................................</td>
<td></td>
</tr>
<tr>
<td>What was the injury:</td>
<td></td>
</tr>
<tr>
<td>Treatment: Medical Centre □ First Aid □ Hospital □ Sent Home □ Other □</td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>2. Who witnessed the accident/incident?</td>
<td></td>
</tr>
<tr>
<td>Name: ...........................................</td>
<td></td>
</tr>
<tr>
<td>Describe any immediate corrective action taken to prevent further accidents/incidents of this nature:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3. List any more suggestions you have to prevent accidents/incidents of this nature recurring:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Name of person reporting the accident/incidents:</td>
<td></td>
</tr>
<tr>
<td>Date: ........................................</td>
<td>Signature: ......................................</td>
</tr>
</tbody>
</table>
3.3.4 Insistence on Compliance

After thorough training was completed an insistence on accurate reports was monitored. A weekly safety meeting was set up consisting of:

- Mine Manager (Chairman)
- Mine Electrical Engineer in Charge
- Mine Mechanical Engineer in Charge
- Washery Manager
- Undermanager in Charge
- Personnel Manager
- Longwall Coordinator
- Surface Manager

At this meeting each accident report was reviewed in detail and recommendations implemented. Where reports were inadequate they were sent back to the responsible person for modification. Where there was consistent non compliance the originator was counselled, retrained and performance monitored.

Management at the highest level was consistent in its approach to putting in a permanent fix to each accident and demonstrating commitment by stopping production whilst safety inadequacies were being addressed.

Safety performance improved from an LTIFR of 160 to 127. (Refer Figure 3.4)

3.3.5 Special Focus

When accident analysis was carried out it was revealed that the parts of the body most injured were (a) back and (b) eyes and (c) heart disease. As a consequence the following programs were introduced.
a. A Back Care Programme - was run by the company with the assistance of the Joint Coal Board physiotherapist. All employees were put through a programme demonstrating safe lifting procedures and the function of the spine when lifting.

b. Eye Care Programme - an optometrist was enlisted to carry out eyesight tests on employees in Company time. After this assessment an education program on the use of Safety glasses was run before a policy on the compulsory use of safety glasses was instituted (Table 3.8). This compulsion was accepted by the workforce.
The Company is committed to provide a safe and healthy work environment for all employees. One way of achieving this is a policy on Eye Safety.

OBJECTIVES
The objectives of the policy are:

- Education & understanding of the need for Eye Protection.
- For everyone to have a responsible attitude towards the wearing of eye safety equipment.
- To provide appropriate eye safety equipment.
- To take all measures necessary to ensure that eye injuries do not occur.

EYE SAFETY EQUIPMENT
Eye safety equipment is provided by the Colliery in the form of safety glasses, safety prescription glasses or safety visors. Everyone going underground must carry eye safety equipment with them at all times.

AREAS DESIGNATED AS EYE SAFETY AREAS
There are areas and activities where the wearing of eye safety equipment is compulsory. However, all employees are encouraged to wear eye safety equipment at all times whilst underground, in the Coal Preparation Plant (CPP) and working anywhere on the surface.

It was compulsory to wear eye safety equipment:

- Inbye of all development and longwall cribrooms.
- On all belt repair work.
- Whilst performing roof and rib support tasks.
- When transport drivers and shunters, get out of the transport to perform tasks.
- In the surface workshop and environs at No.4 Shaft designated by signage.
- Whilst driving any vehicle without an intact windscreen.
- Any passenger in an unenclosed vehicle.
- On the surface at South Bulli where designated by signage.
- At the CPP, where it is designated by signage.

Other compulsory eye safety activities

- All battery cleaning and filling.
- Grinding machines - bench type and portable.
- Using impact tools.
- Using cleaning fluids, paint or any other solvent, fuel or chemical.
- Working on hydraulic and compressed air systems.
- Using compressed air or airpowered tools.
- In confined spaces.
- Shaft inspections.
- During the installation and removal of flumes.
- Any activities where black wire is used.
- When stonedusting.
- When pressure cleaning with any fluid.
- During roadway dust suppression operations.

PRESCRIPTION SAFETY GLASSES
Employees who require prescription safety glasses were provided with them by the Colliery.

VISITORS
It was decided that visitors who are taken underground must wear eye safety equipment. Visitors to the CPP must wear eye safety equipment at all times whilst in the plant. Visitors to the surface area at South Bulli, in designated areas.
c. Healthy Hearts Programme - During 1992 - 1993 there were 4 employees who suffered heart attacks. An outside consultant was enlisted to educate the entire workforce on (i) diet (ii) heart functions (iii) stress (iv) Cholesterol etc.

Each of the three topics listed above once again demonstrated management's commitment to safety both at the workplace and at home. Further improvements were achieved in overall safety performance.

3.3.6 Managing Safety and Working Safely

In the biggest single demonstration of the mines commitment to safety, each supervisor was put through a 3 day Managing Safety Supervisors Course including: Deputies, Leading Hands and Supervising Staff.

In addition every employee was put through a two day Working Safely Course designed specifically for the Mine and presented by mine employees. These being:

- Training Engineer
- Local Check Inspector
- Afternoon shift Undermanager
- Dayshift Deputy
- Employee Relations Manager
- Engineering Manager

Each session is opened by the Mine General Manager or his alternate the Mine Manager. All executive staff are required to be present at the minimum of one module.

The basis structure of the course is:

- Module 1 Management and Safety - (What is it to do with me)
- Module 2 Information, Communication and Behaviour - (What we are)
Module 3  Accident Investigation
Module 4  Safety meetings - (Effectiveness)
Module 5  Audits and Safety Checks - (Eliminate the cause)
Module 6  Accountability - (Why me)

At the conclusion of the programme participants were able to:

- plan, organise lead and control safety.
- determine who is responsible for safety.
- practice effective, practical communication including listening.
- understand the design, environment and behaviour accident chain.
- understand that safety can not be delegated.
- understand that all accidents are preventable.
- understand that all hazards can be eliminated or the risk managed.
- understand that it is good for business to prevent injuries and illnesses.
- accept that all employees are accountable for their contribution to a safe working environment.

3.3.7  Enhanced Management Policy

In order to continue to strive for improved safety performance there were nine points required to continue improvement. These were:

3.3.7.1  Visible Commitment

Achieved by insisting that whenever a situation exists where the welfare of Employees may be affected that activities must cease to rectify the threatening situation. This was demonstrated at the expense of production.
3.3.7.2 Sound Policy

A typical Policy is given in Table 3.9 Safety Policy in Mine “A” - Occupational Health and Safety Policy (OH&S).

Table 3.9 Safety Policy in Mine “A” -OH&S Policy

<table>
<thead>
<tr>
<th>MINE OBJECTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Company is committed to provide a safe and healthy work environment for all its employees whilst maintaining an efficient and productive operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPANY’S RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Company and Management would provide a working environment conducive to the safety and health of the workforce. This will lead to the elimination of risk for personal injury, property damage and to the environment. Management will continuously review its programme of safety and training of its employees to meet its responsibility.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUPERVISOR RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisors are expected to:</td>
</tr>
<tr>
<td>i) prevent unsafe practices,</td>
</tr>
<tr>
<td>ii) develop and communicate safe working procedures,</td>
</tr>
<tr>
<td>iii) take immediate action to minimise the danger from unsafe conditions, and</td>
</tr>
<tr>
<td>iv) ensure the appropriate officials have been informed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EMPLOYEES’ RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every employee had an obligation to work safely and co-operate with management in the fulfillment of their responsibilities to achieve the Mines safety objective.</td>
</tr>
</tbody>
</table>

All employees must take immediate action to minimise the danger from any existing unsafe condition and ensure that the appropriate mine officials are notified immediately.

The Company is totally committed to this policy and to strategies and procedures necessary to achieve continuous improvement in the management of occupational health and safety at South Bulli Mine. The co-operation and active involvement of the workforce and each individual is essential to its success.

General Manager

3.3.7.3 Line Management Responsibility

Safety performance was measured by the line supervisors. Each supervisor was given targets to be achieved annually and safety compliance reviewed during six monthly performance appraisals. Prior to this insistence, safety was perceived to be the safety officers responsibility.
3.3.7.4 Competent Advisors

Historically the safety officer has been a failed operator and as such has had little or no respect from the general workforce. A competent advisor was selected from outside the coal mining industry although he had extensive experience in heavy industry. The individual had intensive training and reported directly to the General Manager and not in a Line Supervisors role.

3.3.7.5 High and Well Understood Standards

These standards were set after Risk Assessments and Hazard Identification process had been undertaken.

3.3.7.6 Techniques to Measure Performance

Performance measures were:

- Lost time injuries
- Medical treatment cases
- First Aid Cases
- Accident Reports
- Near misses
- External Compliance Audits

3.3.7.7 Realistic Targets

Safety Performance Targets were based on a 30% reduction in all those described in section 3.3.7.6, however, accident reporting was encouraged as the 30% reduction was not designed to impede people reporting accidents as this may make the overall objective of reducing potential accidents.

Chapter 3  42  The Effects of Safety Performance for Improving Productivity and Viability of Underground Coal Mining
3.3.7.8 Audits of Standards and Practice

Audits carried out monthly by Safety Committee, weekly audits by In-Charge Engineers, Supervisors, ie. Electrical, Mechanical and Undermanagers and a minimum of 4 External Compliance audits carried out on Statutory Compliance Policy Compliance and Procedural Compliance.

3.3.8 Tripod Accident Investigation

TRIPOD is a safety research program initiated by the Exploration and Production function of the Shell Company developed in the Hague in late 1987. The programme looked into the human factors in accidents and developed into a working model of accident causation.

Frequently when accident investigations are carried out the real cause was not identified and recommendations do not eliminate the possibility of a similar accident/incident re-occurring.

TRIPOD takes its name from the three key aspects of accident causations (Refer Figure 3.5). Unsafe acts, Accidents and General Failure types. Unsafe acts represent the human fallibility in the accident process. The accident itself results when the defences have been breached by actions of person. Latent failures stemming from decisions taken elsewhere in time and place and are the "blunt" end of the process and form the core of the model. These are termed the General Failure Type.

The understanding of how accidents are caused was integrated into the methodology of accident investigation. The causation model (Figure 3.6) was combined with the method of accident trees. In this way an accident analysis technique was developed which encouraged the investigator to pursue the causes of an accident through to the failures content in the organisation. The method makes it obvious when there is more information to be revealed and discourages shallow analysis.
Manage and Control

The TRIPOD accident causation model involves a number of stages of failure essential to the accident.

![Figure 3.5 The Three Feet of TRIPOD (Source: Challenger and Joycey, 1993)](image1)

![Figure 3.6 Tripod Accident Causation Model (Source: Challenger and Joycey, 1993)](image2)
At the time of an accident there are failures in the defensive barriers. These are the last line of defence established to guard against expected hazards. e.g. in a typical outburst management plan the following would apply (Refer Figure 3.7).

![Diagram](image)

Figure 3.7 Tripod Typical Outburst Management Plan

The equipment required for outburst mining is used to guard against expected hazards as shown in Figure 3.8. The Tripod model sees the need for five layers of effective defence (Challenger, and Joycey, 1993).

- Awareness
- Detection/Warning
- Recovery
- Protection/Containment
- Escape Rescue
The defences are caused to be deficient by unsafe acts and/or an external trigger. People commit unsafe acts because of some precondition, personal or organisational, which encourages or forces them to behave unsafely.

A range of deficiencies in the organisation many of which may have been present for years, set up the conditions for these failures which occur immediately before the accident. These failures are categorised as general failure types, most of which are latent failures.

The General Failure types are set in place by the fallible decisions of people or groups at the higher or top levels of the organisation, without realising it at the time.

In theory, the complete removal of only one of the failures will prevent the accident ie. closing one “hole” in the picture model.

A typical Tripod Accident Tree is given in Figure 3.8

![Diagram of Tripod Accident Tree](image-url)
3.4 Conclusion

Whilst safety is considered to be “good business” and the community will no longer accept that people who attend work are injured, the savings in Premiums, Cost of Claims and Replacement Labour have a significant impact on the viability of the industry.

As demonstrated these cost savings can be up to $1.00 per tonne. This saving on operations producing 3 million tonnes for 15 to 20 years can represent savings up to $60m.
CHAPTER 4

THE IMPACT OF HUMAN RESOURCES MANAGEMENT FOR IMPROVING PRODUCTIVITY AND VIABILITY OF UNDERGROUND COAL MINING

4.1 Introduction - History of Coal Mining Industry

Coal was first discovered in the First Settlement days and a mine new Newcastle was established. The workforce was recruited by prison officers from convict labour.

Early coal companies combined to set prices for both coal and labour causing adversarial relationships between worker and owner.

As the industry expanded it was established early on that it would be beneficial if individual mines formed their own union to improve work conditions and gain increases in wages. Strikes were used as a tactic to better their cause. Financial support was given to miners when they were on strike by members of other union lodges (Ross, 1970).

Miners were generally on contract so that employers could control supply of coal and also manipulate the wages of employees. Miners reacted by adopting the attitude that radical industrial action was the only avenue to achieve gains from employees.

On the political front miners were demanding state ownership of the coal industry. Demand for coal was basically for power generation, to fuel blast furnaces at Port Kembla and Newcastle, for the supply of steamships and for steam driven locomotives.
In 1946, the Coal Industry Tribunal was set up in an attempt to mediate conflict between employees and employers. The Coal Industry Tribunal was set up under the Coal Industry Act 1946 - 1973. (Anon., 1946-1973).

The Coal Industry Act was to “provide means for securing and maintaining adequate supplies of Coal throughout Australia and for the Regulation and improvement of the Coal Industry in the State of New South Wales, and for other purposes”.

Within the Coal Industry Act the structure of the Coal Industry Tribunal was formed (Refer Fig 4.1).

Even after the formation of the Coal Industry Tribunal the more recent disputes were extensive strike action was undertaken was the fight between the Government and mineworkers over a proposal to tax subsidised housing in remote mining towns. Workers regarded this as a gross injustice considering the high cost of living in such areas. The industrial action lasted ten weeks and cost coal mining companies approximately $40 million per week. A strike in 1969 lasting a total of 12 weeks

4.2 Catalyst for Change

With the advent of mechanisation in 1959, (Northey, 1972) the traditional contract system was terminated. Employees were instead rewarded for the coal they mined by a basic wage plus a production bonus. The union movement saw mechanisation as a threat to jobs and imposed production limitations that would not allow production using mechanical machines on nightshift. In effect this limited coal production to 16 hours per day and five days per week.

In line with mechanisation there was an opportunity for Australia to export coal to the Japanese Steel Mills in 1962. This decision was significant in that Australia was no longer a domestic market for coal and a different emphasis was to be placed on the Coal Industry Tribunal in dispute resolution.

in 1969 demands by unions for a 35 hour week led to a trade off for continuous production 24 hours per day five days per week. The 35 hour week was implemented in two stages; a 37½ week during 1970 and ultimately the 35 hour week in 1971.

The first successful longwall mines were being developed throughout the 1970’s and the oil crisis increased demand for coal and a subsequent rise in coal prices. Demands were placed on coal companies for higher wages and these conditions were won through the Coal Industry Tribunal that was operating under its mandate to “continue the flow of coal”.

Chapter 4
During the downturn in both demand and prices for export coal from 1980 to 1990 changes were being made to the structure of the industrial relations system in the industry. This culminated in the Coal Mining Industry Restructuring Agreement February 1990.

4.3 Coal Mining Industry Restructuring Agreement

In February 1990 a restructuring agreement was signed between coal mining companies and the United Mineworkers Federation of Australia, the F.E.D.F.A., the E.T.U. and A.M.W.U. The Agreement “sets out a program which is designed to improve the efficiency of the industry and to provide employees with access to more varied, better paid and secure jobs” (Anon., 1990b).

Whilst there were several terms to this agreement the most significant were:

a. The reduction in awards from 14 to 4 and a rewriting of these awards.

b. Pay increases linked to the August 1989 National Wage Case.

c. Cross skilling of the workforce so that traditional production workers could use their engineering skills as long as they were “safe, legal and logical”.

4.4 Human Relations Management - Theory

In 1912 the Coal Mines Regulation Act was introduced as a result of the disasters that had struck the industry in previous years.

The impositions of the Coal Mines Regulation Act and the qualifications requires by statutory officials impose operational experience on Managers only.
The Coal Mines Qualifications Board sets the requirements needed for statutory officials. The Board of Examiners for Managers Certificates of Competency, Undermanagers Certificates of Competency, Deputies Certificates, Mine Electrical Engineers and Mine Mechanical Engineers set examinations on a practical experience in mining methods, ventilation and legislation. A minimum of 5 years underground experience or a Degree in Mining Engineering with two years underground experience are the prerequisites prior to attempting such examinations. The curriculum does not include a requirement for any man management skills.

More recently Coal Companies have engaged Employee Relations advisors to assist management in addressing the concerns of the workforce. This change has provided some tools to manage employees and their needs.

The Coal Industry has been in constant change particularly since coal prices have commenced declining in the middle 1980's and new machinery technology is in some respect stable without major capital outlay.

A major obstacle to the implementation of policies, goals or methods of operations is the resistance of organisation members to change. The resistance is quite often felt by supervisors.

4.4.1 Uncertainty about the cause and effects of change

Organisation members may resist change as they wish to avoid uncertainty (Stoner, Collins, Yetton, 1985). Traditional ways of doing things offer precedent that guide members actions and the consequences of established procedures are at least well known and predictable. Unwilling to give up tasks and relationships that are familiar may cause resistance to change, so may realistic anticipation of practical problems (such as the need to learn new technologies).
Misunderstandings readily arise when change is introduced and it is the managers job to spot and clarify them at the onset. Employees may be unsure of their ability to learn the new skills or to do the new jobs required of them. They may also resist because they are distrustful of any change initiated from above. Employees feel pressured because changes are made or they may interpret the changes are being made because they have not done their jobs properly.

Even a change that employees can recognise as being good for the organisation may be resented.

"Unwillingness to give up existing benefits" for some individuals the cost of change in terms of lost power, prestige, salary, quality of work or other benefits will not be sufficient offset by the rewards of change.

"Awareness of Weaknesses in the changes proposed" - organisations member will resist change because they are aware of potential problems that have been overlooked by the change initiators. This form of resistance is quite desirable.

Inadequate attention has been paid in Australia to the role of unions in the change process. Frequently managers categorise unions as a major source of resistance to change and fail to recognise some of the resistance is precipitated by a failure to include unions in the change process. In those programs in which unions have been consulted and actively involved there is a greater likelihood that resistance to change will be reduced significantly.

There are six ways of overcoming resistance to change as suggested by Koffer and Schlesinger. (Koffer and Schlesinger, 1979). These are:

4.4.1.1 Education and Communication

One of the most obvious ways to overcome resistance to change is to inform people about the planned change and the need for it early in the process. If the need for and
logic of, the change are explained - whether individually to subordinates, to groups in meetings or to entire organisations through elaborate audiovisual education programs, the road to successful change may be smooth.

4.4.1.2 Participation and Involvement

If potential resistors are drawn into the actual design and implementation of the change, it may be better prepared as well as earlier to effect. Change imposed from above is likely to make people feel that their knowledge and skills are being ignored.

4.4.1.3 Facilitation and support

Easing the change process and providing support for those caught up in it is another way managers can deal with resistance.

4.4.1.4 Negotiation and Agreement

Another technique is negotiation with allowed or potential resistors.

4.4.1.5 Manipulation and Co-option

Sometimes managers covertly steer individuals or groups away from resistance to change. They may manipulate workers by releasing information selectively or by consciously the sequence of events. Aside form the doubtful ethics of such techniques, they may also backfire.

4.4.1.6 Explicit or Implicit Coercion

Manager may force people to go along with change by explicit or implicit threats involving loss of jobs, lack of promotion and the like. Managers also dismiss or
transfer employees who stand in the way of change. As with manipulation and co-optation, such methods, though not uncommon, are risky and make it more difficult to gain support of future change.

### 4.5 Changing Industrial Traditions

When trying to understand the impediments placed when trying to affect change in the workforce and gain greater utilisation of the individual attributes of the workforce it is important to understand the motivating factors that influence behaviour.

Maslow's Hierarchy of Needs (Stoner, Collins, Yetton, 1985) has probably received more attention than any other theory of motivation. This is because Maslow’s theory not only classifies human needs in a convenient way but also has direct implications for managing human behaviour in coal mines.

Maslow views human motivation in terms of a hierarchy of five needs.

![Maslow's Hierarchy of Needs](image)

**Physiological**
Includes the need for air, water, food.

**Security**
Includes the need for safety, order and freedom from fear or threat.

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Chapter 4  
55  
The Impact of Human Resources Management for Improving Productivity and Viability of Underground Coal Mines
Social

The need for love, affection, feelings of belonging, and human contact.

Esteem

Includes the need for self respect, self esteem, achievement and respect from others.

Self Actualisation

Includes the need to grow, to feel fulfilled, to realise ones potential.

When deciding where the mining industry stands in relation to Maslow’s theory one would suggest that employees are generally past the Physiological stage. This is best exemplified by the fact that the average weekly earnings of NSW and QLD Coal Miners exceeds $1200 per week. In respect of safety the underground mining industry has improved safety performance as described in Chapter 3.

It can then be assumed that the major areas to concentrate efforts in improving Human Resource Management can be concentrated in the areas of Social, Esteem and Self Actualisation.

As a result of the changes made through industry agreements the use of these management theories are exemplified in the case studies of the newest mine in Australia, Dartbrook, and the oldest mine South Bulli.

4.6 South Bulli Workplace - Changes

In early 1992 several changes were made in management philosophy at South Bulli. The mine had been through voluntary redundancies in late 1990 and compulsory redundancies in early 1992. The workforce was disrupted by the loss of the younger employees. The average age of the remaining workforce being 52 years of age.
The mine had re-established under Cataract Reservoir and the opportunity for introducing a team based workplace was accepted.

The first step in the change was to enlist a consultant “Outdoor Insight” to provide experiential outdoor team building training. Each development and longwall crews were taken off site for two days and presented the Companies Vision and Mission Statements and asked for their input into the Objectives for the mine for the next five years.

In conjunction with the team based training lasting six months each level of the organisation received job descriptions based on the objectives set by the organisation.

The outputs and Key Performance Indicators for the Deputies were:

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Key Performances</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Compliance with Coal Mines Regulation Act, Managers Rules and OH&amp;S Act</td>
<td>Compliance</td>
</tr>
<tr>
<td>b. Number of Accidents/Incidents</td>
<td>In line with objectives</td>
</tr>
<tr>
<td>c. Metres per cutting hour</td>
<td>Minimum of 3</td>
</tr>
<tr>
<td>d. Metres per shift</td>
<td>Minimum of 15</td>
</tr>
<tr>
<td>e. Panel extensions</td>
<td>20 hours</td>
</tr>
<tr>
<td>f. Crew attendance</td>
<td>Absenteeism</td>
</tr>
<tr>
<td>g. Panel Shift Availability</td>
<td>Minimum 60%</td>
</tr>
</tbody>
</table>

Deputies Review meetings were instigated and held two weekly. At these meetings each section deputy was led through the previous two week performance with the
appropriate comparisons between shifts. The plan for the next two weeks was presented with the input of each deputy. It was the deputies responsibility to present this plan to their crews.

The improvement in development productivity as a result of both the team building exercises and deputies review meetings was an increase of one metre per cutting hour overall as depicted in Figure 4.3.

Three other initiatives that were undertaken to demonstrate a change in Management Philosophy were:

(a.) Three monthly workforce meetings - All employees were given the opportunity to understand the position of the business. The presentations were given by both the General manager and Mine Manager. All employees were given the opportunity for input into improvements initiatives.

![Figure 4.3 Development Metres per Cutting Hour](image-url)
(b.) Monitoring Committee Meetings - This committee was set up to recommend improvements to the business. It consisted of the Mine Manager, two members of the United Mineworkers Union, one member of the Colliery Officials Association, one member of the Colliery Staff Association and the District Vice President of the United Mine Workers Union.

(c.) A task force was set up with the Charter of developing a workplace agreement to be implemented in the first quarter of 1996.

The success of these initiatives was demonstrated by the signing of a workplace agreement by April 1996. The major components of this agreement were (a.) inbuilt flexibilities, (b.) Annualised salaries, (c.) A performance based bonus, based on profitability and (d.) Planned reductions.

The results of this agreement is still to be measured, however, initial indications are that the workforce has made the transition from the traditional award based salary system to the new system without disruption.

4.7 Dartbrook Experiences (Hayward, 1994)

Dartbrook mine is a coal project located in the Upper Hunter Valley. Production will exceed three million tonnes from one longwall unit supported by three development units.

Prior to recruiting employees at Dartbrook a Workplace Agreement was negotiated and signed off by the Northern District Union Officials of the CFMEU (Mining Division). Dartbrook was classified as “Greenfields Site”.

Chapter 4 59 The Impact of Human Resources Management for Improving Productivity and Viability of Underground Coal Mines
The recruitment process followed five steps.

(a.) Literacy, Numeracy and Mechanical Reasoning.
(b.) Base Interview (a screening process)
(c.) Selection events which included a full day of two target selection interviews, teamwork exercises and written and verbal tests.
(d.) Reference checks.
(e.) Job specification medical examinations.

Once shift coordinators were selected they were trained in the recruitment process giving in the selection of their crews.

All Dartbrook people were trained in the virtues of teamwork, planning, target setting and the accountability and responsibilities involved in the team based philosophy. These training sessions involved classwork, outdoor team building exercises and workplace equipment familiarity. A minimum of eight weeks was involved.

To date Dartbrook has met its development targets, however, unpredicted geological problems have delayed the introduction of its longwall equipment. Dartbrook has been seen as a model for new coal projects and similar strategies are being use at another new mine in Central Queensland.

4.8 Conclusion

Whilst major improvements have been made in company, employee relationships over the last 10 years, most Enterprise Agreement negotiations involve either District or
National Union Officials prior to them being ratified by the Australian Industrial Relations Commission.

The Centralised Union decision making process hinders progress when negotiating Work Site Specific Agreements. This mechanism largely prevents agreements being site specific, they do not address the economic circumstances or operational constraints.
CHAPTER 5

MACHINERY SELECTION FOR IMPROVING VIABILITY AND PRODUCTIVITY OF UNDERGROUND COAL MINING

5.1 Introduction

Longwall productivity in Australia measured in terms of tonnes per day has increased in the period from 1984 to 1994 from 4,500 to 8,500 tonnes with the higher producers averaging 12,000 - 15,000 tonnes per day. Roadway development rates in that time have not increased at this pace. (Kelly, 1994)

Table 5.1 and 5.2 demonstrate the improvement in productivity required to reach the level of those longwall mines operating in the United States.

A survey carried out of Australian Longwall Mines to which there were 18 respondents of the 29 Longwall Mines indicates that development rates are the single biggest impediment to achieving production rates similar to those in the United States.

This Chapter therefore concentrates on the development machinery presently available to assist in achieving the desired targets in order to remove development as an impediment to bulk tonne production.

5.2 Conventional Systems

Traditional continuous miner systems rely on three distinct steps in the process. The first step is to cut the coal from the face, the second is to transport the coal via shuttle car from the miner to the section conveyor via a shuttle car in quantities varying from 8 to 11 tonnes and the third is to support the exposed excavation.
Table 5.1 Production Tonnes Per Man Year United States Mines (Source: Boyd, (1995))

<table>
<thead>
<tr>
<th>Mine</th>
<th>Production (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shamrock No.18</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Enlow Fork</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Mingo Logan</td>
<td>15000-20000</td>
</tr>
<tr>
<td>West Elk</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Bailey</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Arch No.37</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Powhatan No.6</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Mettiki</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Twentymile</td>
<td>15000-20000</td>
</tr>
<tr>
<td>McElroy</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Pinnacle</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Buchanan No.1</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Potomac</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Suco</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Crandall Canyon</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Zeigler No.24</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Powhatan No.4</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Meigs No.2</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Zeigler No.24</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Lightfoot No.1</td>
<td>15000-20000</td>
</tr>
<tr>
<td>Deer Creek</td>
<td>15000-20000</td>
</tr>
</tbody>
</table>
Table 5.2 Production Tonnes Per Man Year - Australian Mines (Source: Boyd. (1995))

<table>
<thead>
<tr>
<th>Mine Name</th>
<th>Production Tonnes Per Man Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Bulga</td>
<td></td>
</tr>
<tr>
<td>German Creek Central</td>
<td></td>
</tr>
<tr>
<td>Wambo</td>
<td></td>
</tr>
<tr>
<td>Baal Bone</td>
<td></td>
</tr>
<tr>
<td>Ulan</td>
<td></td>
</tr>
<tr>
<td>German Creek Southern</td>
<td></td>
</tr>
<tr>
<td>Gordonstone</td>
<td></td>
</tr>
<tr>
<td>Gretley</td>
<td></td>
</tr>
<tr>
<td>Oaky Creek</td>
<td></td>
</tr>
<tr>
<td>Newstan</td>
<td></td>
</tr>
<tr>
<td>West Wallsend</td>
<td></td>
</tr>
<tr>
<td>Cordeaux</td>
<td></td>
</tr>
<tr>
<td>Clarence</td>
<td></td>
</tr>
<tr>
<td>North Goonyella</td>
<td></td>
</tr>
<tr>
<td>Teralba</td>
<td></td>
</tr>
<tr>
<td>Wyee</td>
<td></td>
</tr>
<tr>
<td>Cooranbong</td>
<td></td>
</tr>
<tr>
<td>Elouera</td>
<td></td>
</tr>
<tr>
<td>Angus Place</td>
<td></td>
</tr>
<tr>
<td>Appin</td>
<td></td>
</tr>
<tr>
<td>Springvale</td>
<td></td>
</tr>
<tr>
<td>Cumnook</td>
<td></td>
</tr>
<tr>
<td>Oakdale</td>
<td></td>
</tr>
<tr>
<td>West Cliff</td>
<td></td>
</tr>
<tr>
<td>Tahmoor</td>
<td></td>
</tr>
<tr>
<td>Tower</td>
<td></td>
</tr>
<tr>
<td>Pelton/Ellalong</td>
<td></td>
</tr>
<tr>
<td>South Bulli</td>
<td></td>
</tr>
<tr>
<td>Metropolitan</td>
<td></td>
</tr>
</tbody>
</table>
Roof support density determines the advance between cycles and bolting technology has advanced from hand held compressed air percussive bolters to hand held compressed air rotary borers to on board hydraulic bolters.

Distance from the cut face to the bolters varies from 3 metres using the Joy 12CM11 and Jeffrey 1036 Continuous Miners (leaving them unsuitable for production in poor roof conditions) to 1 metre using Joy 12CM20 and 12CM30 Continuous Miners. In each case production from the continuous miner has to cease whilst the bolting process takes place. This means that improvement in efficiencies can only be achieved by either increasing the size of the coal carrier (shuttle car), increasing the speed of the conveyance or reducing support density. Whilst these factors may be considered there is no opportunity to make the quantum leap in development performance.

5.3 Voest Alpine ABM20

The Voest Alpine ABM20 was the first machine introduced with the ability to simultaneously cut and load coal whilst installing roof and rib bolts. (Figure 5.1)

A slide frame allows the cutter drum and loading apron to move independently from the machine and crawler tracks (Melrose, 1995).

The temporary roof support stabilises the machine while cutting and allows roof bolts to be installed 1.5 metres from the face. The temporary roof support also provides for a safer working environment as it ensures exposed roof is left unsupported for the minimum length of time.
The advantage of simultaneous cutting and bolting as opposed to conventional wide head cutting machines is best illustrated by comparing the development rates of both machines. The ABM20 by nature of design allows two processes (ie cutting and bolting) to be completed in parallel, whilst with a conventional miner, these processes need to be done in series. As a result the development rates achievable from each machine is significantly different.

At a South Coast Mine where the roof support pattern was 4 x 2.1 metre roof bolts inserted into a 4.8 metre ‘W’ strap and a 1.2 metre rib support installed at 1 metre spacing the average advance rate was increased from 10.4 metres per shift to 15 metres per shift over a representative period after the introduction of the ABM20. This improvement was measured against a 12CM20 conventional miner.

In addition the previous shift record of 24 metres has been broken on several occasions with the current record 41 metres or a 71% performance improvement.
5.4 Flexible Conveyor Train

The Flexible Conveyor Train is a mobile fixed length, belt conveyor supported in cars that are uniquely connected, permitting the belt to negotiate several 90° turns. The Flexible Conveyor Train (FCT) extends from the panel belt entry to the face, following the continuous miner into each working place and provides continuous haulage from the face to the section belt. Accurate guidance and easy tramming that are independent of the floor conditions are provided by suspending the FCT from a monorail attached to the mine roof as depicted in Figure 5.2.

![Figure 5.2 General Arrangement of Flexible Conveyor Train (Source; Anon., 1995e)](image)

Original designs improved development performed at Southern Colliery, however, poor availability led to this improvement being unsuitable.

The FCT was withdrawn from service in 1993 for modifications required for it to be incorporated into the Integrated Development System.

Average development rates at Southern Colliery prior to the introduction of the FCT was 14.1 metres per unit shift and the improvements after its introduction are depicted in Table 5.3.
5.5 Place Changing Method

The place changing method is a system of mining using a continuous miner, shuttle cars and a dedicated roof bolting machine. The cutting of coal and the support of the opening are two parallel concurrent activities as opposed to what we consider as conventional mining in Australia where the face is either supported as you cut (with the ABM20) or supported alternatively with cutting (as with a Jeffrey 1036 with Joy 12CM20 machine mounted rigs or handheld rigs). In the continuous miner cuts out a place and then is fit to the next place where it starts to cut again. A dedicated roof bolting machine follows the miner, supporting the roof in the recently vacated place. Improved productivity is achieved through a number of factors. The relative fit times are smaller than the support times experienced normally, the method requires a panel geometry that maximises shuttle car access. In a larger mine normally in main development using 5 - 6 headings each piece of equipment is to a degree independent and therefore does not suffer the compounding effect of downtime and the system in general is more flexible. Performance of the place changing method is demonstrated in Tables 5.4 and 5.5.

5.5.1 Panel Geometry

Panel Geometry that has pillar dimensions of up to 50 metres which allows minimum wheeling distances and increased panel room for shunts and storage. The panel geometry is relatively flexible in numbers of roadways and layout, (refer Figure 5.3) the limitation being the compatibility with the coal transportation method from miner to bootend.
5.5.2 Place Changing Equipment

Small purpose built continuous miner with the following features:-
- low weight
- high cutting and loading power
- narrow head to maximise ease of flitting
- hard head to increase simplicity
- radio remote control to allow long cut outs under unsupported roof
- fitted with onboard fan and dust scrubbers to reduce dust at the face
- tramming functions to ensure minimum flitting times
- modular design reduce complexity and time of repairs

Purpose built roof bolting machine with the following features:-
- dual boom mounted drill rigs
- temporary roof support
- protective canopy for each operator
- safe access to the face through centre passage in machine
- ability to either wet or dry drill
- increased power available for thrust and torque functions for roof bolt installation
- large platform for storage of supplies immediately adjacent to operator

Figure 5.3 Place Change System General Layout
Table 5.4 Performance of Australian Placechanging Methods

<table>
<thead>
<tr>
<th>Mines</th>
<th>Prior to Placechanging (mpus)</th>
<th>Placechanging (mpus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myuna</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>Coorabong</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>Newstan</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 5.5 Performance of United States Placechanging Mines

<table>
<thead>
<tr>
<th>Mine</th>
<th>Aver. Production per shift (mpus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer Creek</td>
<td>50</td>
</tr>
<tr>
<td>Trial Mountain</td>
<td>48</td>
</tr>
<tr>
<td>Shoshone</td>
<td>52</td>
</tr>
</tbody>
</table>

5.6 Sump Shearer

They Joy Sump Shearer has been trialed at both Angus Place Colliery and Southern Colliery over the last five years.

The machine is a short based miner with the main frame just over five metres long and it is approximately 3.5 metres wide.

The main features of this machine is its ability to cut and bolt simultaneously and provide the operators with adequate workspace to carry out the bolting pattern using four automatic bolters.

The machines cutting action is two ranging arms that are programme controlled. All cutting profiles can be programmed into the onboard computer where variations are required. The cutting profiles available are depicted in Figure 5.4.
At Angus Place Colliery the rib arch profile was selected to assist in gaining roof stability whereas Southern Colliery used the semi arch where roof conditions were considerably more stable.

![Figure 5.4 Sump Shearer Cutting Profiles](image)

The Sump Shearer takes slices of approximately 300 mm from the coal face allowing roof support installation as the immediate strata is exposed, once again paramount at Angus Place Colliery.

The original design at Angus Place Colliery provided for five compressed air bolters and cycle times were approximately eight minutes. The overall maximum development rates achievable were therefore 7.5 metres per cutting hour. When the semi-automatic drill rigs were installed prior to the Sump Shearer being introduced at Southern Colliery the cycle time was reduced to 6 minutes or 10 metres per cutting hour maximum.
A major impediment to the Joy Sump Shearer’s performance after the introduction of the semi-automatic drill rigs was both the shuttle car wheeling times and the time taken to advance ventilation ducting. Southern Colliery subsequently installed a flexible conveyor train behind the sump shearer. The FCT had an auxiliary fan attached to the tail section and ventilation ducting suspended underneath the cars carrying the coal. The rigid ventilation ducting was connected to the tail of the sump shearer using flexible ducting allowing positive ventilation at the face via the ventilation system through the throat of the Sump Shearer.

Initial trials of the system at Southern Colliery gave encouraging results albeit availability was plagued by software failures in the profile cutting system.

In March 1996 the sump shearer reached nine metres per cutting hour at Southern Colliery using the fully integrated system, however, after that time the machine was plagued by major electrical failures on traction motors. The machine was withdrawn from service in April and returned to the manufacturer for more modifications to the electrical system prior to returning underground at Southern Colliery.

5.7 Tunnel Boring Machine

Tunnel boring machines have been widely used internationally and have been proven to be a cost efficient method of driving tunnels at high rates. Nearly all types of conditions have been negotiated from Hard Igneous Rocks to wet soils and free running sands (Phillips, 1996).

A Tunnel Boring Machine (4.6m disc) at Kalamazoo Mine in Arizona averaged 22.6 metres per day in faulted and wet conditions requiring extensive ground support and water control (Anon., 1995c). Difficult igneous conditions were encountered in
Norway and rates of 300 metres per week were constantly achieved in a 3.5 metre inside diameter tunnel (Anon., 1995c).

The Lesothlo Project in South Africa used a 5.4 metre diameter Tunnel Boring Machine to achieve up to 984 metres per month (Anon., 1993b), and a Norwegian Unit achieved 395 metres per week with a machine utilisation of 68.2% (Anon., 1993b).

It should be noted that these tunnels require lining that requires shotcrete applications. It is common for a T.B.M. to use the tunnel support as the base from which it forces the cutter head forward, hence the support must be allowed to set prior to further advancement.

The T.B.M. system is separated from the support cycle allowing potential for rapid entry development rates in the Coal Mining Industry.

5.7.1 Development System

Initial estimates of development rates achievable using the “MOGURA” Tunnel Boring Machine for longwall development are 50 metres per shift or on a 10 shift per week basis 500 metres per week. Panel layout (refer Figure 5.5) would typically provide for the development of two 3 million tonne longwall blocks using one T.B.M. to develop gateroads and one conventional miner to develop main headings. Compared to current techniques the savings in man power using a T.B.M., if a coal specific machine is feasible, should provide a cost advantage at development rates less than 50 metres per shift.

Panel design would be as shown over:-
5.7.2 Coal Conveying

Once the coal is cut it is delivered by an enclosed armoured face conveyor through an onboard crusher via a swivel tail into a mobile bootend.

The mobile bootend transfers coal onto the panel belt and provides the platform from which the conveyor structure is mounted from the roof. This will allow panel belt structure to be installed without affecting production.

A loop take up capable of storing 200 metres of belt will be required to allow planned advance rates of 100 metres per two production shifts. The third shift per day will be to delivery supplies and extend other services.

5.7.3 Transportation of Supplies & Personnel

Containers containing the required number of supplies will be packaged on the surface ready for transport to the face. On the shift when supplies are delivered they will be attached to the pre-installed monorail and placed on the T.B.M.
The monorail system will be capable of transporting men into the face area using the ski-lift concept. This monorail will be powered by compressed air negating the need for electric cables and be provided with a battery backup.

Present restrictions laid down by the Inspectorate under CMRA 1982 and CMRA (Ventilation Underground Mines) Regulation 1984 restricts the number of personnel in a single entry zone to a maximum of 15 people.

5.7.4 Ventilation

The face will be ventilated using two 900 mm vent ducts requiring 300kW of fan power. At the end of the 2,600 metre drivage air quantities of 5.0m³/sec is expected. One length of duct would be provided to the T.B.M. whilst the other to approximately 2,000 metres from the panel entry. (Refer to Figure 5.6 and Figure 5.7)
5.8 Conclusion

Whilst development rates in the Australian Coal Industry inhibit utilisation of the highly productive longwall faces. The introduction of the ABM20 cutting and bolting machine has assisted in lifting rates of advance.

Mobile boot ends have had mixed success in removing waiting times for shuttle cars. Flexible Conveyor Trains have had success in lifting development rates at Southern Colliery by removing shuttle cars from the critical path in development systems.

The Place Changing system demonstrates that development rates required to match longwall retreat rates are achievable in favourable roof conditions.

The quantum leap required for all mines, particularly those with poor roof conditions will come when the Joy Sump Shearer availability rises to acceptable levels.
The Integrated Development system combining the Joy Sump Shearer and the Flexible Conveyor Train equipped with ventilation ducting will achieve rates of between nine and 10 metres per cutting hour or between 50 and 70 metres per unit shift.

Tunnel Boring Machines need to be further developed and trialed in the Australian coal mining industry for the drivage of longwall gate roads.
CHAPTER 6

MACHINE MAINTENANCE FOR IMPROVING PRODUCTIVITY
AND VIABILITY OF UNDERGROUND COAL MINING

6.1 Introduction

Since the 1930's the evolution of maintenance can be traced through three generations or major steps (Moubray, 1994). The First Generation covers the period up to World War II. In those days industry was not very highly mechanised, so downtime was not recognised as an impediment to product. This meant that prevention of equipment failure was not a very high priority in the minds of most managers (Figure 6.1). At the same time, most equipment was simple and much of it was over designed. This made it reliable and easy to repair. As a result, there was the need for systematic maintenance of any sort beyond simple cleaning, servicing and lubrication routines. The need for skills was also lower than it is today.

Things changed dramatically during World War II when wartime pressures increased the demand for goods of all kinds while the supply of industrial manpower dropped sharply. This led to increased mechanisation. By the 1950's industry was beginning to depend on machines of all types which were more complex and numerous.

As this dependence grew, downtime came into sharper focus. This led to the idea that equipment failures could and should be prevented, which led in turn to the concept of preventative maintenance. In the 1960's this consisted mainly of equipment overhauls done at fixed intervals.

The cost of maintenance also started to rise sharply relative to other operating costs. This led to the growth of maintenance planning and control systems. These have helped greatly to bring maintenance under control, and are now an established part of the practice of maintenance. Finally, the amount of capital tied up in fixed assets

Chapter 6  78  Machine Maintenance for Improving Productivity and Viability of Underground Coal Mining
together with a sharp increase in the cost of new capital led people to start seeking ways in which they could maximise the life of the assets.

Since the mid seventies, the process of change in industry has gathered even greater momentum. The changes can be classified under the headings of new expectations, new research and new techniques.

<table>
<thead>
<tr>
<th>Step One</th>
<th>Step Two</th>
<th>Step Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fix it when it broke</td>
<td>- Higher plant availability</td>
<td>- Higher plant availability and reliability</td>
</tr>
<tr>
<td></td>
<td>- Longer equipment life</td>
<td>- Greater safety</td>
</tr>
<tr>
<td></td>
<td>- Lower costs</td>
<td>- Better product quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No damage to the environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Longer equipment life</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Greater cost effectiveness</td>
</tr>
</tbody>
</table>

![Figure 6.1 Growing Expectations of Maintenance (Source; Moubray, 1994)](image)

_Downtime_ has always affected the productive capability of physical assets by reducing output, increasing operating costs and interfering with customer service. By the 1960’s and 1970’s, this was already a major concern in the mining, manufacturing and transport sectors.

More and more failures have serious safety or environmental consequences, at a time when standards in these areas are rising rapidly. In some parts of the world, the point is approaching where organisations either conform to society’s safety and environmental expectations, or they cease to operate. (Refer Figure 6.2)
Maintenance is also responding to changing expectations. These include a rapidly growing awareness of the extent to which equipment failure affects safety and the environment, a growing awareness of the connection between maintenance and product quality, and increasing pressure to achieve high plant availability and to contain costs.

The changes are testing attitudes and skills in all branches of industry to the limit. Maintenance people are having to adopt completely new ways of thinking and acting, as engineers and as managers. At the same time the limitations of maintenance systems are becoming increasingly apparent, not matter how much they are computerised.

Prior to 1982 the Coal Mines Regulation Act required the Manager of the mine to maintain machinery in accordance with General Rule 5. General Rule 5 stated "A competent person or competent persons, appointed by the Owner, Agent or Manager for the purpose, shall, once at least in every twenty-four hours, examine the state of the external parts of the machinery and shall mark with chalk his, her or their initials, together with the date of the inspection, on or near such machinery. Such persons or persons shall also examine the state of the guides and conductors in the shafts, and the
state of the head gear, ropes, chains and other similar appliances of the mine which are in actual use both above ground and below ground, and shall once at least in every week examine the state of the shafts by which persons ascend or descend, and shall make a true report of the result of such examination and every such report shall be recorded without delay in a book to be kept at the mine for the purpose and shall be signed by the person who made the inspection”. (Anon. 1982).

Most mines abided by this prescriptive legislation and appointed personnel to carry out the tasks. This became the standard maintenance. The appointed personnel whilst largely trades qualified also consisted of colliery fitters and colliery electricians with no formal trades qualification.

The Colliery fitters and electricians were generally good “trouble shooters” and could repair machinery when broken down. Very little if any pro-active maintenance was carried out.

In 1984 the revised Coal Mines Regulation out required that the Mine Manager prepare Rules and schemes under Section 103 and submit them to the Department of Minerals and Energy for approval. Each set of rules and schemes were designed to be site specific, however, when they were scrutinised by Department Inspectors impositions were made on mine managers to the extent that Industry based maintenance schemes were once again imposed.

One of the advantages of the 1982 reformed Coal Mines Regulation Act (CMRA) was that it demanded certain qualifications be held by people who were appointed to the positions. Mine Electrical Engineer and Mine Mechanical Engineer. Prior to 1982 the Mine Mechanical Engineer was not required to possess any formal qualifications but could have “come through the ranks” (Anon., 1982).

A typical organisational structure imposed by statute in 1982 remained as previous e.g. is given in Figure 6.3.
Improving Productivity & Viability of Underground Coal Mining Operations

As can be seen there was no emphasis on Maintenance. The role of the shift Engineer was to supervise breakdown repairs and routine "103 Scheme" inspections as required.

Over the past 15 years, maintenance philosophy has changed, perhaps more so than any other management discipline.

6.2 Application of new maintenance strategy to the Coal Mining Industry

Maintenance cost in the Australian Underground Coal Mining Industry is $6.50 to $7.50 per ROM tonne representing about $450 million per year.

Best United States of America practice has maintenance cost 30% lower than the Australian average. This is more cost effective maintenance sustains higher production.

A 10% increase in production rate for a mine producing 2 million ROM tonnes could represent around $6 million increase in revenue per annum (Rudkin, 1991).

- A significant opportunity to improve the competitive position of many underground coal mines is being missed because of the lack of corporate attention to the maintenance function.
- Maintenance costs for underground coal mining are typically around 30% of operating costs.
- The industry is not using a sufficient range of relevant performance indicators to pursue best practice.
- Very few mine sites have a maintenance plan established using any form of structured analysis of the equipment.
- Site culture and work practices do not support the maintenance function.
- The maintenance workforce is generally technically experienced but under utilised in terms of being used by management to achieve improvements.
- Maintenance training is generally ad hoc and not business focused. Sites are starting to realise that maintenance scheduling involves the coordination of maintenance functions and production operations.
- Maintenance information management is fragmented and not coordinated.
- Many mine sites are not in a position to know the ownership costs for their equipment.
- The maintenance function tends to under utilise the resources available in the purchasing department.
- Site spare parts stores are generally well controlled but lack of integration and support from the maintenance group.
- The identification of opportunities and the improvement process are not well managed.
6.3 Changing Maintenance Attitudes/Philosophy

During the late 1980's to early 1990's most mines changed their management structure to place a larger emphasis on maintenance. (Refer Figure 6.4)

![Figure 6.4 Typical Management Structure 1980 - 1990's](image)

This change increased the focus on maintenance in that the person responsible for the process now had the people skilled in maintenance reporting directly to them. Their responsibilities were for Production, Machine Availability, Utilisation and Cost Control.

Computer based maintenance systems allowed them to gain the information he needed to manage the process efficiently.

The more Senior Engineering Personnel, ie. the Electrical and Mechanical Engineers in charge required by the Coal Mines Regulation Act acted as advisors to the coordinators with an audit role for compliance with legislation and corporate policy. They were also given the role of monitoring the progress and compliance with standards when machine overhauls and repairs were to be undertaken.
6.3.1 Identification of Skills

In order to provide the coordinators of each process the skilled people they required, two (2) steps were undertaken.

a. Skills audits to identify the level of competency of existing employees.

b. Maintenance requirements as set out by the original equipment manufacturer.

When these processes were undertaken it was possible to recognise the gap between what was required to effectively maintain equipment and the skills available in the workforce. Whilst there was some suspicion by the workforce as to why this process was being undertaken running in conjunction with this process were wage rises being handed down by the Coal Industry Tribunal in 1990 for “Special Class Tradesman”, ie. those employees with post trade qualifications. Additionally an industry wide taskforce was working on Work Models that would eventually grade all workers from 1 to 6 in either the maintenance or production Stream.

6.3.2 Use of Computer Based Maintenance System

During the early 1990’s many computer based maintenance systems were introduced as a tool for the person responsible for the process (Figure 6.5) either longwall, conveyor or development. These systems addressed four (4) main areas. (Moubray, 1994).

i. Maintenance Planning

A system suitable for maintenance planning can pull together the outstanding corrective maintenance and the planned preventative maintenance when it is due. The system provides the planner the tools with which to manipulate the outstanding work together with the human resources needed to carry out the work, the material resources and plant availability to construed an achievable plan to carry out the maintenance in a cost efficient manner. This plant will be flexible enough to allow for the by crisis caused by an unplanned breakdown (Anon., 1994d).
ii. **Cost Control**

Process managers are being held responsible for the cost involved in their process. To do this they need direct access to the data and this is only really possible through a computerised system. These systems allow the process manager to tunnel down from the high levels of accounts to who has drawn out of the store which job.

iii. **Plant History and Analysis**

A properly managed information system can store significant volumes of data relating to items of plant. This data is often collected during routine inspections. The tools found within this application is able to sort this data selectively and provide for the requisite analysis.

iv. **Productivity Enhancement**

A large proportion of all maintenance activities can be set up as “Standard Jobs” complete with job instructions and parts lists. Along with an integrated maintenance and materials system parts can be ordered rapidly when associated with standard jobs.

v. **Flow Chart Summary of Computer Based System**

```
Gather Data
   ▼
Record History
   ▼
Monitor Costs
   ▼
Analyse Data
   ▼
Make Decisions
   ▼
Give Feedback
```

**Figure 6.5 Flow Chart Summary of Computer Based System**
6.4 Case Study - South Bulli Conveyor System

6.4.1 History

South Bulli Colliery is situated on the Southern Coal Fields approximately 80 kms south of Sydney, the mine is the oldest operating mine in Australia commencing production 1887 on the Escarpment west of the town of Russell Vale.

During its time in production it has gone through all of production from land mining to modern longwall production. It pioneered Australia Longwall retreat mining in the late 1960's. South Bulli produces a high quality export coking coal to markets in Japan, Korea, Taiwan and Europe. In 1989 South Bulli produced 2.95 million tonnes of raw coal relating to approximately 21 million tonnes of product coal. This production was won by using two modern longwall systems in the Western Reserves some 18 km from the surface portals.

In 1992 operations were suspended in the West due to changing as regimes (ie. from predominantly CH₄ to CO₂) thinning seam from 2.4 metre to less than 2 metres and poor geological floor conditions.

The future of South Bulli depended on mining a small reserve of coal under the Cataract reservoir using one longwall and two continuous miner units. Being under Cataract Reservoir longwall faces were limited to 96 metres and chain pillar sizes to 65 metres solid in order to cause no surface subsidence.

A reliable belt system was required to transport coal from the production units to the surface and instance of up to 17 kms. (Refer Figure 6.6) The belt system had evolved since an upgrade in 1967 and it had become unreliable and in certain conditions hazardous.
6.4.2 South Bulli Conveyor System

No. 4 Bin Cat. East
Cat. South
S Main
G 508
G 507
L/W 506
Cat. North
R Main 1
R Main 2
O Belt
60" Belt
No. 2 Bin
9.3 km 1200 tph
7.5 km 800 tph
No. 2 Belt
Steel Cord Belt

Figure 6.6 South Bulli Colliery - Conveyor System 1995

Description

Steel Cord Belt
- Length : 4.8 km long
- Capacity : 800 tonnes per hour
- Speed : 3 metres per second
- Width : 900 mm installed
- Installed : 27 years
Improving Productivity & Viability of Underground Coal Mining Operations

Martin Ryan

No. 2 Belt
- Length : 2.7 km long
- Capacity : 1000 tonnes per hour
- Speed : 3 metres per second
- Width : 900 mm installed
- Installed : 1990
- Replaced : 1994

No. 2 Bin
- 600 tonne capacity

60 Belt
- Drift Belt : 1 in 4
- Capacity : 1400 tp hour
- Width : 1200 mm

"O" Belt R Main 1 R Main 2
- Length : 6.5 km long
- Capacity : 1400 tonnes per hour
- Width : 1200 mm

Other Belts
- Capacity : 1500 - 1800 tonnes per hour
- Width : 1200 mm

6.4.3 Hazard Identification Process for Belt Availability (HAZOP)

In 1993 it was decided to carry out a hazard identification process (HAZOP) to systematically evaluate the maintenance issues impeding belt availability at South Bulli. At this stage availability was as low as 85% where requirements were in excess of 95% to carry the coal required to produce a business that would break even. Each 1%
Improvement represented an additional 1.2 carrying hours or 1,000 tonne per week or approximately $50,000 per week.

Prior to carrying out this Hazop, the following steps were required:

(a.) Define objectives.
(b.) Select the team
   - Engineer
   - Fitter
   - Electrician
   - 2 operators with belt experience
(c.) Select outside facilitator
   - Jim Joy - Mine Risk
(d.) Develop realistic standards
(e.) Audit against standard
(f.) Risk analysis of findings
(g.) Aggregate similar problems
(h.) Develop action plan including detailed costing
(i.) Have plan approved by senior management

The issues that were found to be deficient during the process were:

(a.) Coal Mines Regulation Compliance
(b.) Design inadequacies and outdated Engineering Standards
(c.) Belt selection and Splicing Standards
(d.) No formal documented standards
(e.) No planned Maintenance approach
(f.) Training inadequate
(g.) Inadequate control and communications strategy
(h.) Excess water on belts
(i.) Engineering and roadway problems on specific belts
6.4.4 Action Plan for improvement

6.4.4.1 Coal Mine Regulation Compliance

A senior Engineer was appointed as Belt Engineer and the following reporting system put in place. (Figure 6.7)

<table>
<thead>
<tr>
<th>Belt Fitters (6)</th>
<th>Belt Electricians (6)</th>
<th>Belt Deputies (12)</th>
<th>Upgrade Leading Hand Crew (3)</th>
</tr>
</thead>
</table>

Figure 6.7 South Bulli Colliery Personnel - 1995

Each of the people involved in this process were led through the standards required, the reports required and the work job schedules. It should be noted that traditionally, people who were poor performers were placed on the Conveyor System and not made accountable.

6.4.4.2 Design Inadequacies

An outside Consultant was engaged to design a standard to upgrade the belt system with priorities given to the belt with the greatest risk (ie No.2 belt), (see Figure 6.6).


Availability : 97%.

6.4.4.3 Belt Selection and Splicing

Selection of suppliers and splicers asked to attend interview with proposals. Contracts let for both supply of conveyor and maintenance of splicers.

Result : 1 broken belt from November 1993 to November 1995

6.4.4.4 No formal Documented Standards

People on the job particularly the leading hand and his upgrade crew were required to write standards in conjunction with suppliers, as upgrades were completed.

Result : Compliance with Coal Mines Regulation Act.

6.4.4.5 No Maintenance Planned Approach

Specific belt maintenance times were provided. They were planned using a computer based system identifying priorities and labour resources.

Result : Increase in planned maintenance time. Increase in availability

6.4.4.6 Training Inadequacies

The systems developed were prepared by the responsible supervisors. Tools used to prepare these systems were process mapping, quality assurance document control, standards.

Result : Standards transferable to upgrades and new installations.
6.4.4.7 Engineering & Roadway Problems on Belts

Systematic approach to re-support of old roadways consistent with mechanical maintenance philosophy, particularly on steel cord belt, (See Figure 6.6).

Result : Confidence that roadways along belt will remain open for mine life. These roadways are up to 80 years old.

6.4.4.8 Water on Belts

A Water Management Plan was developed for the whole mine. The flow on from this was also improved travelling roadway conditions.

6.4.4.9 Overall Results of Improvement Conveyor Availability Graph

The overall improvement in belt available can be demonstrated in Figure 6.8.

![Figure 6.8 Belt System Availability](image-url)
6.5 Partnership with Original Equipment Manufacturer

In the past ten years purchasers of new equipment have been seeking out new ways of conducting business. Greatly influenced by the much hyped up experiences in Japan there has been a desire to move away from adversarial relationships to those involving greater co-operation between buyer and seller. In the western world the idea has surfaced as the “Partnership Sourcing” concept. (Figure 6.9)

The advocates of these types of relationships, and there are many, start with the premise that arm’s length and adversarial relationships are wasteful and prevent both parties maximising benefit. If companies can learn to work together in a more co-operative manner then costs will come down and many other benefits will be realised.

Without careful planning a partnership may become a supplier’s gold mine.

However there is no doubt that there are many recorded examples showing an outstanding improvement in certain supply situations.

The characteristics of a partnership which are not the same as ordinary, perhaps long term, business relationships are:

- Participants in some way share risk and reward
- There is a climate of openness and trust
- There is scope for joint activity which creates added value

Partners who become an integral part of each other’s business can make radical improvements in costs, responsiveness and quality.

The practice involves “open” commitment - a willingness to do more than is formally required and being prepared to accede to a request from the partner or to any observed opportunity that would improve performance (It is implicit that partners refrain from opportunistic behaviour).
Using the Supply Positioning grid, we may identify differential relationships.

The essential ingredients for successful partnerships are from both the purchaser and supplier are as follows:

- Genuine commitment from the top of both organisations to make it work.
- A firm understanding by both parties of what is expected in principle and in detail.
- Sufficient resources to ensure success which requires competent people sufficiently trained to effectively carry out their jobs.
- Patience to tackle obstacles and teething problems.
- Open communication between both parties.

The benefits from a partnership are:

- Less working capital
- Lower operating costs
- Better value for money
- More efficient and economic use of resources
- Shorter project timescales
- Less effort to manage the interface
• Improved relationships
• Monitored performance
• Improved long term planning
• Better flow of information
• Joint Research & Development
• Security of supply
• Standardisation
• Mutual benefit

6.5.1 The pitfalls in a partnership

• Impatience in gaining immediate results
• Complacency on the part of the supplier knowing that they have secured a market
• Over dependency on the services provided by the O.E.M.
• Reduce market options and create monopolies

6.5.2 Commencing a Partnership

To start partnership sourcing, considerable emphasis needs placing upon preparation, analysis and planning, internally within your own organisation. The four points below encapsulate the four simplest elements of “Where do I start”.

Starting begins at the top - business management within an organisation must buy-in totally to Partnership Sourcing as a concept, in order to pursue the benefits that may be gained. As Partnership Sourcing is not appropriate for every customer supplier relationship, a documented selection process needs to be undertaken to determine the tender process.

In order to measure progress, simply-defined targets, must be set. A documented process is required to make changes to the original agreed contract.
6.5.3 Internal Research

- Discuss and debate with management in own company what Partnership Sourcing means and implies. The key is to get understanding and commitment from your own management.
- Decide with whom it is appropriate to set up a partnership arrangement. Use supply positioning to assist with this.
- Start with strategic suppliers.
- Set clear, simple and easily achievable targets.
- Create a mechanism for driving Partnership Sourcing forward.

Once the internal decision making and preparation has been completed, you should then turn your attention to your suppliers.

6.5.4 External Research

- Improve the detail and quality of information that you have with suppliers.
- Select potential supplier partners with care.
- Discuss Partnership Sourcing with your own suppliers, eg: open day or briefings.

Once you start to initiate Partnership Sourcing concepts with your own suppliers, please remember that the process will take time and effort. Many different questions will be raised and have to be answered in the process of building understanding.

6.6 Conclusions

A change in the emphasis on maintenance in the Coal Mining Industry will provide greatly improved availability. This is demonstrated in the South Bulli Conveyor Case Study where belt availability improved from 85% to 95% or a return of approximately
$500,000 per week in revenue. This improvement was gained by a systematic approach to maintain and providing the training and management structure to support his approach.

A study by Price Waterhouse on behalf of the Australian Coal Association (Anon., 1995d) recognised the benefits available in a change in maintenance philosophy of up to $450 million per annum which in turn assists in the profitability of the industry.

Whilst the case study demonstrates only a small portion of the savings available when the same philosophy is extended to development machinery, longwall systems and diesel machinery availability, these savings are achievable through the industry.

The introduction of partnerships with the original equipment manufacturers in the industry needs to be further addressed, however, this is difficult in face equipment due to the fact that there only two companies supplying longwall equipment, (Australian Longwall and Westfalia) and three in development equipment (Joy Manufacturing, Jeffery Mining and Voest Alpine).

Opportunities exist for component parts required for maintenance of these machines to be sourced from outside the O.E.M. supply thus greatly reducing the cost of component changeout required in a planned maintenance approach.
CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH FOR IMPROVING PRODUCTIVITY AND VIABILITY OF UNDERGROUND COAL MINING

This thesis demonstrates the interdependencies of exploration, land use, marketing, safety, human resource management, selection of machinery and maintenance of this machinery for a viable, productive coal mine.

In order to take the “quantum leap” in improving viability and productivity of underground coal mining operations each of these areas need to be addressed.

Whilst there have been improvements in exploration techniques Chapter 1, demonstrates the inadequacies when coal mining operations commence after the seam has been accessed. Springvale, Tower, Gordonstone, North Goonyella and Dartbrook Collieries have suffered in productivity and ultimately viability by lack of knowledge on how strata conditions react to the extraction of coal. Further research is required to understand how specific new coal projects will be affected by extraction.

Australia being the largest exporter of coal in the world is dependent on competitive port and rail freight charges to remain viable. Australian underground mining operations are charged between $11 and $17 per tonne of freight. This compares with $2.75 per tonne for Indonesian operations. With increased competition from China, Indonesia, Venezuela and Colombia freight rates will need to be brought in line with these competitors for the Australian Industry to remain viable.

There is an expectation that employees should return home from work in the same state that they left. This expectation demands a high safety culture in the workplace. Whilst improvements in safety performance have been significant the influence of larger coal companies with experience in the oil industry demand performance similar to
those of that industry. This chapter demonstrates that savings of up to $1 per tonne can be achieved by further improving safety performance. These savings are gained in premiums, cost of claims and replacement labour. It can only improve the viability of an operation.

The flexibilities gained through recent changes to the industrial relations system in Australia allows for traditional Human Relations Management theories to be used. Chapter 4 demonstrates the increase in productivity achievable through workforce involvement in decision making. The traditions of the union movement also demonstrate a mistrust of employers thus both the National and District Union Officials are involved in Enterprise Agreements. Further emphasis needs to be placed on encouraging employees to trust coal mine operators and work with them to improve productivity without large cost imposts incurred.

While longwall productivity in Australia has improved largely over the last 10 years development rates have not increased at this pace. In order to improve these rates to levels that match United States mines new initiatives and machinery need to be trialed. Whilst the FCT, AMB20, Sump shearsers and place changing methods have been implemented further development of these systems needs to be undertaken to achieve the desired rates. The Tunnel Boring Machine concept is still in the design stage for underground coal mining use and further research is required prior to its implementation. The Tunnel Boring Machine has the potential to deliver gateroad development rates that match longwall retreat production.

Maintenance of underground machinery has largely been carried out to satisfy statutory requirements. Changes in maintenance philosophy and training of personnel in the benefits of planned maintenance will improve availability and ultimately productivity. Improvements in Human Resource Management has allowed the introduction of partnerships with the original equipment manufacturer including maintenance agreements. This change will not only reduce the cost of maintenance however, it will also improve viability in line with increased productivity.
Specific Research Recommendations

i) Determine the impact of mining operations on strata during the exploration process.

ii) Discover the requirements for safety performance to match industries with similar hazards namely the Oil Industry.

iii) The needs for employees to depend on employers rather than union officials to determine their livelihood.

iv) Determine the specific operating parameters of the Tunnel Boring Machine and conduct field trials.

v) The substantial benefits achievable through planned maintenance and partnership techniques.
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