EXPERIENCES ON PRE-DRAINAGE OF GAS AT WEST CLIFF COLLIERY

by

P. Marshall*, R.D. Lama** and E. Tomlinson***

INTRODUCTION

Drainage of gas has been practiced overseas for almost half a century. Real advances in drainage of gas to combat high emissions became practicable in the late fifties and early sixties when the technology was standardised to use it under a variety of mining and geological conditions. Today methane drainage is practiced in the United Kingdom, Germany, France, Belgium, Poland, Czechoslovakia, Hungary, Romania, U.S.S.R., China, Japan, Canada, U.S.A. and Mexico. Australia entered the list of countries using gas drainage on 3rd March, 1980 when the first full scale gas drainage system was set up and commissioned at West Cliff Colliery to drain gas from the Bulli Seam. Methods used in Europe are different from those used in North America, Japan and Australia mainly because of the different mining methods and also because of the limited number of seams under extraction, relatively new coal fields, and comparatively larger distance between the seams. In spite of the difference in the technique, the basic aim is the same and that is to improve ventilation and reduce ventilation costs, alleviate dangerous gas accummulation, overcome outburst hazards and ultimately make mining safer and more efficient. Over the last decade, there has been large growth in the number of mines using methane drainage. This has chiefly come about due to an increase in mining depth resulting in higher gas contents of coal seams.

In the seventies six countries (Mexico, Australia, China, Canada, U.S.A., Romania) have adopted methane drainage as a standard practice in some mines. In Australia there are two mines which have surface gas drainage installations and at the end of 1981 there were three other mines (Collinsville, Leichhard, Tahmoor) which were conducting investigation on drainage of gas. There are other mines in New South Wales and Queensland which may be brought into the category, but may not necessarily adopt the techniques of drainage that have been adopted at West Cliff.

MINING CONDITIONS AT WEST CLIFF COLLIERY

West Cliff Colliery mines the Bulli Seam at a depth in excess of 500m (430-530m). The thickness of the Bulli Seam varies for 2.3-3.0m. The immediate roof of the Bulli Seam consists mainly of Coal Cliff sandstone (fine to medium grained sandstone containing occasional conglomerates and shale sands) but in the northern and western limits of the colliery holdings the immediate roof becomes shale. A number of minor dip-slip

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faults occur in the seam and at some places have displaced it up to a maximum of 10m, but most of the faults are smaller ($<$ 1m). The seam is interfaced by a number of shear zones (Strike-slip fault) running E-W which contain highly pulverised coal and form focii of outbursts of gas and coal.

The development workings are affected by outbursts and 125 outbursts (February 1982) have occurred since production commenced in October 1976.

Since 1976, in excess of 6M tonnes of coal (ROM) has been produced. This coal has been mined by development and depillaring operations using the modified Wongawilli method of mining. In June 1982, a high capacity longwall system will become operational. The system will use 900t yield chock shield supports with a double ended shearer and is planned to produce 6000t/day with a face length of 130m.

PROBLEMS OF GAS AT WEST CLIFF COLLIERY

Gas compositions at the colliery vary from almost pure methane in the western and southern sections and reaching up to 80% of CO_2 in the northern areas. The majority of workings however, contains about 90% of CH_4.

High gas emission at the faces in the development headings have resulted in reduced productivity rates in some panels.

Comparatively favourable roof conditions, efficient layout, proper selection of equipment, and innovative mining and management techniques have ensured that high outputs could be obtained using Joy Continuous Miners and shuttle cars. A production rate of 2000t per day for a single machine is possible and has been achieved except when gas emissions became so large at the face that mining had to be stopped and dilute away excessive methane emissions. Presence of quartz in the roof has aggravated the situation and a few ignitions have occurred at the face as a result of sparking.

The present production of the mine is about 7000 tonnes per day. The ventilation capacity of the fan is 350 m^3/s. The exhaust shaft is equipped with the coal winder and in accordance with the New South Wales Coal Mining Law, the maximum amount of pure methane in the main return shaft ventilating current is limited to 3.544 m^3/s. Investigations over two year period (Fig. 6.) showed that the amount of methane emitted with the ventilation circuit continues to increase almost linearly with time and reaches a critical limit even when there is no extraction of coal. In December 1979, the gas emission had already reached 2.315 m^3/s. This quantity had increased by 30% over the six months period. This would necessitate changing fan capacities and relocating of winding necessitating sinking of another shaft unless steps are taken to decrease gas emission into mine workings. The only accepted method of control is drainage of gas. It was also realised that if seam can be pre-drained, it may be possible to decrease the intensity and frequency of outbrusts, improve safety and increase efficiency of cutting operations at the face.

Changes that have occurred in mining technology over the last decade and particularly in the last 5-6 years in the development of high capacity shield roof supports for mining of thick seams cannot be overlooked in any progressive operations. In 1979, it was realised that if a high capacity retreat longwall mining was to be introduced, methods of reducing high gas emissions were necessary. These factors led to the conclusion that gas drainage is a necessity for the future of the mine.

Methane gas content of Bulli, Balgownie, Capehorn and Wongawilli seams and the interlaying rocks has been estimated. Total reserves of methane gas at West Cliff, West Cliff Extended and North Cliff leases is of the order of 7.7×10^9 m^3. It is possible to pipe 40-50% of this gas using drainage technology. Without gas drainage, methane will enter the workings and dilution using standard ventilation techniques will not be adequate. It is impossible to work these areas efficiently without supplementary gas emission controls.

INVESTIGATION INTO DRAINAGE OF GAS AT WEST CLIFF COLLIERY

To properly plan a gas drainage system at a mine, requires information on gas pressure, gas qualities, location of the gas reservoirs, permeability of the seam. It is essential to determine optimum suction, area of influence of the drainage holes, effect of various geological factors on flow rates and interaction of mining method, stress and rock properties and development of fractures and relaxation zones around mine excavations.

Phase I of the investigation included gas content, in-seam gas pressure, optimum suction, area of influence of holes placed in coal in pre-drainage. The results of these investigations and development work required for the purpose are described elsewhere (Lama, R.D. 1980), and are only summarised here.

Gas content of the seam determined by both direct and indirect methods resulted in a value of 13 m^3/tonne (raw coal) for the Bulli Seam. Gas pressure measurements gave a maximum pressure of 2670 kPa, at a hole depth of 40m but it is expected that higher pressures of the order of 3500 kPa do occur. The zone of fracturing around roadways was measured using indirect techniques and it was found that the zone extended not beyond 8m from the coal rib. These parameters formed the basis of the design of grouting system. The sphere of influence of drainage holes in coal was determined utilising insitu gas pressure and it was found that the maximum distance between drainage holes could be as high was 60m. The various parameters are given in Table 1.

Table 1

Pre-drainage parameters,
Bulli Seam, West Cliff Colliery

Paramater	Value
Maximum gas pressure	2670 kPa
Gas Content	13 m^3/t (raw coal)
Zone of fracturing around roadways	6 - 8m
Sphere of influence of holes in coal	27 - 60m
Initial flow rate (pure methane at free flow)	3.3×10^3 l/d/m
Flow rate at a suction of 150mm of Hg	6.6×10^3 l/d/m

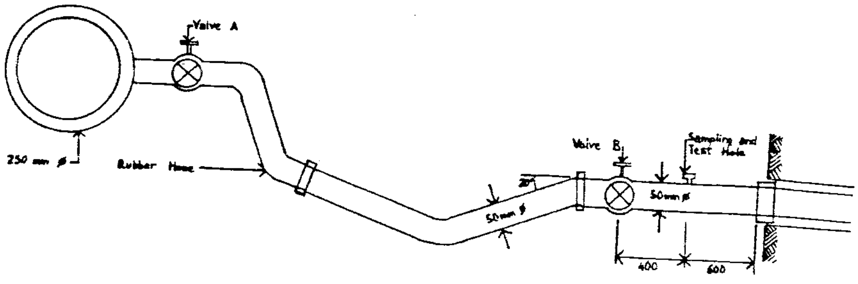

Fig. 1 Arrangement at an -in-seam drainage hole, West Cliff Colliery

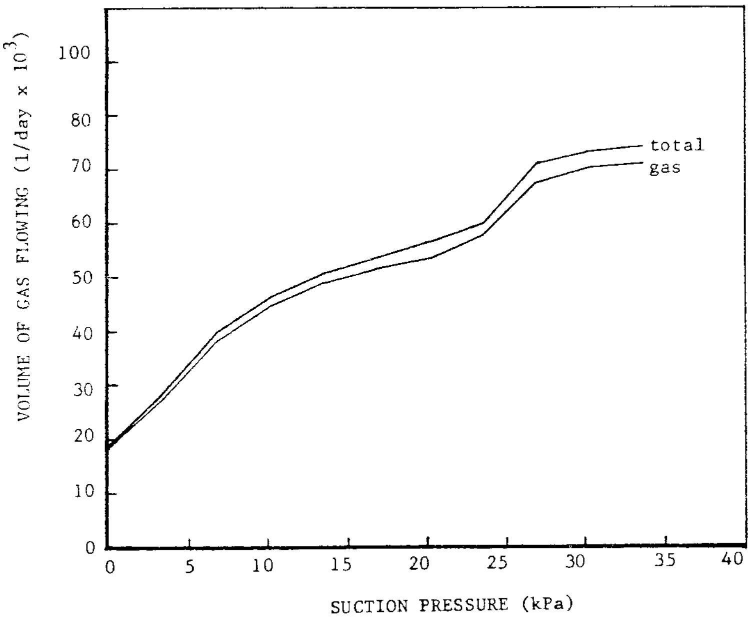

Fig. 2 Effect of suction on flow rate from an in-seam hole, Bulli seam, West Cliff Colliery

Optimum spacing of drainage holes drilled into the solid was determined based upon flow rates and lead time and varied between 12-18m. The suction at the holes varied from 25-30 kPa and the percentage of methane gas from the solid has varied between 95 - 97%. Overall percentage of methane drained from the solid varied between 80 - 85%. Figs. 1 and 2 give the general arrangement at the hole and typical effect of suction on drainage of gas from the holes in the solid coal.

Drainage holes are connected to 250mm diameter main gas drainage ranges which are connected to the district ranges having a diameter of 350mm.

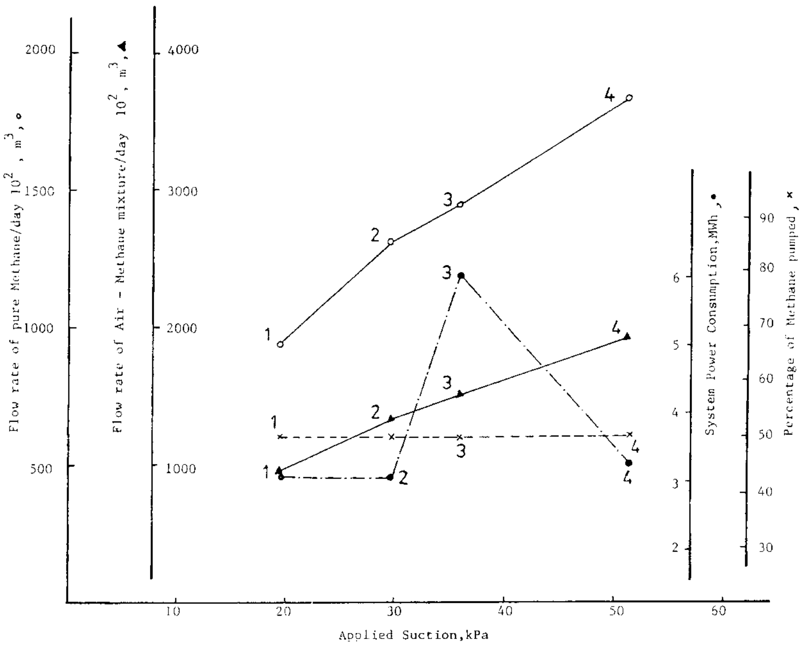

Fig. 3 Effect of suction on gas extracted and drainage system parameters Total number of holes on line 306 + goaf drinage, test duration 24 hours at each suction.
Test Point 1: 1xCL3002 with 30% recirculation; Test Point 2: 1xCL3002 with no circulation; Test Point 3: 1xCL3002 + 1 CL3002 with 50% recirculation; Test Point 4: 2xCL3002 with no circulation

Monitoring of drainage holes is conducted at regular intervals throughout the life of the holes. Each hole is monitored with respect to the following parameters:-

flow rate
gas composition
applied suction at the borehole

Drainage holes are disconnected when flow rate drops to about 10% of the initial flow rate, or if the percentage of methane gas drops below a pre-determined limit.

All district ranges are monitored for purity of gas and can be isolated in case the purity drops below a certain limit or, if these ranges require repair or extension. Automatic continuous monitoring of methane percentage incorporating an alarm system ensures that necessary remedial action can be performed quickly.

In the last 24 months to March 1982, 482 holes have been drilled in coal with a total length of approximately 51000 metres.

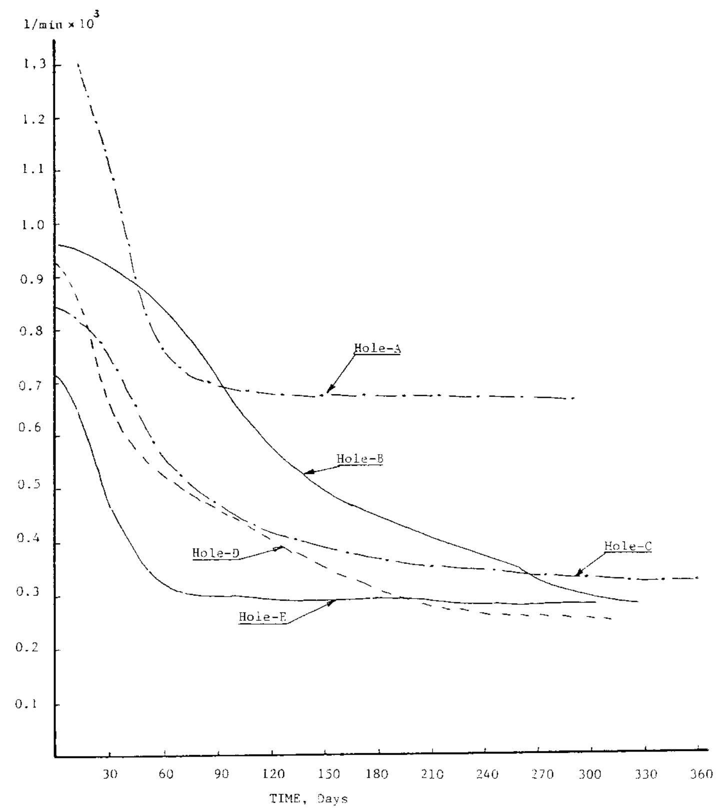

Fig. 4 Flow rate from horizontal drainage holes in coal (Bulli Seam) as a function of time. Average length 93m, average suction = 25 kPa.

The effect of suction on the increase in flow has been questioned by various investigations on theoretical grounds. Experiments however, show very clearly that suction does increase flow rates not only in short term tests but also in tests over extended periods. Fig. 3 shows the effect of suction over 360 holes. These tests were conducted over a 24 hour period. These results support the short term tests that suction does increase flow rates by a factor of approximately two (Fig. 2).

Rate of flow for holes varies considerably. Very high flow rates are obtained when holes intersect outburst zones. In such cases average flow rate are 3 - 7 times higher compared to other holes.

The effect of time on flow rates from holes is given in Fig. 4. Flow rates have been corrected for any change in suction during the period. The life of the holes is approximately 4 months. The predicted values at no suction were about 240 days. Since suction increases flow rate by a factor of approximately 2, the production time has dropped to half. This conclusively proves the effect of suction on increasing rate of flow.

Table 2

Drilling performance using Acker "Big John" drill machine

Hole Number	Panel	Length of Hole, meters	Drilling Time	Changes in Height over the Length	Deviation in azimuth over the Length
1	211	72	1 hour	- 2	0^{o}
2	211	352	4 days	+ 12	44^{o}
3	211	223	8 days	- 7	1.5^{o}
4	312	196	4 days	+ 7	1^{o}
5	312	442	5 days	+ 13	18^{o}

Longhole Drilling

The present system of drilling holes in coal and in the floor utilises a modified Atlas Copco Diamec 250 machine. This machine has capacity to drill up to 200m, and hole length of 174m have been drilled successfully in coal and 120m in rock. The diameter of holes for pre-drainage in coal is 50m with reaming of the hole collar to 85m to a depth of 9m to accommodate PVC carbon impregnated anti-static standpipe. The diameter of the floor holes is 57mm with the top 6m reamed to 100mm.

Longhole drilling in coal presents some major problems. It is essential that both the horizon and the direction is maintained within limits. A number of different machines including Gardner Denver, Edeco and Acker "Big John" drill have been tried. A length of 160m was successfully drilled with Edeco. The maximum length that has been drilled with Gardner Denver was 40m. Both these machines proved very slow though the holes maintained their horizon and direction within limits.

A large scale trial was conducted using the Acker "Big John" drill in conjunction with A.C.I.R.L. This system utilises stabilisers and monitoring of both azimuth and inclination is done using Eastman single shot survey tool.

A total of 9 holes were drilled using this machine with a total length of 2200m. The maximum length of the hole drilled was 471m The experience in maintaining both the horizon and the azimuth of the holes has not been encouraging. The major problem occurs when the holes hit a mylonitic zone. At this stage, stabilisation of the drill string was to be discontinued due to blockage around the stabilisers, slowing down of penetration and stalling of the machine. Drilling through these zones needs higher horse power than provided by a 50hp motor on the machine. The machine also suffers due to high immobility if it has to be moved from one section to another. Setting up time is long and tramming of the drill rig under its own power is not possible except over small

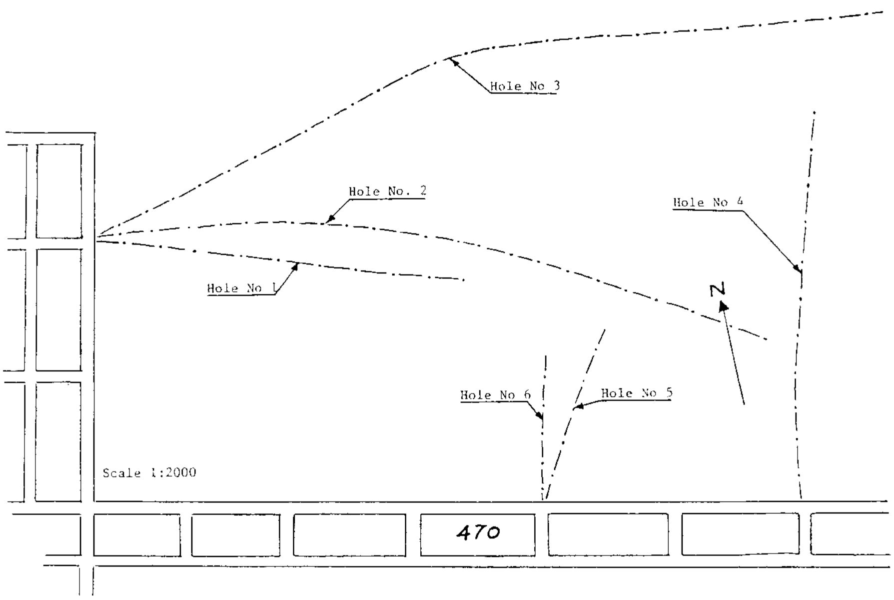

Fig. 5 Horizontal deviation of holes drilled using Acker Drill

distances. Excessive length of the machine makes its setting up to 90^o to the axis of roadways impossible. Table 2 gives some details of the experience with this machine. More details are given in another paper presented at the Symposium (Hebbelwhite, B. 1982).

Drainage Requirements of Longwall Mining

Various considerations have been given to ventilation requirements of a high capacity longwall mining of Bulli Seam at West Cliff Colliery. Total emission rate measurements at the mine with Bord and Pillar mining without depillaring show that about 40 m^3/t of gas is being liberated at a production rate of 4000 t/day.

Depillaring areas increased gas emission to over 35 m^3/t from the goaf area. These initial observations prompted a revised approach into the rate of emission from the longwall face. Various methods were used to predict gas emission quantities. Tables 3 and 4 give the results of selected calculations. It is obvious that the ventilation of such a face would be impossible without pre-drainage. Pre-drainage of the coal seam was essential to increase rate of drivage of development headings. Post-drainage is essential to reduce emission from the goaf areas. The method of goaf drainage is given in Fig. 7. It is estimated that about 50% of the gas from the goaf shall be captured by floor holes. In-seam drainage will reduce gas emission at the face by 50%. This would result in an overall efficiency of about 60%. The amount of air quantity at the face will be reduced to about 30 m^3/s, and in the whole district to less than 70 m^3/s.

EFFECT OF DRAINAGE ON VENTILATION CONDITIONS AT FACES AND OUTBURSTS

Pre-drainage of Bulli coal seam has

Table 3

Summary of gas emission calculated by using different methods, Longwall Panel, West Cliff Colliery (Lama, R.D., 1982)

Method	Specific Gas Emission (Floor) (m^3/T)	Specific Gas Emission (Seam) (m^3/T)	Total Specific Gas Emission (m^3/T)	* Total Gas Emission (m^3/min	** Total Gas Emission Into Vent Air (m^3/min)	*** Air Quantity Required to Dilute to 1.25 (m^3/S)	**** Air Quantity Sweeping along L.W. face (m^3/S)
Fluge	1.17	4	5.17	21.54	19.10	37.63	55.28
Gunther	14.79	2	16.79	69.96	39.15	77.13	27.64
Jeger	10.41	2	12.41	51.71	30.02	59.14	27.64
Lidin	1.13	4	5.13	21.38	19.02	37.43	55.28
Schulz	2.76	4	6.76	28.17	22.42	44.17	55.64
Winter	7.89	4	11.89	49.54	33.10	65.21	55.64
Koppe	10.62	4	14.62	60.92	39.21	77.24	55.64
Airey	15.01	1.82	16.83	70.13	38.85	76.53	25.15
Barbara) Exp. Mine)	6.88	4.16	11.05	46.04	31.67	62.39	57.49

* Production in 3 shifts at a rate of 6,000T/day.

** Assuming 50% capture rate for the gas from the floor, gas from worked seam emitted fully into the air stream.

*** Assuming irregularity coefficient of 1.5.

**** Quantity calculated on assumption that CH_4 % must not exceed 0.5.

Table 4

Floor Borehole Parameters
(Lama, R.D., 1982)

Assumptions: Number of boreholes operative = 6 at a given time.
Average length = 100 m.
Dilution = 20%

Method	Total Methane Captured (m^3/min)	Total Mixture (m^3/min)	Mean Flow Rate per hole (1/s)	Maximum Borehole Velocity (m/S) W max	Pressure Loss (kPa) φ = 57mm	Pressure Loss (kPa) φ = 100mm
Gunther	30.81	38.52	106	43	12	7
Jeger	21.69	27.11	76	30	6	3.4
Winter	16.44	20.55	57	22	3	1.7
Airey	31.28	39.10	108	42	12	10.8

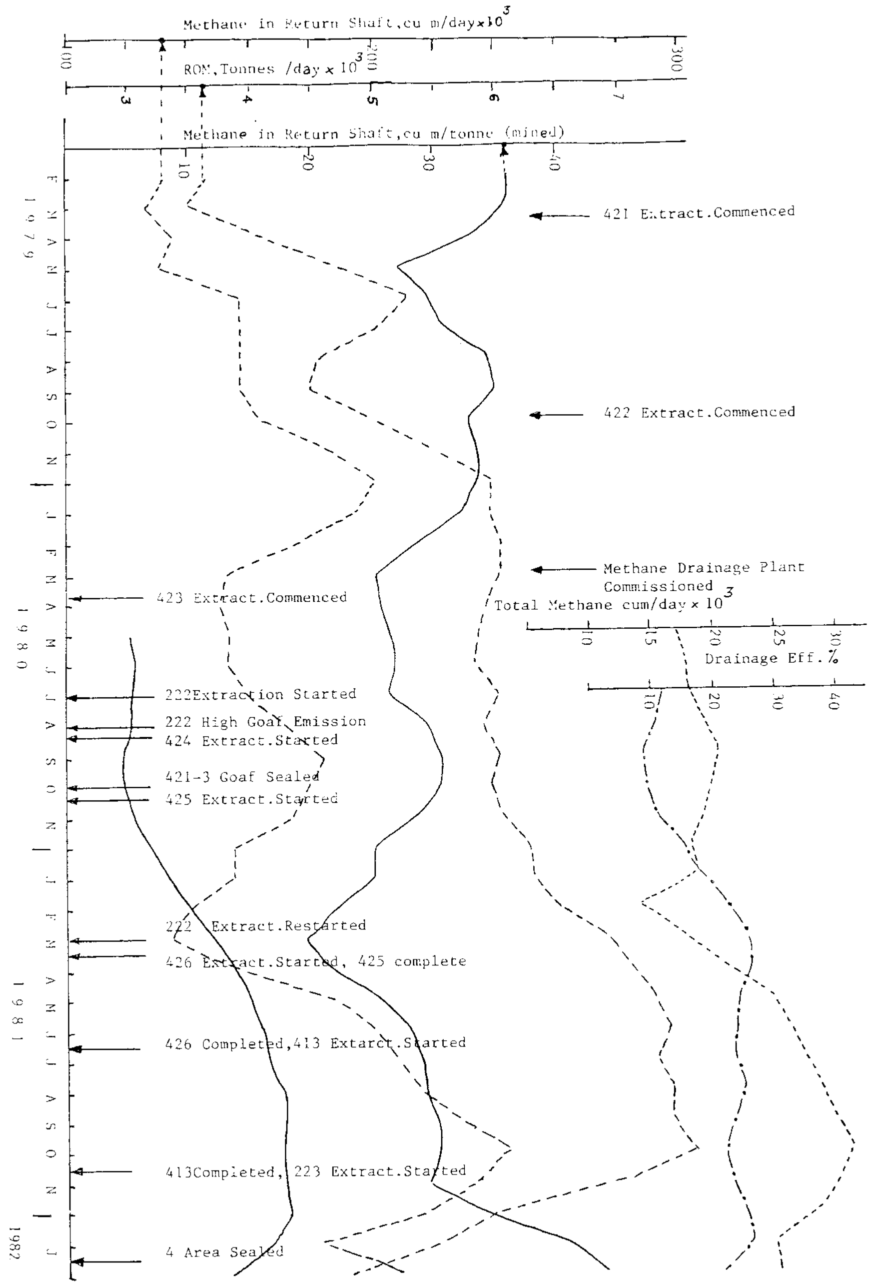

Fig. 6. Methane Gas Drainage Indices, West Cliff - first gas drainage installation in Australia

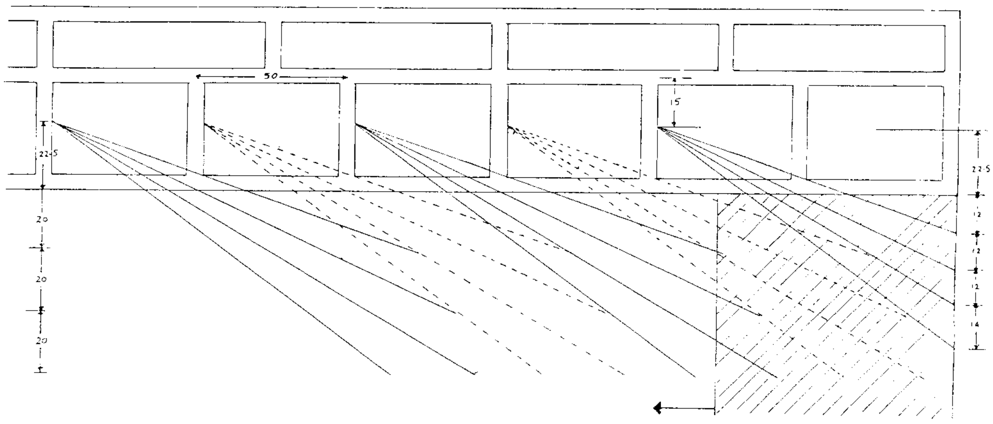

Fig. 7 Pattern of drainage of gas from the goaf using floor holes

improved ventilation conditions at the faces (Fig. 8) considerably. The 304 Panel (Fig. 8) was driven as a three heading development over a length of 1800m. The average shift production over the whole length of the panel was 180t/shift. The general body methane percentage at the return end of the panel was 0.6-0.65% with a total ventilating air quantity of approximately 25 m^3/s. Face stoppages occurred intermittently and there was one ignition of gas at the face.

The northern rib was drained using 50mm diameter holes placed in coal at distances of 12-18m for a period of about 270 days. A total of 97 holes were drilled in the block of coal. Flow rates varied from 300-1200 l/min initially which dropped over a period of 100-150 days to negligible limits. The length of holes varied between 70-90m though the planned length was 90m.

The 470 panel was a two heading development. The rib side of the heading A was at a nominal distance of 100m from the collar of the drainage hole and 10m from the planned end of the drainage hole (Fig. 8). The production rate achieved during the complete life of Panel 470 was 260t/shift. The 1800m length of the roadway was driven in 300 shifts. The rib emission in the intake roadway was almost eliminated and the methane gas content of the fresh air reaching the face was below the resolution of methanometers. The return air from the panel had gas content of 0.2% at $18m^3/s$. The stoppages in the driveage of the intake heading (A) were completely eliminated. The heading B of the 470 panel had a few problems at the face due to gas emissions.

The effect of drainage on the outbursts is indicated in Fig. 8. The shear zone at point where it intersects the heading A has a width of about 0.7m. Wherever this shear zone was intersected by other headings in Panel 304, it precipitated an outburst. The effect of drainage resulted in the absence of violent failure on intersection of the shear zone by heading A (Panel 470). The face just slumped in front of the continuous miner with emission of gas sufficient to trip off the miner. The left side of the heading though sheared stood well without much damage.

However, when this shear zone was

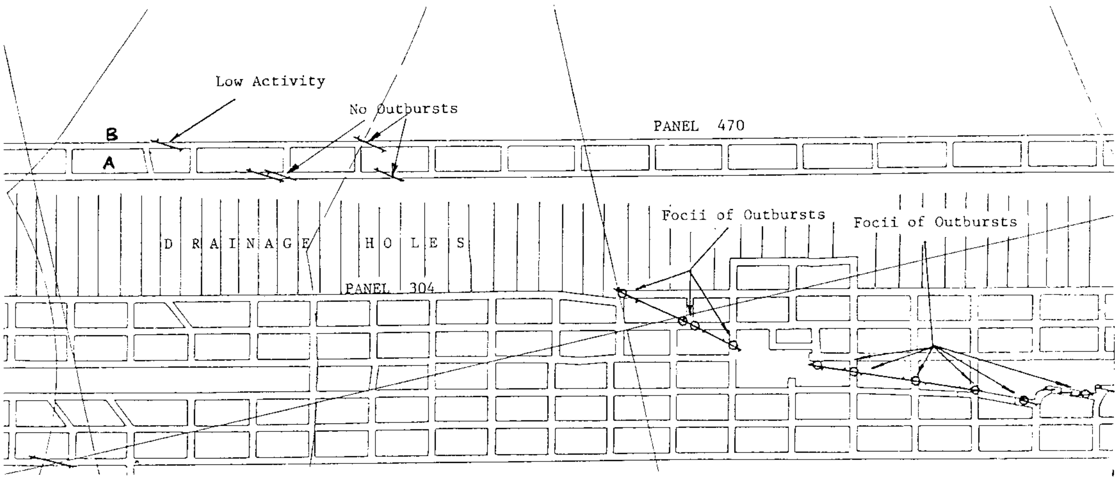

Fig. 8 Effect of drainage of gas on outburst activity

intersected by the heading B of the 470 panel, an outburst occurred. A total of about 32 tonnes of coal was ejected. The occurrence of the outburst in the B heading was expected. The average radius of influence of a hole in the Bulli Seam at West Cliff Colliery is 22m, and the maximum distance is 30m. The distance from the end of the drainage holes to the B heading in 470 panel was 36m which is far in excess of the radius of influence and hence the heading B could not be drained effectively. This clearly demonstrated not only the accuracy of the measurements of radius of influence of boreholes but also the beneficial effect of drainage on increased production, reduction in stoppages, decreasing danger of ignition of gas on the face, improvement in safety and reduction in overall gas emissions in the headings driven into solid. Successful drainage also helped in cutting down the number of headings to be driven, decreased development time, decreased ventilation requirements in the district and improved ventilation efficiency.

Surface Installations and Controls

Methane gas from the main ranges is brought to the surface through a 500mm diameter cased borehole especially drilled for the purpose (Fig. 9). A schematic of the surface plant is shown in Fig. 10. Gas from the borehole passes through a water trap and flame arrestors before going to the pumps and is exhausted on the top of the fan evasee for quick dilution. A secondary exhaust system is provided to discharge gas in case of the main ventilation fan shut down. The evasee discharge range is protected against lightening strikes by lightening arrestors. An automatic pressure relief valve is provided which by-passes the pumps and delivers gas to the secondary exhaust in case gas pressure on the intake side exceeds 103 kPa (abs). The FLP and I.S. equipment and the open sparking equipment are housed in separate rooms. The present capacity of the drainage plant consists of the following:-

1 Nash Hytor H8 Pump - 1000 m^3/h
1 Nash Hytor H10 Pump - 2000 m^3/h
2 Nash Hytor CL3002 Pumps - 6000 m^3/h
1 Nash Hytor CL4002 Pumps - 4000 m^3/h

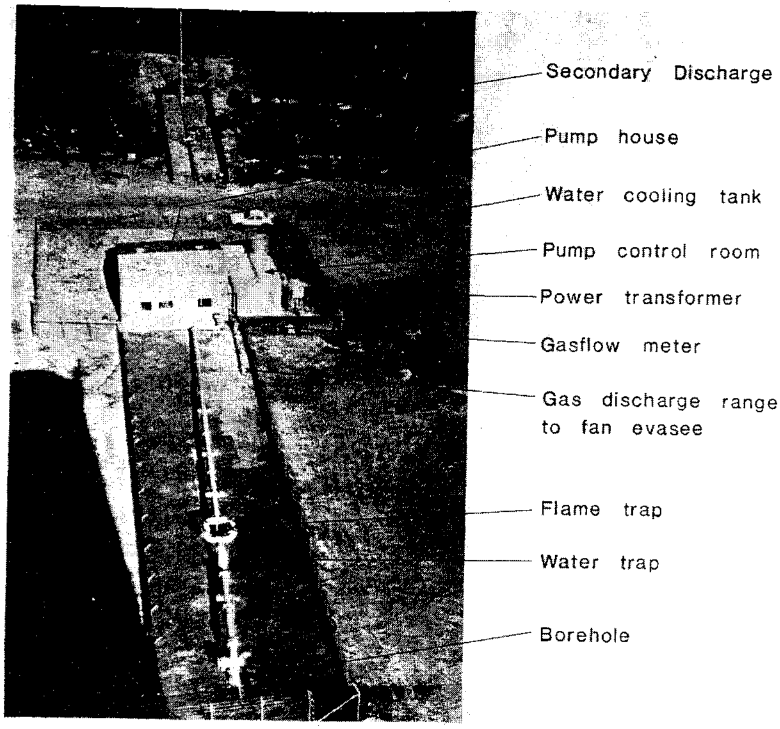

Fig. 9 Birds eye view of surface gas drainage plan

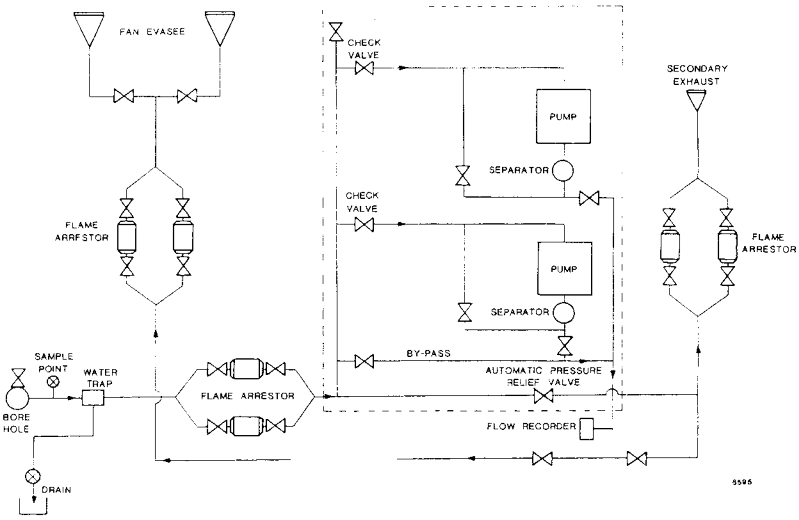

Fig. 10 Layout of surface plant for gas drainage system

The system provides that pumps can be operated in parallel. The system applied vacuum can be regulated by recirculation if required. Presently, the system is working at a vacuum of 30-40 kPa.

Control systems on the surface plant include the following features:-

1. Automatic monitoring of purity with a cut off system and alarm signal if the methane percentage drops below a pre-set limit.

2. Continuous flow monitoring with visual display of flow rate and cumulative flow.

3. Safety arrangements which include leakage detection, excessive rise in temperature of equipment, motors, bearings, cooling water temperatures and pump shut down, etc. are provided along with automatic fire protection and fault detection system.

Surface drainage plant became operational on 3rd March, 1980 and in the last two years, approximately 50 x 10^6 m^3 of methane air mixture has been pumped. By the end of 1982, it is estimated that about 86 million cubic metres of methane air mixture would be pumped and thereafter the pumping rate would be of the order of 80 million cubic metres of methane air mixture per annum.

GAS UTILISATION

In the year 1981, West Cliff Colliery exhausted to atmosphere 35.5 million cubic meters of methane air mixture of calorific value of 18-23 megajoules per cubic meter. This important source of energy has been vented into the atmosphere. It is possible to commercially utilise this gas and the company has investigated a number of options. These include:

(a) upgrading of the gas and direct sale to the marketing companies

(b) upgrading and conversion to other chemicals such as methanol etc.

(c) generation of electric power using gas turbines

Considerations have shown that under present conditions, the third proposal is most economical. A pilot gas turbine of 1.2MW capacity is being planned which is due to become operational by end of 1982. The unit is a KG2 Kongsberg gas turbine which is capable of operating between 45-70% methane mixture without any substantial loss in its efficiency. This unit will consume 750 m^3/hour of methane-air mixture. The unit has a high degree of automation control and has a proven reliability record. A similar unit is operating at Point of Ayre Colliery (Wales) at 50% methane air mixture. The unit will provide enough power for essential services such as gas drainage plant, slope winder and ventilating fan (at reduced speed).

With the introduction of the longwall face, the gas output in the drainage system will increase by at least 25000 m^3/day (pure methane). This would permit increasing the generating capacity to meet almost all the power demands at the West Cliff and West Cliff Extended Collieries.

Conclusions

Experiences at West Cliff Colliery have shown very clearly that methane drainage is successful in controlling gas emission rates at the face in a seam under extraction by pre-draining the seam gas using in-seam horizontal holes. It has also proved that pre-drainage can cut down the number of development headings to two (intake and return) if need be and that rib emissions can be almost eliminated. Drained areas have reduced the intensity of outbursts at shear zones greatly to the extent of almost eliminating them. In this case, however, advance time for drainage is extremely important. The success of drainage at West Cliff has led the way to drainage investigations at a number of mines in Australia and helped convince operators that low permeability coal seams in Australia can be successfully drained using the existing technologies.

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DISCUSSION

R. PHILLIPS (Capricorn Coal Management Pty. Ltd.): Has the percentage or the content of methane per tonne out of a drained block been determined?

E. TOMLINSON (West Cliff Colliery): Not specifically, not the way described by Highton. It has been determined initially that the content of the seam is in the region of 13 cubic metres per tonne. All that has been done was to estimate from the total flow of a block of holes in a particular area and then compare that with the total tonnage of coal in that area and this has produced figures of for instance 80/85% drainage from that block, in-seam drainage. This has been done, and the data has been presented by Hayes. Tests done by Hayes have proved that the gas content of the seam has been reduced from 13 down to as low as 4 cubic metres per tonne after drainage.

I. GRAY (A.C.I.R.L.): In Figure 3 the top-most curve gives the flowrate of methane, pure methane, per day versus applied suction. For how long were those tests performed to gain that extra flow. It shows quite markedly an increase in flow with suction, but the flow should increase markedly for a short period afterwards and then decay back. Is the value given after the decay back and at a steady state flow? Was it left for one hour, one day, one week or a month before the measurement shown?

E. TOMLINSON: Figure 3 shows the effect of suction on gas extracted and drainage system parameters and is specifically referring to the extraction station on the surface. These tests were done with a duration of 24 hours at each suction period - over 24 hours. The top line shows the flow rate of pure methane. The tangent of the line between for instance one and two indicates the increase in flow between A having one C.L. 3,000 extractor on its own with 30% recirculation. In other words it is drawing some of its own exhaust, which gives a low vacuum. That is situation one, giving a low vacuum and a flow rate of just under 2,000. It is over a 24 hour period. But just to expand on that slightly, what this figure indicates is that using various configurations of pumps on suction at any one time there is an increase in flow together with an increase in vacuum, but it is apparent that the hatched line which shows purity stays the same. The vacuum can be increased to a certain level, pulling more gas out of the pit and, providing the source is there, providing that it is not pulling from holes that have been on line for more than 120 to 140 days, that purity will still be maintained. But there will be more of it.

L. LUNARZEWSKI (Visiting Polish Methane Drainage Specialist to BHP Steel Division Collieries): Was the accuracy of the prediction of gas emission examined at West Cliff Colliery and how accurate was the prediction?

R. LAMA (Kembla Coal & Coke): It had been estimated that the holes should be under suction and extracting about 80% of drainage from the block. To achieve this the holes should be drilled for about 240 days. These holes had been drilled for 240 days and a bit more (270 days exactly). The values came out like this. The amount of gas emitted in the headings dropped. The amount of gas released in the headings when Panel 470 was driven was almost a quarter of what would normally have been expected if there was no drainage. So while expecting an efficiency of 85%, actually about 75% was achieved, and that was alright as far as drainage from the solid was concerned. One reason was, that quite a bit of investigation had been done and the parameters were far better for solid coal.

From the data about the floor holes which was used, it was estimated that drainage from the floor holes would cease as the face advanced to a distance of some 70/80 m. But actual observations which have now started indicate that is not so. The drainage from the floor holes continues to beyond about 250 m behind the face, so the estimate should have been 200 to 250 m. Also it is found that flow rates that have been estimated are a bit higher, but then the estimates are for longwall and not for the bord and pillar mining. So possibly it may be found that the flow rates would be less than the estimated flow rates. How the actual observations would compare with the theoretical calculations remains to be seen.

A.J. HARGRAVES (BHP Steel Division Collieries): Figures of output of the plant of 5½ to 7,000 cubic metres per hour were given, has the plant ever been shut down to give an indication of what the free flow would rise to after a period of shut down?

E. TOMLINSON: Yes, only last week there was occasion to close the plant down because of a malfunction in the gas analyser. Within 30 minutes of closing the plant down there was free flow at the surface which after 2 hours reached 4% as against 50% when the two C.L. 3,000 pumps were running. 4% of 10,800 is what? 400 cubic metres an hour on free flow conditions, at a purity, measured with the Riken interferometer because the analyser was malfunctioning, of 78-80% methane. This gas, apparently was principally from the floor holes underlying the 223 and 222 extraction panels.