RETREAT MINING METHANE DRAINAGE

By
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ABSTRACT

From the ventilation aspect, there is a basic difference between advancing and retreating longwall layouts. Particular problems with retreating, using differing mining methods and layouts include high gas emissions, spontaneous combustion and gradients.

There is an acceptable method of controlling the environment at the return end of a retreating longwall face without the use of a multiple heading system. Incorporated in the design is the facility to practice extensive methane drainage, thus ensuring a control of the rate of methane emission into the main roadways.

Case studies highlight varying mining conditions under which the proposed system of ventilation was practised.

INTRODUCTION

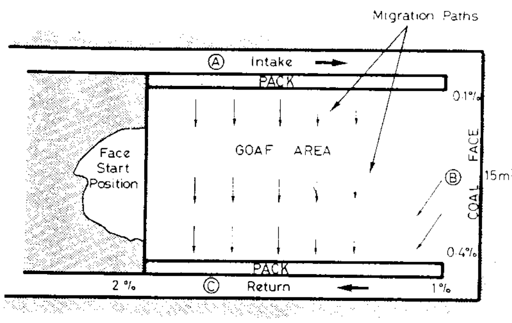
The success or failure of methane drainage depends on the correct assessment of the source of methane in the strata section associated with the seam or district being worked. Experience in the U.K. over the past decade suggests that with a properly designed methane drainage system, the gas emission from a retreat face can be effectively controlled and the efficiency of the system can be as high as that of an advancing unit with similar gas emission rates.

The techniques described in the paper have been in use over the past decade and have satisfactorily controlled high rates of gas emission. Floor emissions have also been controlled and electricity can generally be used, even where methane makes on individual longwall faces may be in excess of 1,000 litres per second.

THE DIFFERENCE IN METHANE DRAINAGE TECHNIQUES FOR A RETREAT FACE

With the advancing method of extraction, the district ventilation pressure difference contributes in controlling the methane emission on a gassy district, so that a system of methane drainage can effectively capture the gas. A typical advancing layout, in moderately gassy conditions, without a methane drainage system is shown in Fig. 1. The methane migration paths and the main source of pollution where the methane would pollute the mine airways are indicated.

FIGURE No. 1



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"Seam Gas Drainage with particular reference to the Working Seam", May 1982

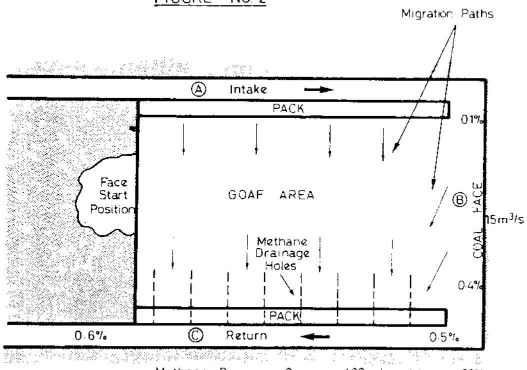
Ventilation pressure difference between intake and return diminishes as the face line is approached (A and C). This pressure difference creates migration paths of air leakage, which although of a very small value, can be many in number. Thus, air leakage passes between intake and return roadways in the goaf area and in the small breaks in the destressed strata. Thus, any methane which is released from gas bearing strata, either above or below the working seam is entrained by these migration paths and to some extent diluted by them; the extent of dilution being dependent upon the quantity of leakage and the distance of the leakage paths from the working seam level.

In a gassy district, these migration paths where methane drainage is not practised can be polluted with high purity methane and eventually spill the entrained methane into the return roadways of the mine.

At the return end of the face, the pressure difference across the goaf from the face line to the return (B and C), tends to minimise methane emission from the area of the return pack on to the face. The methane tends to be forced back into the goaf and eventually spill out into the return airway back from the face. The combined effect of the migration paths caused by the ventilation pressure acting between AC and BC causes the methane to spill out into the return roadway, and the maximum methane content is usually recorded just outbye of the original face start line. These migration paths not only assist in removing the methane from the most vulnerable section of the district, the face area, where activity takes place, but also directs it into a zone where an effective methane drainage system can capture it.

Consider the same district, but with a standard system of cross measure methane drainage installed. The system would consist of both up-holes and down-holes drilled at 10 metre centres from the return gate parallel to the face line and inclined at the appropriate angle.

FIGURE No 2



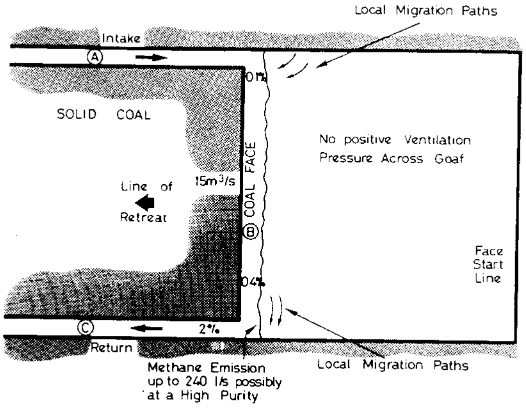
Methane Drainage Capture 420 l/s mixture at 50%

A correctly designed methane drainage system will capture a large proportion of the methane released from the strata above and below the working seam. Thus, only a small percentage of the total methane released which which migrates along the paths close to the seam will eventually enter the district return roadway.

Consider the layout of a simple retreat face with no ventilation behind the face, methane emission rates and ventilation quantities being of the same order as in the two preceding examples. (see Fig 3)

In this case the ventilation pressure difference between intake and return roadways (A to C) is acting against a barrier of solid coal and not across a longwall goaf. Unlike the advancing face, where the maximum methane content can be expected at the outbye end of the return, the maximum methane content will be close to the return end of the coal face at the goaf edge. There is little or no ventilation pressure across the goaf, few migration paths and thus very little goaf drainage.

FIGURE No. 3



The methane released in the goaf area fills up the voids until it overspills into the working sections of the mine roadways at the return end of the face.

Once the goaf area is full of methane, the rate of emission into the mine roadways will be dependent upon:-

(i) The amount being liberated by the seam being worked.

(ii) Barometric pressure changes and the rate of such change.

(iii) Movement of ground in the goaf area, causing displacement of the goaf atmosphere.

(iv) The gradient of the face and the associated roadways.

This type of layout does not readily lend itself to conventional methods of cross measure borehole methane drainage systems. Comparing the two systems (ie. advance and retreat); it can be seen that when advancing, the ventilation pressure across the goaf area creates migration paths which tend to control the methane emission at the face return end. With a simple retreat layout, however, there is little or no such control. It follows, therefore, that in gassy conditions the retreat layout should be so designed to simulate the effect of an advancing layout at the return end of the face.

DESIGN OF A VENTILATION SYSTEM TO EFFECTIVELY CONTROL GAS EMISSION ON A RETREAT FACE

In the mid 1950's, more retreat faces were laid out mainly to achieve higher rates of production per face. Severe gas problems resulted, however, and these difficulties caused setbacks in the introduction of retreat layouts in the gassier seams.

In the early 1960's, because of these setbacks, it was quite widely accepted that retreat mining in gassy conditions was difficult and certain areas would not permit the working of retreat faces at a rising gradient in gassy conditions. It was not until the mid 1960's that further consideration was given to working by retreat methods a very gassy seam in the Western Area (i.e. Wigan Four Feet). The known faulting structure was such that if the retreat method was to be implemented, then the faces would have to be retreated out to the rise at gradients of between 14° (1 in 4) and 9° (1 in 6); a quite severe gradient against which to control methane migration, especially as the Wigan Four Feet in virgin conditions has a gas content in excess of 140 m^3 per tonne of coal mined.

Retreating, however, was considered to be a pre-requisite, because of two main reasons:-

(i) Low productivity when worked by the advancing method.

(ii) The Wigan Four Feet Seam has a high spontaneous combustion risk.

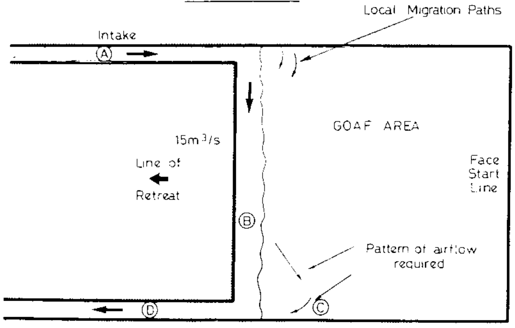
The decision was taken to extract the coal by the retreat method, thus the problems associated with methane control would have to be overcome. A complete study of all retreat layouts was carried out throughout the country and all the shortcomings of the various systems were examined.

The outcome was the designing of the "Back Return" system.

THE PLANNING BEHIND THE ORIGINAL CONCEPT

Accepting that the normal advancing longwall coal face can be designed to control the rate of methane emission, then with a retreating coal face, in order to control the methane the return end of the face should be so designed that it simulates the return end of an advancing unit. In the advancing unit the air is taken back away from the face end the same design must be incorporated at the return end of the retreat face. Fig.4 shows what should be achieved

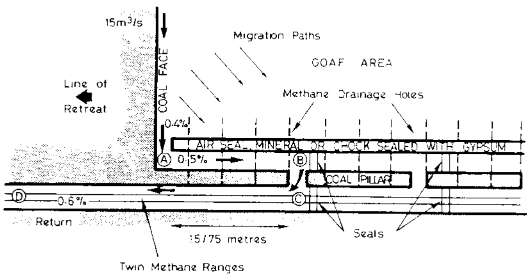
FIGURE No 4



To create a Pressure difference from B to C in order to create a series of migration paths some method of causing the air to flow from B to C to D must be implimented To practise methane drainage access to C must also be afforded

Various methods of coursing the air back into the goaf area were considered, but all were finally discarded except one. In the system adopted a small coal pillar was left between the coal face and the main return. The coal pillar acting as a barrier for coursing the ventilation back away from the coal face. Figure 5 illustrates the principles of the back return system.

FIGURE No 5



In this system, at the return end of the face, the airflow pattern of an advancing face is simulated by taking air back from the face into a back return. Depending upon gas emission, gradient along line of retreat and seam height, this back return can vary in length from a 15 metre minimum to a 75 metre maximum. It is bounded on one side by a coal pillar and on the other side by a pack or air barrier. The pack or air barrier is constructed of mineral, wood chocks, or other suitable material to deflect part of the air. Its purpose is not to support the roadway, but to create a resistance against the migrating methane and to force the migration paths back away from the face area. The air leaves the back return AB via a cut through in the coal pillar BC. The cut through should not create a measureable resistance to the air flow, so it should be of sufficient cross sectional area to achieve this object. The air then travels via the main return CD. The air seals at B and C are repeated at every shortening of the back return. They are simply air seals, not explosion proof stoppings.

When methane drainage is practised, the holes are drilled either over and/or under the goaf from a position immediately behind the face line. The roadway conditions in the back return and in the main return gate road determine from which roadway the holes are drilled. Normally if conditions permit, methane holes are drilled from the return gate road as the connecting pipework is far less complicated. The methane holes one completed, and connected to the methane range are left connected to the main pipe range, when new seals are constructed.

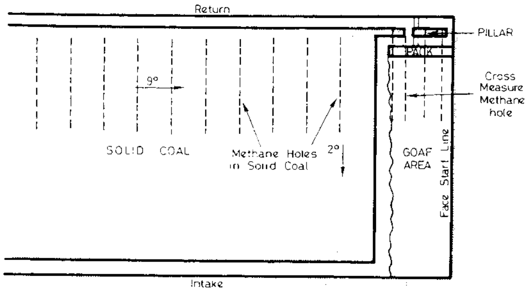
Since the successful development of the back return system, this method of ventilating retreat faces has been extensively used in Britain. Two of the more interesting cases are discussed in this paper.

CASE STUDY - WIGAN FOUR FEET DISTRICT - CRONTON COLLIERY

This was the first total retreat face worked to the rise and using the back return system of ventilation.

The 200 metre face in the Wigan Four Feet Seam had a working section of 1.8 metres. The gradient along the face was 2° (1 in 30) dipping from the return to intake and the roadways were rising at an average gradient of 9° (1 in 6) along the line of retreat; the face had a total distance of 1,000 metres to retreat. The seam was liable to spontaneous combustion.

FIGURE No6



The ventilation standards at the commencement of production were:- District air quantity circulating - 21 m^3/s. General body methane content 10 metres from face in the intake - 0.1%. General body methane content 10 metres from face in the back return - 0.4%. General body methane content at the outbye end of the return - 0.6%

A series of in seam methane holes had been drilled in the return gate. The holes were drilled in the solid and at right angles to the roadway, in front of the retreat face. The holes were 100 metres in length and drilled at 50 metre intervals. Previous experience when working the Wigan Four Feet Seam in virgin conditions indicated a fairly high gas emission rate, and with this in mind an extensive cross measure methane boring pattern had been agreed upon before production commenced. The details of the boring programme were:-

Upholes at 15 metre intervals 45 metres long at an angle of 60° to the horizontal.
Downholes at 15 metre intervals 45 metres long at an angle of 55° to the horizontal.

It was agreed that as the main and back return roads behind the face deteriorated, then new thirlings would be driven and the old sections periodically sealed off. In the main chamber produced by the erection of stoppings, all the boreholes were directly coupled to the methane range and this procedure was repeated at every sealing; no holes were disconnected as the face retreated.

As the face retreated out, it was found that by adjustment of the methane drainage system, it was possible to quickly create an extinctive atmosphere behind the newly constructed seal, thus minimising the risk of spontaneous combustion.

Example of the atmosphere behind Chamber No.4

Period	Day After Sealing	7 days later
CH_4	6.15	30.00
O_2	16.0	6.7
N_2	72.26	61.08
CO_2	0.88	2.2
CO	0.0086	0.0150

This type of result was repeated for all the other seals as the face retreated. As a further safeguard against spontaneous combustion the time the back return was left open and thus exposed to the air current, was never allowed to exceed half the estimated incubation period for the district.

The output from the face varied between 6,000 and 8,000 tonnes per week, and the combined effect of the methane drainage in the zone close to the face and from the sealed chambers effectively controlled the methane in the general body and kept the methane fringe in the goaf well back from the working face area. This was established by the probing of the waste using long probes, and no methane content in excess of 1% was found.

The efficiency of the methane drainage system can best be seen by illustrating the ventilation and methane drainage conditions at various distances as the face retreated out.

After 10 Metres Production

District air quantity circulating - 21.1 m^3/s. General body methane content 10 metres from the face in the intake - 0.1%. General body methane content 10 metres from the face in the back return - 0.6%. General body methane content at the outbye end of the return - 0.8%. Methane drainage - 100 l/s at 50%. Pure methane - 50 l/s. Efficiency of system - 22%.

After 100 Metre Production

District air quantity circulating - 22.5 m^3/s. General body methane content 10 yds. from the face in the back return -0.5%. General body methane content at the outbye end of the return - 1%. Methane drainage capture - 400 l/s at 50%. Pure methane - 200 l/s. Efficiency of methane drainage system - 47/55%.

After 800 Metres Production

District air quantity circulating - 20.6 m^3/s. General body methane content 10 metres from face in intake - 0.1%. General body methane content 10 metres from face in back return - 0.4%. General body methane content at the outbye end of the return - 0.6%. Methane drainage capture - 666 l/s at 60%. Pure methane - 400 l/s. Efficiency of system 76%.

The ventilation results from this unit were most encouraging and providing the 'Back Return' was effectively controlled between a minimum length of 15 metres and a maximum length of 50 metres, then the buoyancy effect of the methane was effectively controlled. The correct application of methane drainage, controlled the total gas emission in the district and satisfactorily controlled the general body methane contents in the airways.

CASE STUDY - 206's TEN FEET AT HEM HEATH COLLIERY

This is an example of retreating to the dip in a moderately gassy seam with a high spontaneous combustion risk using the "Back Return" system of ventilation. This was the first occasion when the Ten Feet Seam had been worked by the retreat method using the "Back Return" system. The face was 180 metres long, the coal obtained by a double ended ranging drum shearer. The gradient along the face was level and along the gates 9° (1 in 6) dipping along the line of retreat. The Ten Feet Seam in this section of the coal field is approximately 4.75 metres thick of which 2.1 metres was extracted, leaving a considerable amount of top coal.

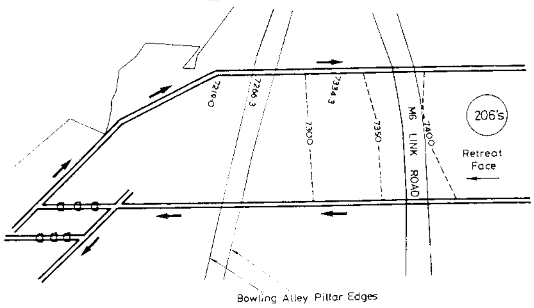
When the district initially thirled a

methane sample taken at the return outbye end was 0.4% in an airflow of $15m^3$ per second. Whilst the district was being equipped, the methane percentage at the outbye end increased to a figure of in excess of 0.8%.

A detailed methane survey of the district gave the following readings:- General body methane content at the outbye end of the return - 0.8%. General body methane content 10 metres from the face in the back return - 0.7%. General body methane content 10 metres from the face in the intake - 0.6%. General body methane content half way along the intake gate - 0.55%. General body methane content at the outbye end of the intake gate - 0.05%.

A detailed survey of the intake between the outbye end and a point some 300 metres inbye revealed methane pollution from the floor. A study of a composite plan showed pillar edges in the Bowling Alley Seam some 30 metres below, and these were thought to be a contributing factor.

FIGURE No. 7



A programme was initiated to drill a series of downholes from the Ten Feet Seam to a level just above the Bowling Alley Seam. To bore into the Bowling Alley goaf or roads would have been the wrong policy as it was thought that the old goaf was full of methane and it would not have been practical to drain the large volumes of methane involved, however, if the boreholes were drilled short of the goaf, but crossed the breaks causing the pollution, the drainage system would prevent the pollution without overloading the system by draining from a vast reservoir.

A series of holes were completed to the agreed depth and connected to the methane range. By the time the sixth hole had been completed and connected, a total of 150 litres per second mixture at a purity of 65% was being captured.

A survey of the district at this time showed the following methane percentages:- General body methane content at the outbye end of the return - 0.3%. General body methane content 10 metres from the face in the back return - 0.25%. General body methane content 10 metres from the face in the intake - 0.2%. General body methane content half way along the intake - 0.1%. General body methane content at the outbye end of the intake -0.05%.

The downholes to the Bowling Alley Seam certainly appeared to remove the pollution methane and district conditions returned to normal. The equipping of the face was then completed. Before production commenced a strict set of standards for controlling the environment was laid down. These included a system of cross measure methane drainage holes to be drilled from the main return.

Upholes

At 10 metre intervals, 66 metres long at 55° to the horizontal. The holes were drilled at 80 mm diameter for a distance of 14 metres to accommodate the 12 metre x 51 mm standpipe. The remaining length of the hole was drilled at a diameter of 50 mm. The anulus between the standpipe and the strata was sealed with a cone of densotape. The upholes were drilled to capture the methane from the Bellringer Seam some 23 metres above and the Hams Seam some 55 metres above.

Downholes

These were drilled at 27 metre intervals, 43 metres long at an angle of 60° to the horizontal. The dimensions of the downholes were similar to those of the upholes, but the standpipe seal in this case was completed with gypsum. These holes contacted the Bowling Alley Seam some 30 metres below. Where the Bowling Alley had previously been worked out, then the holes were only drilled to a distance just short of the Bowling Alley horizon. To ensure sufficient capacity for the methane drainage system, two 150 mm steel ranges were laid in the return gate. Production commenced in late 1976 with a distruct air quantity of 17 m^3 per second.

As the ventilation system became established and the face retreated out, monitoring was introduced on a daily basis at what were considered to be critical points, these included:-

(i) The outbye end of the return gate.
(ii) Behind the back return seal.
(iii) The methane drainage ranges.

The methane drainage system soon became established and by mid January, the ventilation conditions were:-
District air quantity circulating - 20 m^3/s.
General body methane content 10 metres from face in intake - 0.1%. General body methane content 10 metres from face in back return 0.2%. General body methane content at the outbye end of the return - 0.54%. Methane drainage system - 480 l/s at 50%. Pure methane flow - 240 l/s. Efficiency - 68%. Carbon monoxide content of methane drainage range - 125 ppm.

The length of the back return varied between 15 metres and 45 metres and the first indication was that a back return length of between 20 metres and 30 metres appeared sufficient to effectively control the methane. Working within these lengths the ventilated section of the return would be open to the air for a considerably less than the incubation time for spontaneous combustion.

By the middle of April, 1977, the ventilation conditions had stabilised and a ventilation survey of the face revealed the following conditions:-
District air quantity circulation - 17 m^3/s.
General body methane content 10 metres from face in intake - 0.1%. General body methane content 10 metres from face in back return - 0.2%. General body methane content at the outbuy end of the return - 0.5%. Methane drainage flow - 510 l/s at 68%. Pure methane flow - 346 l/s. Efficiency of system - 80%. Methane drainage range CO content - 250 ppm.

The ventilation was considered to be completely satisfactory, with an increase in the methane drainage capture and a very satisfactory general body methane content. The only disturbing factor was the increase in the CO content in the methane drainage range.

Further results were carefully monitored and it was shown that the carbon monoxide content in the two 150 mm ranges varied widely.

No.1 range 80 parts per million.
No.2 range 600 parts per million.

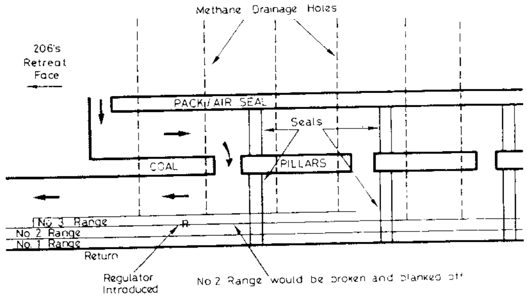
Whilst both ranges extended back to the face startline, it was the No. 2 range which was connected to the first series of holes drilled as the face commenced production, the No.1 range was not connected to any methane holes until the face had retreated out some 50 metres.

The section of goaf behind a dip retreat face, can be considered as an inverted vessel with the methane migrating to the top of the vessel. The methane drainage holes are connected to the pipe system as far inbuy as the face commencement position, and it is possible to overdrain fromthe inverted vessel and lift the gas ceiling away from the intake side of the face.

The highest CO content was found in No.2 range and this range was connected to a series of methane holes at the face startline. It was considered that overdraining of these holes had created a migration path along the collapsed main gate back to the face start-line and across the goaf. In this circuit the oxygen had created an increased rate of oxidation, thus producing the high CO readings. Further air analysis results taken from the methane drainage ranges appeared to confirm this theory. The methane drainage samples appeared to be more responsive to changing conditions than were the return general body samples. This, of course, is easily understood when considering the buoyancy factor and the volumes of the respective airflows, i.e. the methane drainage system takes its mixture from the highest part of the district and it is not subject to much dilution. Whilst the migration flow out of the back return seals only entrains the fringe of the inbye atmosphere and when it passes through the seal, it is immediately diluted by the large volume of air passing around the district, thus masking a small rise in the rate of oxidation.

Considering the facts, it was agreed that No.2 methane range was over-draining the area close to the face startline, thus introducing oxygen into this zone. The decision was taken to reduce the methane drainage flow on the No.2 range by regulating the applied suction. The extracted flow was reduced by some 100 litres per second mixture and a careful control maintained on the methane and carbon monoxide contents in the firedamp range and in the general body of the air circuit. By the following day, the carbon monoxide content in the No.2 range had reduced from a high 600 parts per million to a figure of 300 parts per million, and by a further 24 hours this was reduced to a level of 150 parts per million, a figure which was considered satisfactory. The basic reason for installing two methane ranges is in case a range is lost due to damage. As soon as the decision was taken to reduce the section on the No.2 range, a third range was then introduced into the system. This meant carrying three ranges for a short period.

FIGURE No 8



The new boreholes would be connected to the new range (No.3) and once this range had been established, the No.2 range would be cut off. With constant monitoring of the ranges, the Possibility of completely losing drainage capacity can be avoided. This case study highlights certain factors which are most important when planning retreat faces in gassy conditions, liable to spontaneous combustion and retreating to the dip.

Firstly, when retreating to the dip, the rate at which the firedamp drainage is extracted from the goaf area must be carefully monitored and controlled, otherwise excess oxygen may enter the area and could subject the carbonaceous material in the migration paths to critical airflows, i.e. sufficient oxygen for oxidation, but insufficient to carry away the excess heat, thus finally leading to spontaneous combustion. The results obtained from the methane drainage ranges on this face indicated higher carbon monoxide contents when the methane purity fell below 50% and the oxygen exceeded 8%. When the methane purity exceeded 80% and the oxygen fell below 2%, the carbon monoxide content in the range was insignificant.

Secondly, when retreating to the dip the samples from the immediate return seal indicated a relatively high oxygen content, between 10 and 19% yet when retreating to the rise with similar gas emissions, the oxygen content was as low as 6%.

SUMMARY OF BACK RETURN SYSTEM

Experience over the past decade has established that the back return system in conjunction with a cross measure methan drainage system can adequately control the environment, both behind the working face and in front of the face in the gate roadways. Certain aspects are worthy of highlighting and may be considered as basic rules on which to design the layout of retreat faces using the back return system.

(i) Methane Drainage

Despite misgivings in some quarters, experience has shown that the cross measure borehole system of methane drainage on a retreating face is in most instances as efficient as that of an advancing face, and in some instances even more efficient.

The pattern of methane drainage boreholes should be designed specifically for the district, depending on the expected source of the methane that could pollute the district. The intention to work by the retreating method rather than advancing should not greatly influence the design. The upholes would be drilled just behind the face in the destressed zone and never in the solid in advance of the face. The length, direction, and spacing of both upholes and downholes should be decided by a careful assessment of the possible gas bearing horizons.

In districts liable to spontaneous combustion, the rate of methane drainage flow must be so adjusted to maintain an atmosphere behind the seals, that will control the rate of oxidation. Over drainage can accelerate the rate of oxidation by maintaining a high oxygen content, whilst under drainage is likely to create a gas problem at the return end of the face and in the general body of the air. Experience has shown that the length of the back return is more critical on faces retreating to the rise, and this length should be kept as long as possible in order to maintain access to a maximum number of boreholes on the methane drainage system.

Generally it is the return roadway from which the cross measure methane drainage holes are drilled. However, in certain cases where roadway stresses have severely reduced the cross sectional area of the return roadway, the holes have to be drilled from the back return, where roadway conditions are better. The stresses upon the return gate are relatively similar to those acting on advanced headings whereas the stresses upon the back return roadway are more like those acting on the roadway of a conventional advancing face.

(ii) Pipe Ranges

For a methane pipeline to handle the maximum emission rate normally encountered a diameter of 250 mm would suffice. However, experience has shown that a system of two 200 mm ranges is a more efficient and safer alternative. Where gas from a district is drained through a single pipeline, if the range gets fractured or partially restricted by a fall, part or all of the drained methane could be lost, resulting in a severe pollution problem. On the other hand, where twin pipes are used and the number of methane holes connected to each range is balanced, then in the case of damage to one range only a portion of the drained gas may be lost.

Moreover, in practice it has been found that the remaining range captures a proportion of the methane previously captured by the damaged range. It is important that immediately the monitoring of the ranges indicates either a restriction in flow or a reduction in purity due to a possible fracture, a new range is connected through the seals. The suspect range will be dispensed with as the new range takes over its duty.

(iii) Descentional Ventilation (Relationship with Methane Drainage)

The limited amount of experience obtained when retreating a district where the ventilation was descentional has indicated that there could be an unsatisfactory level of methane pollution from the goaf.

Experiences with retreating faces of lengths of 200 metres has indicated that severe pollution problems can arise where the gradient falls from intake to return. The released methane migrating away from the influence of the methane drainage, towards the intake or higher side of the face.

On descentionally ventilated retreat faces working out to the rise the problem was even more severe, and it is recommended that whenever possible descentionally ventilated (face line) retreat faces should not be planned.

(iv) Length of Back Return

The length of the back return within limits is critical and the limits should be specified and adhered to for each face. The main factors influencing this are:-

(a) Gradient

On a face retreating to the rise, the ventilation pressure drop in the back return circuit must be sufficient to counter the methane buoyancy and also to facilitate the movement of methane into the zone influenced by the methane drainage holes.

On a face retreating to the dip, the length of back return normally maintained open can be less than on a face retreating to the rise as the effect of buoyancy is to take the methane away from the face. However, care must be taken to ensure that the length of the back return is sufficient to deal with heavy waste falls and periods of low barometric pressure.

(b) Spontaneous Combustion

In order to prevent spontaneous combustion, the length of the back return should be such that the length of time any section of the return remains open as part of the district ventilation circuit is approximately half the incubation period for the seam being worked.

(c) Frequency of Cut Throughs

The coal pillar forming the back return must not be holed closer to the face than the agreed minimum length of back return. The immediate effect on ventilation of holeing near to the face on a district retreating to the rise is similar to that which would result from a sudden barometric depression. A lowering of the methane "ceiling" in the goaf area, would release methane on to the face and into the air stream. If production necessitates the breaching of the pillar at regular intervals (e.g. ease of disposing of the mineral on to the face conveyor), the newly breached hole must be sealed until the correct distance back from the face is reached. The cross sectional area of the cut through in the coal pillar is important. It should be such that the air velocity never exceeds 5 metres per second. An excessive pressure drop across the cut through will tend to produce greater volumes of air back into the goaf and out through the seal in the return gateroad. The effects of this would be to reduce the efficiency of methane drainage and to create a higher level of methane pollution in the return airways, and increasing the risk of spontaneous combustion.

(v) Width of Coal Pillar

Experience on a number of faces has shown that the coal pillar in the back return should be of sufficient width to act as a barrier to course air back from the face, but of insufficient width to act as a permanent support. It has been found that working conditions require widths of between 2 and 5 metres. Below 2 metres the pillar begins to break up before the section is sealed off; at a greater width than 5 metres it provides too much support. When the pillar provides too much support not only does it fracture the methane drainage upholes and severely reduce the methane drainage efficiency, but it also throws weight on to the return gate road and causes severe floor lift.

MULTI ROAD SYSTEM WITH A CONNECTION TO A MAIN RETURN BEHIND THE FACE

The use of the 'Z' system or bleeder entries maintained as travellable roadways behind the retreat face certainly has advantages from the ventilation aspect over the simple retreat face layout (Fig.3)

If one considers the layout of this system (Fig.9) against a standard advancing face (Fig. 1) then it can readily be seen that the ventilation migration paths at the return end of the face are somewhat similar and, therefore, the conclusion can be made that this system will control the methane emission providing the roadways behind the face are maintained in good condition.

Whilst this sytem of ventilation will control the methane aspect of the environment, it is always suspect from a spontaneous combustion incident, because of the migration paths in the goaf area.

Experience in the Western Area has been rather mixed, with at least three instances of spontaneous combustion occurring.

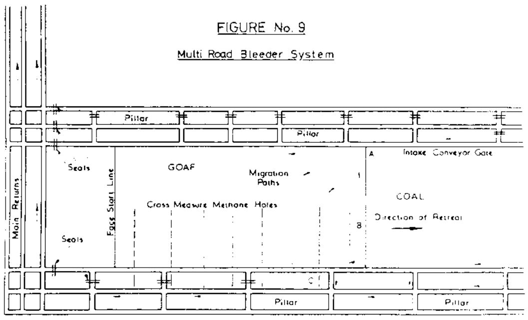


FIGURE No. 9

Multi Road Bleeder System

On one district in an effort to control or minimise the migration paths in the goaf, the seals were strengthened by the application of Gypsum. However, irrespective of the sealant applied, the air samples from the goaf continued to deteriorate until the following results were obtained from behind the seals:-

CH_4	- 2.64	CO_2	- 0.75
O_2	- 15.29	CO	- 0.0335
N_2	- 81.29	CO/O_2	- 0.46

The sealant applied to the seals appeared to make little or no difference to the continuing deterioration. Production on the face continued for a further month with a continuing worsening of both goaf and general body CO samples.

The sample from the goaf showed:-

CH_4	- 2.5	CO_2	- 0.86
O_2	- 18.15	CO	- 0.0900
N_2	- 78.40	CO/O_2	- 3.45

with a CO content in the general body return behind the face of 0.0035%. Immediately before the district was effectively sealed off, the goaf sample was:-

CH_4	- 1.4	CO_2	- 2.38
O_2	- 14.56	CO	- 0.2500
N_2	- 81.47	CO/O_2	- 3.68

with 100 parts Carbon Monoxide in the main return.

Whilst this system will give the facility to control the rate of methane emission from a district, its serious disadvantage of being just as liable to spontaneous combustion as a normal advancing unit cannot be discounted as once increased oxidation occurs it is very difficult to control it without sealing off extensive areas of the mine.

Where methane drainage is practised then generally the system is not as efficient as that on a face practising the "Back Return" method as the drainage is taking place from a partially ventilated area and not from an unventilated area.

SUMMARY OF BLEEDER SYSTEM

To summarise on the general application of the "Bleeder Road" system, I believe it can with sufficient forthought and planning adequately ventilate panels of coal, providing certain basic safety factors are considered.

(i) If a seam is found to be liable to spontaneous combustion then this method of ventilation is not advocated.

(ii) The return roadways behind the face line must be maintained at an adequate cross sectional area to ensure not only sufficient ventilation quantity but to minimise the pressure loss across the goaf area.

(iii) Full extraction of the working seam is beneficial.

(iv) Pillar sizes should be sufficient to prevent severe crushing.

(v) The goaf seals should be of monolithic construction keyed into the surrounding strata.

(vi) The seals should be equipped with means to take air samples from behind them on a regular basis.

(vii) Pressure equalisation chambers should be constructed in front of goaf seals with a high leakage potential.

(viii) Where methane drainage is practised then the gas should be sampled regularly to ensure overdraining is not taking place.

(ix) Using correctly placed and designed pressure chambers in conjunction with methane drainage, both from cross measure boreholes and goaf areas, then the atmosphere in the goaf should, if possible, at all times, be maintained at an extinctive level.

(x) The layout should be so designed that if a spontaneous incident does occur, then the isolating or sealing of the suspect area can be carried out with the minimum number of extra seals and with the minimum loss of coal reserves.

(xi) The roadway adjacent to the goaf at the return end of the face must remain open long enough and must pass sufficient air back to the open cut through until the face retreats out to the new cut through. If sufficient air is not passed back from the face, methane pollution will occur at the return end of the face.

CONCLUSION

If the area of coal to be worked is not very liable to spontaneous combustion then multi entry systems using bleeder roads behind the face can be used, providing the roadways behind the face can be maintained at a satisfactory cross sectional area.

Where the seam is liable to spontaneous combustion then I would strongly advocate the "Back Return System" of ventilation be practised.

With district gas emission figures in excess of 200 l/s then I would recommend a system of cross measure methane drainage be installed.

Irrespective of which system, the "Bleeder System" or "Back Return", be utilised the cross measure drainage should if correctly designed capture in excess of 50% of the total district gas emission.

A final aspect that might influence future designs and planning, is the number of development roadways required with either of the two systems described in the paper.

Once the methane problems associated with driving single entries long distances on auxilliary ventilation have been overcome, then it is quite possible the trend may move to the single entry method of development. Thus only requiring at the maximum two drivages for each retreat panel.

To conclude, providing the differing ventilation concepts between advancing and retreating are fully understood and cognizance taken in the environmental design, then ventilation standards when practising the retreating method of mining should be completely satisfactory.

DISCUSSION

E. TOMLINSON (West Cliff Colliery): Referring to figure 8 in the paper and advice that the size of the pillars is limited to enable crushing to take place, would that then interfere and possibly allow damage to the inbye gas range to take place?

W. HIGHTON (N.C.B. United Kingdom): No. It must be remembered that the whole of the exercise is based on the concept that what is sought is an extinctive atmosphere behind that area. So where gas emissions are in districts with extensive gas emissions that is to say ensuring that the oxygen has been replaced with methane. So even if there is a partial fracturing of a pipe etc., the drainage is still mainly from a completely unventilated area. It is found that very high capture values can be obtained and high purity gas without many problems. Do the pillars affect the methane drainage? If the pillars didn't crush marginally, yes they would fracture the methane drainage seals.

E. TOMLINSON: What hole length was required to give maximum coverage under or over the goaf?

W. HIGHTON: With the upholes, what is done, there is what is called a little red book, it is geological sections of all the seams in parts of the coalfield and basically it covers a 60 m vertical destressed zone. It is assumed that any seams encompassed in that zone will certainly cause pollution of the mine roadways. This is not to say that seams above that won't eventually create a problem. So initially the intention is to cover 60m above the working seam. Underneath in 90% of the cases, it would probably be enough to take a 45 m zone, but again for absolute security, a 60 m cover zone underneath is taken so the length of a hole is dictated by what it is attempted to cover in relation to the angle they are going to be drilled at. The angle is generally between from about 45°, up to in some places where there are some peculiar gradients, as high as 80. But in each case the holes are probed to ascertain the optimum gas horizons, the best angles and the best length of seal.

E. TOMLINSON: In the proposed system of longwall extraction at West Cliff, which is retreating on Z type ventilation, the recommendation that drilling should take place behind the face line could present some problems in that the drilling would be undertaken in polluted atmosphere if of course the drainage is not 80% efficient such as that described. At the rate of output anticipated it would be difficult to keep up with that face line with the drilling.

W. HIGHTON: This is a practical problem. First of all if the downholes can be dispersed with, they can be drilled whenever wanted in relation to the face. U.K. experience shows that downholes do not normally suffer from being drilled in front of the working face. With upholes, it was found to be very critical and this is being parochial, and talking about what has been found; it may be different in other parts of the world. Categorically if the miners drill a hole in front of the face, no more than about 5 m in front, then the efficiency of that hole by the time it's been on a couple of days is about 30% of what a hole would be if it was drilled behind the face. This is of very utmost importance. The best advice is that wherever possible boring should be done behind the face in the destressed zone. If there are legislative problems, or pollution problems then perhaps it would be better to try and get around those to ensure that better environmental conditions are obtained.

R. LAMA (Kembla Coal & Coke): This question has been raised a couple of times and three different opinions have been presented. It has been very strongly emphasised that the holes should be drilled parallel to the line of the face, whether the holes are in the roof or in the floor. The question Dr. Lunarzewski has raised was whether drilling should be done at an angle. Jeger has said that the vertical cracks in the floor must be taken into consideration. The very important point has been raised in the discussions that the direction of leakage is very important and holes must be drilled to capture gas at these points. A conclusion from that, particularly if looking at floor holes, is that if the floor holes are not damaged as a result of extraction, holes are drilled so that the line of these holes is almost at right angles to the leakage direction. Is that the most effective direction?

W. HIGHTON: Downholes are not as important. What has been found is that if a commencement is made angling downholes, some peculiar conditions can be obtained. There is a line of thought about angling downholes inwards towards the solid coal.

Yes, if looking for a bit of pre-draining of a thick seam below, yes there could be some advantage. There is another line of thought about angling downholes backwards from the face to ensure that the most prolific zones of relaxed strata are being penetrated. But taking cognisance of all the factors, looking for the lateral breaks seems more preferable - to bore the holes at right angles or parallel to the shearing line. That is just an opinion. A lot of analyses have been made on boreholes with districts with up to 150 holes to choose from, and the general consensus of opinion is yes to bore them parallel to the line of shear. But that is not to say there are not circumstances where angled holes are better. There have been instances of potential floor outburst conditions when in moving away from a ribside there has been very severe initial destressing of the lower strata - in that conditions it has been necessary to bore backwards from the face to tap the gas bubble - the bubble was coincidental with the rib start line. It is a little bit of what conditions suit the particular circumstances. But as a general rule of thumb, no, parallel to the shearing line is preferred.