CHAPTER 6: RISKS ASSOCIATED WITH THIN SEAM MINING.

At Dorstfontein Mine all of the mining has taken place in seam heights exceeding 1.5m. The risks and associated mining problems identified during the life of the mine were discussed in Chapter 4 and differ from that identified by Clarke et al. (1982) for very thin seam mining. This chapter discusses the risks as well as the health and safety issues associated with thin seam mining (at Dorstfontein below 1.4m heights). Although some of these risks may be more applicable to hand-got coaling, they may not be omitted as although continuous miners replaced the pick and shovel, people still work and move around in these thin seam CM-sections.

6.1. Geological.

a.) Seam heights. One of the greatest risks in thin seam coal mining is unexpected decreases in the already thin seam height. These changes are unpredictable and may be attributed to various factors for example floor rolls and slumping structures in the roof. These kind of geological features could bring a section to a standstill.

b.) Quality changes. In Chapter 3 it is apparent that the coal quality and product yield of the thin seam areas could be extremely good. Unexpected changes in product yield may increase costs, and might terminate this difficult way of mining. The sulphur content is one of the most important quality parameters that must be monitored carefully. Coal analysis has showed that in some areas the sulphur tends to be high due to free pyrite in the coal seam. An increase in the sulphur content, outside the product specifications, would create a problem on the marketing side.

c.) In-seam partings. Throughout all the exploration programmes there were few in-seam partings intersected. This does not exclude the possibility that extra thin shale bands and flood sheets may occur. This will reduce the yields and create problems for continuous miner production.

d.) Change of parting lithology. The seam-split parting will form the roof of the thin seam section and exploration has shown that this parting has an upwards-coarsening sequence with a lower section of interlaminated sandstone and siltstone. This parting can be supported, as tests have shown, as long as it stays upwards coarsening. Changes in the laminations of this parting may render it a dangerous roof and create production- and yield problems.

e.) Water. Excessive discharge of water from either the coal seam, overlying roof strata or dyke developments would create problems for people working in such conditions. The thin seam does not allow ease of movement and in the event of excess water people would get wet which will lead to health problems. Excess water would also enter machinery and motors and result in breakdowns. Slippery working conditions would lead to injuries.

f.) Unpredicted dykes. Most of the dykes in the thin seam area have been predicted and some of them were intersected during the South Main development. In the unlikely event that some unpredicted dykes do occur it will create a serious problem for production and could result in adverse roof conditions. Some dykes discharge a great amount of water, which could lead to mining problems and health and safety issues.

6.2. <u>Mining Accidents</u>.

An accident has been defined as "any unplanned exchange of energy which degrades the system in which it occurs". The effect of an accident on mine personnel is the most noticeable and the recording of such injuries provides the bulk of the statistical information on accidents. In most countries this wider concept of an accident is reflected in mining legislation that demands more records and reporting of certain dangerous occurrences that may or may not cause personal injury. The major factor in determining whether an accident is recorded and reported is the nature of the injury sustained. That is the effect in terms of disability and the time the injury prevented the person from working (Clarke et al., 1982).

In the United States a relatively low number of incidents were reported in thin seam coal mining. There was no significant variation of the frequency of fatalities between thick and thin seam mining. The average rate for accidents was higher for thin seams than for medium to thick seams. The frequency rate of disabling injuries was approximately 100 times higher than the fatality rate. It was found that the accident rate was significantly higher in the thin seams than in the thicker or medium seam mines. The increase in the level of hazards may be explained by the decrease in lighting and comfort in thin seam working conditions. In the case of injuries from falls of roof, it was suggested that it was more difficult to avoid an imminent fall in the more cramped conditions of the thin seam. Another possible explanation was the lack of protective cabs and canopies on thin seam face equipment (Clarke et al., 1982).

In contrast to the disabling accidents, the reverse trend was apparent for non-disabling accidents. The frequency rate of non-disabling accidents was lower for thin seam than for thicker seam mines. This can be explained by the fact that thin seam coal accidents are likely to be more serious when they occur since it is harder to get away from or to correct a potential accident situation owing to the confined space. It was found from analysis of sub categories of fall of roof that higher proportions of accidents in thin seams occur during installation of timber or other support, than in thicker seams. The difficulty of installing roofbolts was identified and the protrusion of such support resulted in obstructed travel ways, which could lead to head and back injuries during machine movement (Clarke et al., 1982).

It was found that at mines with low accident rates the morale of the people was good, the geological conditions in terms of strong roofs and floors were good and that increased mechanization has led to fewer injuries. The most common single injury on the thin seam mines was that of a sprained back (Clarke et al., 1982).

In the British collieries there was a steady decrease of the accident level as miners became more safety conscious. The fatality rates have decreased from 4 per 1000 men to 0.25 per 1000 men. The most common injuries were from falls of roof and machinery and haulage movement. The fall of roof rates for the thin seam in the U.K. mines are much higher than for all other mines. This may be attributed to the lack of mobility in the thin seam sections and the support tended to be of a lighter construction to maximize available traveling and working space. A relatively small proportion of accidents from machinery and haulage movement occurs at the face. Most accidents in this category appear in the load-out and out-bye areas. The rate in all haulage and transport accidents is higher for thin seam mines than for thicker seams. In the U.K. mines accidents of this nature contributes to over one third of all serious accidents (Clarke et al., 1982).

In the U.K. mines serious accidents from the use of hand tools in thin seam areas are rare. Stumbling and falling accidents account for the highest number of total accidents in a single category. This high rate is reflected in the serious accident category and shows a higher rate for thin seam than for thicker seam. The rate for serious accidents resulting from slip or falls is much higher for thin seams than for all other mines (Clarke et al., 1982).

In the former U.S.S.R. few statistics exist about their thin seam mining operations. It is noted however that augering operations in the thin seam mines have had no accidents. The conclusion can be drawn that remote operation was much safer than any other mining method. No certain conclusions can be made about any of the former U.S.S.R. mining operations (Clarke et al., 1982).

In the Republic of South African most of the thin seam coal mining was done in Kwa-Zulu Natal. The accident rate in the thicker seam levels is lower than in the thin seam levels, except where the No. 5 (not a thin seam) seam has been worked in the old Transvaal province (now Mpumalanga). Accidents from roof falls were more common in these operations due to the weaker mudstone roofs. Haulage and transport accident frequencies were also high due to the use of track equipment and tubs in thin seam mines (Clarke et al., 1982).

In Colombia most of the coal production is from thin seam mines. The collection of accident statistics is not reliable as there is no legal obligation to report and record accidents. The reportedly high accident rate in this country can be attributed to the lack of controls and standards and not so much to thin seam conditions (Clarke et al., 1982).

To conclude: the U.S.A. experience indicates that the accident frequency rate per million man-hours of exposure in thin seams is higher than in medium or thick seam mines. If the accident frequency rate is calculated on the basis of accidents per million tons mined, the thin seam rates are substantially higher than that for medium or thick seams due to the lower productivity in thin seams. In the U.S.A. the occurrence of hazards, involving mobile machinery in thin seams, are partly due to the difficulty of working by means of bord and pillar methods which involves frequent moving of large items of machinery in confined spaces. The difficulty in supporting the roof is another contributory factor. The U.K. and the former U.S.S.R. trials with remote mining systems have indicated that men may be removed from the face with the expected improvement in safety.

6.3. Health and Safety.

Hazards that result in physical injuries are easier to identify than those that affect the health of workers. The reason for this is that the injury normally occurs as a result of some violent event and the object that cause the accident is directly identified. The detrimental effect on health takes place over a period of time and until some loss or impairment of body function has occurred, the employee may not be aware that the process is taking place. The more obvious hazard to health is that affecting the respiratory system, named pneumoconiosis. In thin seams another health problem is beat diseases, which are caused by working and traveling in unnatural positions. Beat diseases are more common in ultra thin seams where miners work on their knees and elbows. These diseases are described as sores, abscesses and swellings due to constant beating of limbs against the roof and floor. Correctly fitting and comfortable knee and elbow pads are important (Clarke et al., 1982). This condition is less likely to develop where remote control equipment is used and the operator sits while working, but may be common amongst the roof support crew and cable handlers.

Other environmentally related health problems are those associated with working in close contact with water and oil, the danger to eyes from particles picked up by high air velocities, noise and poor illumination (Clarke et al., 1982).

Hazards to respiratory health in coal mining come mainly from inhalation of respirable dust particles. In general the relationship between health and dust apply to all seam conditions. The problem may be more acute in thin seams owing to higher velocities of air needed to supply the right velocities to the coalface. In the U.S.A. some thin seam mines required dilution of methane and the only way to get enough volume for the dilution was to increase the velocity. High velocities may produce a counter effect by causing dust pickup. Velocities above 2 m/s cause appreciable pickup of dry dust but, when the dust is wet, velocities of above 4 m/s can be tolerated. Particle size also affects the pickup of dust. Items of equipment in roadways can cause restrictions in cross sectional areas and result in funneling of air with a resultant increase velocity at the restricted point. In the vicinity of any cutting machine at the coalface, the area is reduced causing funneling of the air with an increase in velocity at that point. It is particularly important in thin seam coal mining that adequate dust suppression equipment be used (Clarke et al., 1982).

In thick and medium seam collieries, water on the floor is merely a problem that should be dealt with. In thin seams however the problem is more severe when miners become sodden from crawling and sitting on wet floors. The use of hydraulic fluids in equipment and machinery causes skin diseases such as dermatitis. Spillage must be kept to a minimum and protective gloves must be worn at all times. Complaints such as colds, influenza and rheumatism may develop where the ventilating air is cold and the wet miners move in and out of this cold air (Clarke et al., 1982).

The amount of noise in thin seam working conditions is much more pronounced than in larger working spaces. It is therefore imperative that all workers wear hearing protection at all times. The advantages of remote control operations are obvious as in the case of noise as the operator is physically removed from the source of this noise (Clarke et al., 1982).

6.4. Production rate and costs.

In thin seam mining a greater area of ground has to be mined in order to extract an equivalent tonnage to that from thicker seams. Many of the tasks that have to be performed in underground mines are related to linear advance and so for a given output they must be carried out more frequently in thin seam mining. Extensions of rail track, conveyor belts, water- and power lines can reduce the productivity in thin seam sections. Other tasks such as sweeping and stone dusting needs to be done and are directly related to area extracted and not tonnage mined. These factors reduce productivity in thin seam mining. In the late 1960s many mines still operated at 10 tons per manshift. This production output has increased with the introduction of longwall mining methods and bigger and more powerful continuous miners. The greatest risk to the production rate is the lack of availability of mining equipment, adverse geological conditions, high equipment maintenance and downtime on the transport systems (Clarke et al., 1982).

The direct result of a low productivity is the escalation of cost. Although the fixed costs cannot be changed, its component in the Rand / ton cost of the R.O.M. tons, will increase. With the high output this component becomes less pronounced in the Rand / ton costs of the R.O.M. tons e.g. if the fixed component equal R 200 000.00 per month and the section produces 20,000 tons per month, the R.O.M. fixed cost is R 10.00 / ton. If the section only produces 10,000 tons for that month, the R.O.M. fixed costs will be R 20.00 / ton. Likewise the variable cost will be influenced by additional maintenance and repair costs during adverse mining conditions. It is common for collieries to have a high fixed cost and relatively small proportion of variable cost. This feature of a mine makes it imperative that output targets are achieved. Nearly all the profits come from marginal tonnage i.e. tonnage mined over and above the base tonnage.

Another risk factor that seriously affects the cost of thin seam mining is the yield. By either cutting the floor or the roof the yield from the thin seam sections would be reduced which in turn would increase the costs. Therefore it is imperative that mining horizons being maintained to produce is much coal as possible and exclude contaminants.

CHAPTER 7: CURRENT THIN SEAM MINING TRIAL.

7.1. Continuous Miner and Battery Haulers.

In 2002 the German company Maschinen- und Bohrgeräte Fabrik GmbH designed a thin seam continuous miner that is capable of cutting as low as 1.0m. It is called the Wirth Paurat H4.30. (For specifications see Annexure 3). The main purpose of this design was to directly compete with the American company, Joy Mining Machinery (a subsidiary of Joy Global Inc. Company), which has a huge market share in the U.S.A. coal mining industry and in the R.S.A. and who also specializes in thin seam mining equipment (pers. comm.). T.C.S.A. management heard about the new development and enquired about the possibility to test this machine at Dorstfontein Mine and compare it to the current Joy 12HM15 on the mine. It was agreed to, with the arrangement that Dorstfontein uses and tests the machine for 1 year at a fixed rent after which T.C.S.A. has the option to buy the machine at a reduced price. The Wirth arrived at the mine in middle December 2002 and moved into a section where the seam height is 1.6m. For the coal haulage there are 2 Stamler BH10 thin seam battery haulers (For specifications see Annexure 4).

The Wirth is equipped with a Debbex/Kennametal double rotating drum, which has been designed to be able to cut thin stone bands. The configuration of the cutterhead is such that a fair amount of the large coal fraction is produced and the fine fractions kept to a minimum.

Initially there were problems with the power supply and software of the Wirth as this machine was built and assembled in Germany and needed to be adapted for South African conditions. A few minor design errors also needed to be corrected on mine to suit our specific conditions. Once the Wirth was in operations it was clear that this machine is well constructed and built and should easily cut in-seam partings and even be able to pull down the seam-split parting in areas where roof brushing is necessary. Presently the parting is being blasted down by drilling holes into the upper coal seam as there exist the potential to damage the machine. Further problems needed to be sorted out during the following few months in order to achieve full production. During March 2003 the standing time became less and availability started to increase. The increased availability has led to another problem regarding the availability of the Stamler BH10 thin seam battery haulers. The Wirth machine cuts too fast for the 2 battery haulers and has to wait before it can discharge more coal from its bin. It became apparent that there is a need for another thin seam battery hauler.

The installation of roofbolts to support the parting is quick and no delay times have been experienced during their installation.

The Wirth has a cutting range between 1,0 and 2.8 m but will spent most of the trial time cutting between 1.5 and 1.6m. The maximum allowed cutting depth is 12m, for safety reasons, after which the parting needs to be supported before the machine can cut that heading again. Roof brushing is currently been done only in the combined travel and belt road, while full support of the parting is done in all the other roads. The planned production rate is 1250 tons per day for the first year after which production will be increased to 1500 tons per day for six years and then again reduced to 1250 tons per day for the last three years. This gives an average production rate of 1400 tons per day for ten years. The lower production rate in the first year is to allow time for all the problems with the new machine to be solved while the lower production in the last three years is to allow lower productivity in the very low seam areas.

The current labour complement is as follows:

- 1 x Miner
- 1 x Continuous miner operator
- 1 x Continuous miner assistant
- 2 x Hauler drivers
- 1 x Feeder-breaker overseer

- 1 x Roofbolter operator
- 1 x Roofbolter assistant
- 4 x General labourers

A total of 12 persons per shift.

7.2. Ventilation

The primary consideration when determining the ventilation requirements for thin seam mining is the provision of healthy, safe and comfortable working environment. Sufficient fresh air must be supplied to the workings to keep the concentration of methane in the general body within the legal limits which prescribes an concentration in the air below 1,4% per volume, reduce dust concentration to at least 1,0 mg/m^3 and maintain air velocities of not less than 1,0m/s along the last through road in the section. As shown in Chapter 6 equipment in roadways can cause dust pick-up and choking of the airflow to the face (Clarke et al., 1982).

Methane emission tests are done on a regular basis by taking core samples from a production face at the mine. Some of the results are tabled below.

Gas Content (m^3/ton)	Emission rate (liters/tons/min)
0.95	34.3

Normally a thin seam does not emit large quantities of methane (small volume of coal) but caution should be taken near dykes and where dolerite sills overlie coal seams to form a cap that prevent degassing of the strata during secondary coalification. This is not the case at Dorstfontein Mine and methane gas should not be a risk in the thin seam areas. The maximum allowable concentration of methane in the general body of the air in any place where people are required to work or travel is 1,4% by volume. If a limit of 0,1% is used to determine the dilution volume of air, then a safe volume of air of at least 15m^3/s will be required to ensure that the methane content of the return air volume does not exceed this 0,1%.

Calculation (Van Zyl, 2001, pers. comm.):

- m^3/ton/min = 34.3 liters / ton / min ÷ 1000 => 0.0343 m^3 / ton / min
- The CM cuts 22 tons / min => 22 x 0.0343 = 0.7546 m^3 / min of gas released during cutting.
- To get to the ventilation needed:

  0.7546 m^3 / min ÷ 60 = 0.01257667 m^3 / sec gas released.
- The dilution needed is 0.1%:

  0.01257667 m^3/sec ÷ 0.1% = 12.577 m^3/sec

  To be safe, use 15 m^3/sec

The air volume necessary to ensure healthy and safe working conditions will be more than that required to dilute the methane. The ventilating air will be distributed to at least the last two through roads from the faces at a minimum velocity of 1,0 m/s. This will require a quantity of air calculated as follows:

Average seam height:		1,3m
Bord width:		6,8m
Section air quantity	=	last through road area x velocity
	=	(6,8 x 1,3) m^2 x 1,0m/s
	=	8.8 m^3/s

By allowing 40% for leakage (Van Zyl, 2001, pers. comm.) and adding 15 m^3/sec for dilution, the volume must be increased to at least 27 m^3/s. A conservative figure of 30m^3/s for the Wirth-section will be sufficient which is not much less than the 35 m^3/s currently supplied to the sections on the mine.

The current practice of erecting brick stoppings between pillars to separate the intake and return air roadways will be maintained. A jet fan capable of handling an air volume of 4m^3/s will be used to positively ventilate the advancing face in the Wirth-section. Directional water sprays in association with a dust scrubber are currently been used on the Wirth. So far it has effectively controlled the dust liberated during cutting operations. The dust scrubber installed on the Wirth currently handles an air volume of $7m^3/s$.

In order to achieve a last through road velocity of 1.0 m/s the total amount of air to the section should not be less than 30 m^3/s. The current ventilation fan on the mine is capable of supplying this additional air to an extra underground section. To channel the air to the new working area, some additional aircrossings will have to be constructed at a current cost of R 15,000 each, which have been catered for in the financial evaluation.

7.3. Rock mechanics.

7.3.1. Split-seam parting tests and results.

Detailed evaluations of the seam-split parting were done by Mike Spengler, the practicing rock engineer on the mine. These tests involved impact splitter as well as compressive strength tests. A detailed report is attached as Annexure 6. From these tests it was clear that the parting is strong and competent enough to form a safe beam to undermine. Due to safety reasons and to uphold the safety record of the mine, it was decided to construct a double safe beam by suspending the parting and upper coal from the proper roof using 1.5m full column resin bolts as well as clamping the layers together to for a strong beam (Spengler, 2002).

7.3.2. Support pattern and cutting sequence.

For the support pattern and cutting sequence that will be introduced in the thin seam areas, see Fig. 7.1 and 7.2. The generally accepted safety factor for coal mines is 1.6 where the probability of pillar failure is only 0.998468 (Van der Merwe and Madden, 2002). For shallow to medium depth mines with a very competent roof is general practice to design the bord widths to seven meters while six meters is used in mines with poor roof conditions. With this knowledge and working to a safety factor of 1.6, the pillar widths can be calculated using Salamon's Formula (Van der Merwe and Madden, 2002, p. 51). At Dorstfontein the centers (from the middle of the pillar to the middle of the bord) is 13.5m at a safety factor of 1.6.

7.4. Advantages of thin seam coal mining.

It is human nature to follow the easiest way to reach a goal. So why would companies pursue thin seam coal mining and why would Dorstfontein specifically pursue the thin seam resource? There are many reasons and some of it has been dealt with in other chapters of this treatise. The current mining trial at Dorstfontein Mine has confirmed what has been suspected for a very long time. The following reasons make it worth pursuing the thin seam coal beneath the seam split parting:

a.) During the mining trial with the Wirth machine, the yields increased significantly by 8 percentage points from about 72% to about 80% within a matter of a few days of mining below the parting. In this, one of the most important objectives of this exercise were met namely to improve the yield by undermining the seam-split parting.

b.) There is less standing time due to discharge shoot- and crusher blockages caused by the seam-split parting breaking up in huge lumps and fouling up the coal chain to the plant.

c.) One big advantage is the saving in belt replacements and maintenance. When the seam-split parting gets dumped on to the main belt going out of the mine, holes are punctured into the belt due to the weight and shape of the stone. This has been reduced, as there is less stone coming from this section.

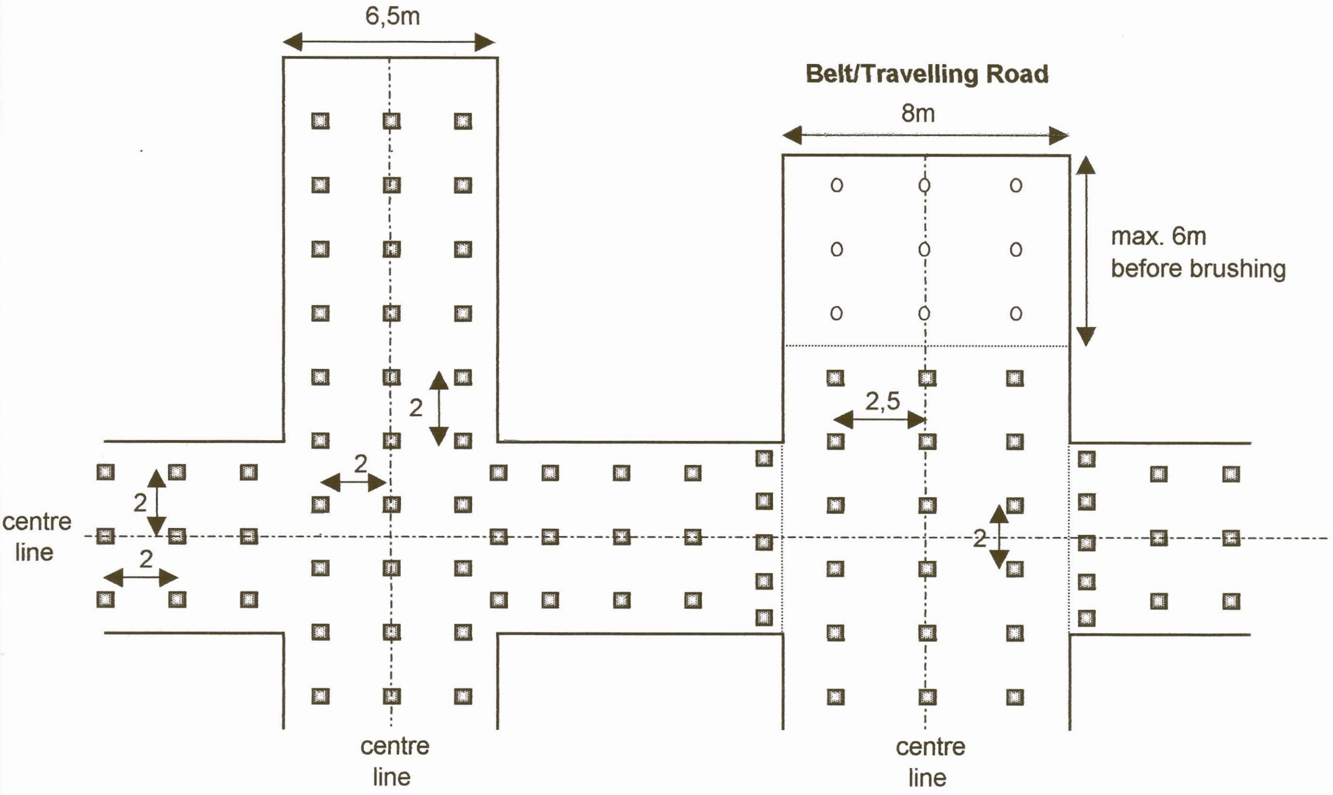
d.) In order to increase yields and prevent damage to the belts the section crew picked some of the stone by hand to be stowed underground. Fortunately no injuries occurred during the handling of the stone, but a chance existed that an accident could have occurred. This kind of injury is now less likely as the current handling of stone underground, has been reduced.

e.) The biggest and most important advantage is the extension in the life of the mine and the longer utilization of existing facilities. Further more there is the extraction of the whole No.2 Seam reserve and the additional revenue coming from this thin seam resource.

DORSTFONTEIN COAL MINE

ROOF SUPPORT: PARTING AND COAL ROOF

REFERENCE	**RED001D**
REVISION No.	
REVISION DATE	
RISK ASS. REF.	**N.A.**



…… Brow

▣ Rockbolt

o Rockbolt after brushing

NOTE
All measurements are metres

RULES

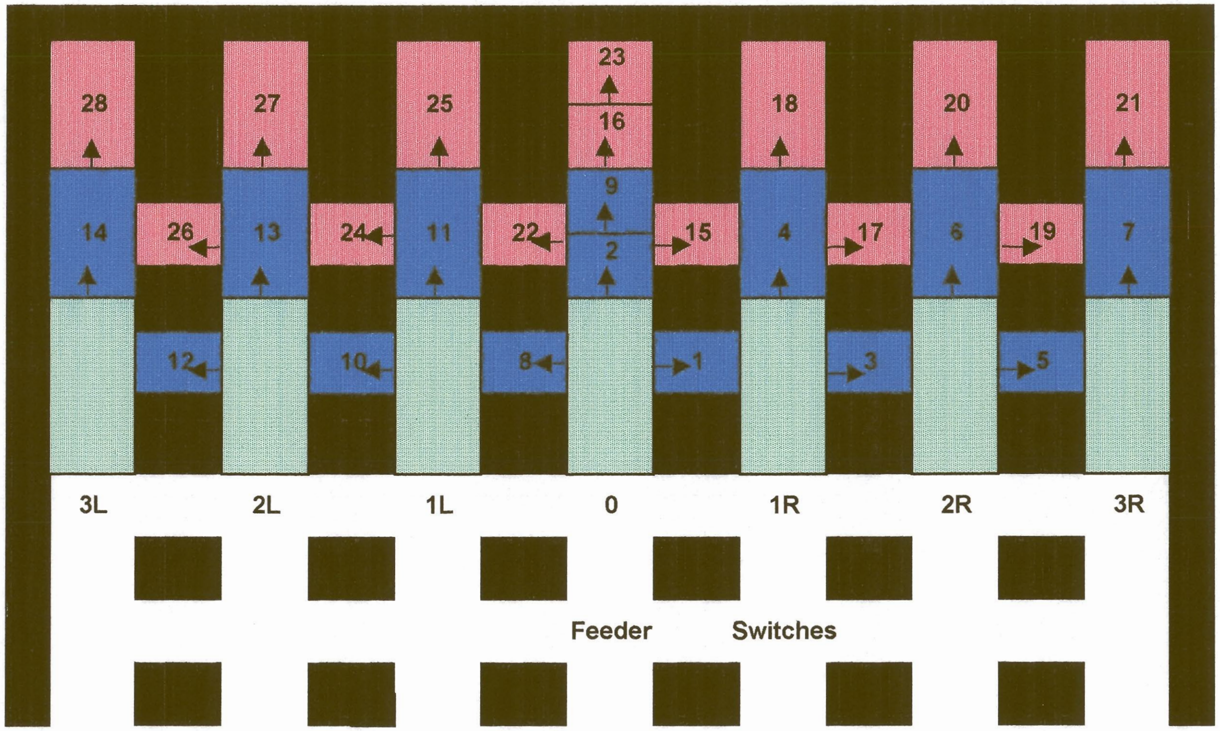
1 Support shall be installed soon as practicable after the installation position has been exposed.
2 Support installation may only advance from secure or previously supported ground.
3 Temporary support shall not be removed until the installation of the roofbolt has been completed.
4 The support will be full column resin anchored 1,2m or 1,5m x 20mm (or equivalent strength) rockbolts.
5 The length of bolt must be at least 400mm longer than the thickness of the parting and the upper coal seam.
6 Rockbolts will be torqued to 150Nm at initial installation.
7 Rockbolts will be installed normal to the roof unless otherwise instructed.
8 No person will be allowed to enter the unsupported 6m undercut. Should it be necessary to enter this area then at least 2 approved mechanical props will be installed every 2m where people are are required to work or travel. The installation of these props will be done under the direct supervision of the responsible miner.
9This standard describes the minimum support requirements and additional support must be installed where necessary.

Fig. 7.1. Roof support: parting and coal roof (Spengler, 2002)

DORSTFONTEIN COAL MINE

CUTTING SEQUENCE: 8m WIDE BRUSHED BELT ROAD

REFERENCE	MS 18b DCM
REVISION No	
REVISION DATE	
RISK ASS. REF.	N.A.



1) Cut split (1) and advance 6m in straight (2).
2) Support split (1) and brush and support straight (2).
3) Cut split (3) and advance 12m in straight (4).
4) Support split (3) and straight (4).
5) Cut split (5) and advance 12m in straight (6).
6) Support split (5) and straight (6).
7) Advance 12m in straight (7).
8) Support straight (7).
9) Continue to follow the mining sequence shown in the sketch and the support sequence described above.

Fig. 7.2. Cutting sequence: 8m wide brushed belt road. (Spengler, 2002)