REDUCING GASSINESS OF OUTBURST-PRONE COAL AT COAL BASIN MINES, COLORADO, USA

By

Bradley J. Bourquin[1] and Tony Martin[2]

ABSTRACT

High methane content of the medium-volatile metallurgical coal mined from the Coal Basin mines causes very difficult mining conditions. Rapid desorption into the mine ventilation system limits coal production, requires huge fresh air quantities and creates mine safety problems. In workings deeper than 2000 ft (600m) gassy coal and heavy cover create outbursting conditions. Cross-measure methane drainage has reduced ventilation requirements on advancing faces, but degasification of virgin coal is needed to improve mining conditions.

INTRODUCTION

Mid-Continent presently operates four mines in Coal Basin, which is located in the White River National Forest, 150 miles (250 km) southwest of Denver, Colorado. Initial mining was done by the Colorado Fuel and Iron Company from 1892 until 1909. Mid-Continent began the present operation in 1956. The four mines now produce about one million tons (900 000 tonnes) of medium volatile high grade coking coal per annum. The coal is marketed to Kaiser Steel and U. S. Steel domestically while export markets in Korea and Japan are being developed for expanded production.

Two seams are mined in Coal Basin. The Coal Basin seam is the lower seam and runs 22 ft to 30 ft (7m to 10m) thick. The Dutch Creek seam is 450 ft (140m) above the Coal Basin seam, stratigraphically, and is 7 ft to 10 ft (2m to 3m) thick.

Seams outcrop at approximately 10 000 ft (3000m) elevation in mountainous terrain dipping at 10° to 12° in a westerly direction under Huntsmans Ridge (see Figure 1). Cover increases rapidly with present workings under 2000 ft to 2800 ft (600m to 800m) depth. All mines are driven as slope mines down dip from the surface.

Currently five continuous miner sections (three pillaring and two development) and a retreating longwall are operating. An advancing longwall will begin operation during the second quarter of this year. It is sponsored by the U. S. Department of Energy for the demonstration of multi-lift longwall mining. Mining from the first bottom lift will begin by early 1985.

METHANE CONTROL

INTRODUCTION

The actual methane content of the Coal Basin seam has been measured to be 500 to 600 cf (14 to 17 m^3) while USBM figures (IC 8659, 1973) place the gas liberation at 1167 to 1750 cf per ton of coal mined. These figures place the Coal Basin mines within the top 10 per cent of the gassiest mines in the country. One reason for such high gas liberation is that only the top 8 to 10 ft (2.4 to 3.0m) of the

[1]Bradley J. Bourquin, Chief Engineer, Mid-Continent Resources, Carbondale, Colorado, USA

[2]Tony Martin, Project Engineer, Mid-Continent Resources, Carbondale, Colorado, USA

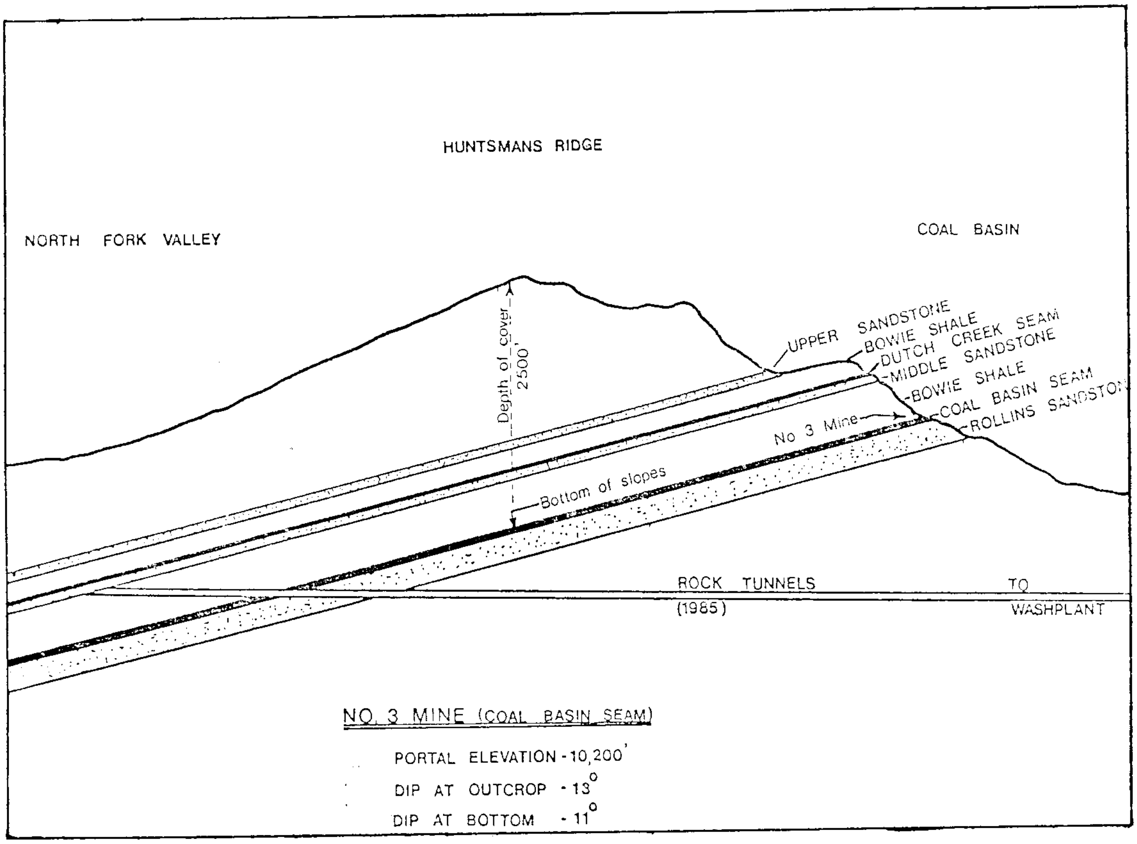

Figure 1 - Cross Section of Seams in Coal Basin

seam is mined, allowing the degasification of the full 28 to 30 ft (9 to 10m) of coal. Consequently, air requirements for development sections are about 100 000 cfm (2800 m^3/s).

Gas liberation has a relatively low base level which increases rapidly in response to mining. After mining ceases, gas liberation returns to base level within eight hours. An investigation by a USBM team (Gabriella et al.) into gas liberation from pillaring and drilling concluded that gas liberation was intimately bound up with the mining operation.

CROSS MEASURE METHANE DRAINAGE

Cross measure methane drainage was successfully used on advancing longwalls beginning in 1976. The system was introduced as an acceptable alternative to bleeder systems as required by US mining law. Simply described, upholes were drilled from the tailgate into the micro fracture zone above the gob. A pipeline with 8 in. line (200mm) in the tailgate and 10 in. line (250mm) in the slopes connected the holes to an evacuation plant on the surface.

Since large amounts of bottom coal were left beneath the longwall face and methane liberation is intimately tied to coal production, methane capture was predicted to be 20 per cent. Actual results were 30 per cent or more.

Upholes were drilled 160 ft. (50m) at an angle of 55° to the horizontal. The first 60 ft (20m) were drilled with a 3 in (75mm) bit. (See Figure 2.) This hole was cased with a stand pipe and the remaining 100 ft (30m) drilled with a 2 in (50mm) bit. Cuttings from the second stage were packed around the case pipe to form a seal for subsequent evacuation. The casing served to promote drainage from the upper part of the hole and to prevent short circuiting. Figure 3 illustrates hole "A" properly located in the micro-fracture zone on the edge of the cave. Hole "C" is destroyed by the cave while hole "B" does not intersect enough fracturing to be efficient.

The drilling machine used was an "Edeco Mini Hydrack". It is a compressed air/hydraulically-driven (10 HP or 7.5KW) skid-

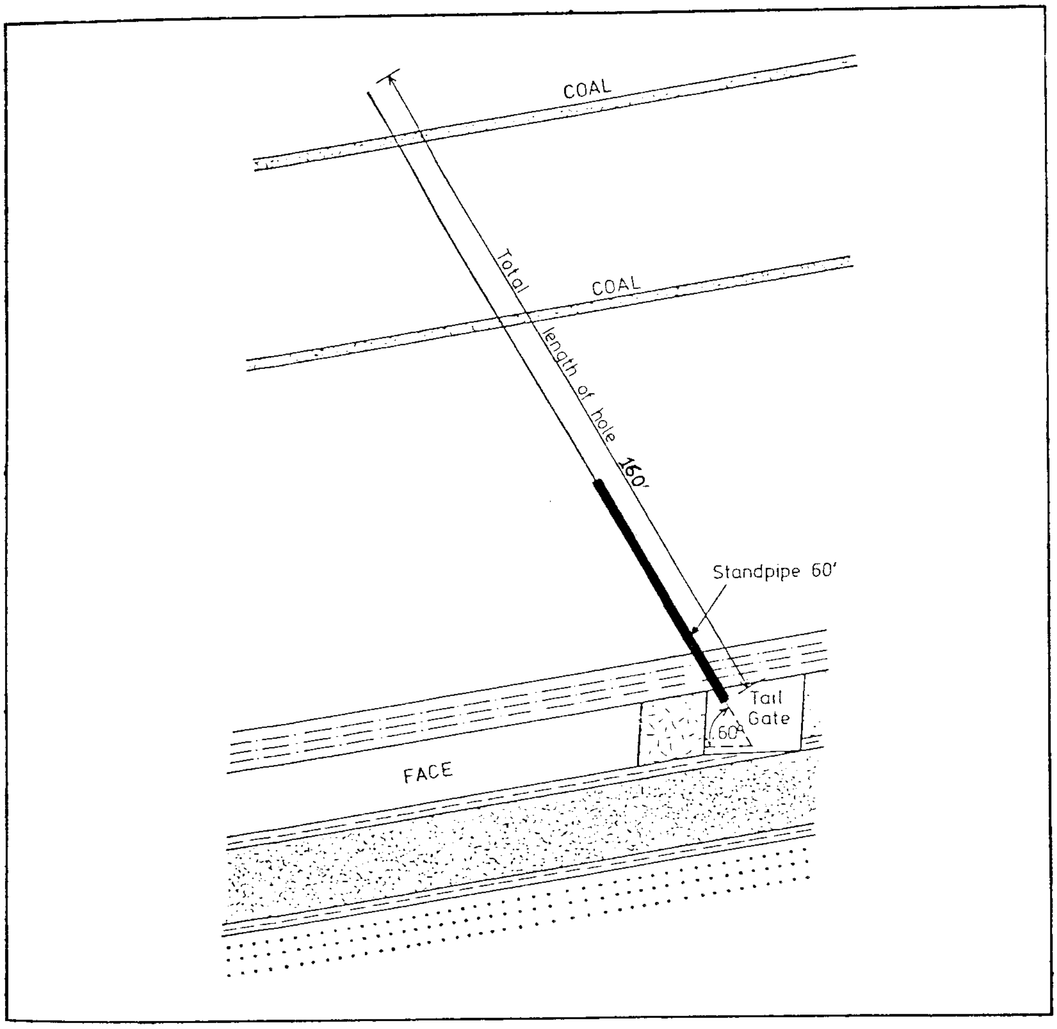

Figure 2 - Drilling Layout for Roof Holes

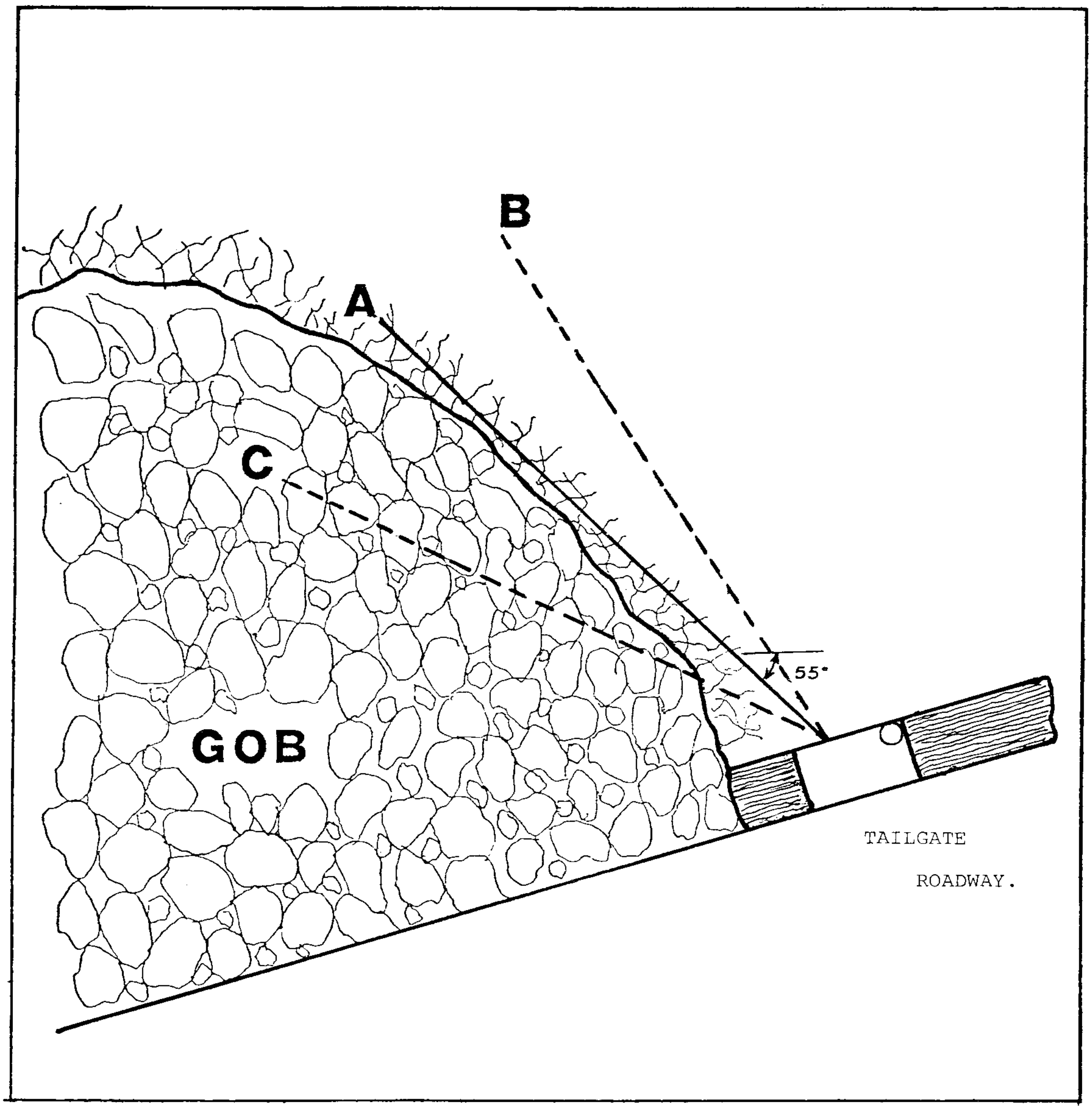

Figure 3 - Optimum Drill Hole Location

mounted rotary drill. The drill was mounted in an "A" frame and had a maximum thrust of 9500 lb (4300 Kg), with rotational speeds of 60 100 and 190 RPM. Each hole took two men an average of three shifts to drill. Holes were drilled at 75 ft (25m) intervals along the tailgate, the last hole being within 75 ft (25m) of the face.

From the pipe casing a 2 in (50mm) flexible hose ran to a 2 in steel pipe with shut-off valves, orifice plate and test plugs (see Figure 4). This fed into the main 8 in (200mm) line in the tailgate, then into the main 10 in (250mm) slope line which carried the gas to the surface vacuum station. Baker couplings were used to connect pipe lengths. The pipe range was grounded at the surface substation and a grounding wire was placed across each coupler. Water traps were placed at low points throughout the system.

At the methane drainage station on the surface flame arrestors separated the three "Nash CL 702" vacuum pumps from the mine and discharge pipes. The gas was vented to the atmosphere or pumped by a Joy reciprocating compressor 4 miles (6.6 km) to the wash plant for use in the thermal dryer.

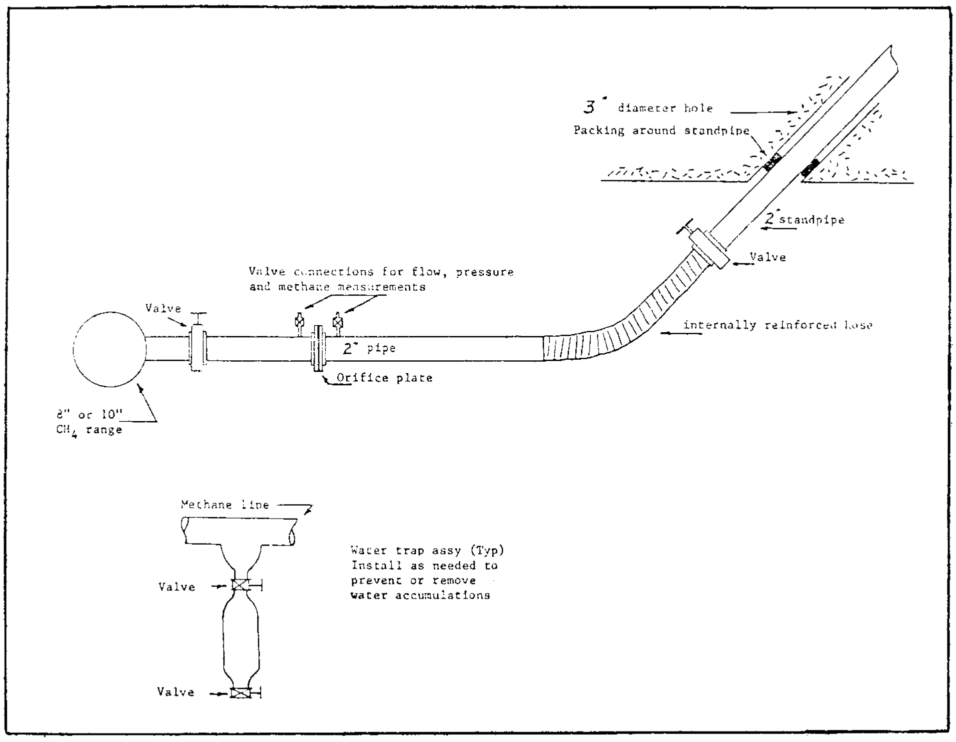

Figure 4 - Connection between Drill Hole and Main Drainage Line

PERFORMANCE OF THE DRAINAGE SYSTEM

Methane concentration was maintained above 30 per cent in the system, well above the explosive limit. Individual holes underground were monitored for concentration; and as the gas percentage decreased the flow was restricted and eventually closed, if required. Likewise, at the methane drainage station the number of pumps on line was varied to control the flow and maintain the concentration above 30 per cent. A fulltime methane drainage engineer ran the system and made the necessary adjustments.

The Nash CL 702's were a constant displacement-type pump producing 680 CFM (20 m^3/s) at vacuum. Intake vacuum ranged from 2 in to 5 in Hg. averaging 4 in while gas ranged from 40 per cent to 60 per cent CH_4, averaging 45 per cent. The average gas flow at STP was 370 CFM

(10 m^3/s) per pump, which at 45 per cent CH_4 was 160 CFM (4.5 m^3/s) CH_4. This is 720 000 cu. ft (20 000 m^3) per day for three pumps. With the longwall releasing about 1 700 000 cu. ft (48 000 m^3) CH_4 per day into the airstream (120 000 CFM or 3360 m^3/s at 0.8 per cent CH_4), the gas capture rate of the drainage system was about 30 per cent of the total gas liberation.

OUTBURSTS

Prior to 1976 all coal at Mid-Continent was mined by continuous miners. As the depth of cover approached 1500 ft (457 m), floor heave became severe. The main entries (slopes) require continuous maintenance to keep them open. As cover increased, bounces and bumps began to occur, becoming more severe as the cover increased. At 2000 ft (610 m) outbursting began to occur. From 1969 to 1977 five fatalities resulted.

The Mid-Continent management made worldwide studies to learn how to mine coal safely under these conditions. As a result, the advancing longwall method of mining was implemented in the Dutch Creek No. 1 mine in 1976 and in the L. S. Wood No. 3 mine in 1978.

The outbursts are classical pressure outbursts rather than nonclassical types associated with faults and dykes. They result when intense stress zones surrounding mine openings fracture the coal when it is instantaneously shifted by mining or volley firing, and massive methane gas desorption fluidizes the pulverized coal.

The advancing longwall method significantly reduced the outburst hazard, although the corners of the longwall face remained stressed. Two unanticipated outbursts occurred in the LW 101 panel, resulting in one fatality in October 1977. After this, a routine mandatory volley-firing program was implemented. With volley firing no unanticipated outbursts have occurred.

In 1979 volley firing was suspended in development headings when radio remote-controlled miners were introduced. The miners were able to stand back and trigger outbursts without the threat of burial by outburst coal.

Outbursts by nature release enormous amounts of methane. Outburst control by radio remote operation introduced electrically powered equipment at the face as a potential ignition source. In 1981 Mid-Continent discontinued this practice and resumed volley firing. Joy CD 71 drills and a conventional mining cycle were introduced to increase production in development sections. This has allowed an acceptable 200 tons per shift production rate.

The ultimate solution to eliminating outbursts is to drain the methane from the virgin coal so that it is not present to serve as the fluidizing medium.

CONCLUSIONS

Mid-Continent has gained experience with seam gas drainage by using Cross-Measure Methane Drainage Systems with its advancing longwalls. The performance of the system has been good from initial startup. If the same quantity of methane had to be removed by the ventilation system, an extra 50,000 cu. ft per minute would have been required. The high concentration of gas has economic uses, as demonstrated at the thermal dryer where it is used as fuel.

For the future Mid-Continent is looking at both in-seam gas drainage and surface borehole drainage as possible methods of reducing both seam gassiness and outburst proneness of virgin coal. Accessibility in mountainous terrain and heavy cover tend to make surface bore holes more difficult.

DISCUSSION

I. GRAY (A.C.I.R.).): In the outburst prone mine, or in the first place, are all of the Mid-Continent mines outburst prone, or is it only one mine where there are problems of that nature?

A. MARTIN (Mid-Continent Resources, U.S.A.): No. the outbursts occur below 600 m.

I. GRAY: It is understood that the conditions are very similar to Leichhardt in the gas pressure gradients, and cleat formations, which are understood to be very directional; is there a wet seam problem making the seam very impermeable? This would be interesting from the outburst point of view.

A. MARTIN: No. The seam is very dry actually. It is just a pure pressure outburst, straight pressure.

I. GRAY: What is the gas pressure there, has it been measured in the virgin condition?

A. MARTIN: There are no figures available.

H. MARSH (BHP Steel Division Collieries): It appears that continuous miners were being driven by remote control as a means of combatting the outburst problem for development. Please enlarge on that a little, especially in the distance from the machine of the operator and means of transport from the face.

A. MARTIN: The miner driver would stand back probably up to about 30 m from the continuous miner driving straight ahead. The shuttle car operator had an umbilical cord from his car, so would drive the car up behind the miner, get out, go back with the miner driver and stand at the intersection usually and just flight the coal back as it was needed. The outbursts were triggered by the miner, the driver would run back to the car and drive it away. That was found to be extremely safe from the point of view of covering people, it was fantastic. In the end there was an outburst that was about 200 shuttle cars of coal, about 800 tonnes, that totally filled an entry 25 m back from the face. Completely filled it. The Federal Inspectors said that the system had to be changed, so now the change has been made to a pseudo-conventional system of shooting it boring with a Joy CD71 and shotfiring and just fracturing the coal.