RECENT EXPERIENCE IN MONITORING MINE VENTILATION AT WEST CLIFF COLLIERY

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ABSTRACT

This paper describes recent developments at West Cliff Colliery in environmental monitoring, using a sophisticated computer controlled system.

The operations involved in environmental monitoring are described and the equipment employed is detailed. It is anticipated that the monitoring system employed at West Cliff Colliery will be expanded to allow total and instantaneous monitoring of roadway environmental conditions.

INTRODUCTION

West Cliff Colliery is located the mid-west of the southern coal fields of New South Wales. Colliery holdings lie between Coal Cliff (eastern end) and Appin Colliery (western end). The colliery mines high quality coal from the Bulli Seam (top seam of the Illawarra coal measures) at a depth of approximately 480m. The average thickness of the coal seam is 2.5m with some minor variations. The immediate roof of the Bulli Seam consists of Coal Cliff sandstone, a fine to medium grained sandstone containing occasional conglomerate and shaley bands. The sandstone generally ranges from 5 - 10m in thickness. Towards the western limits of the colliery holding, the immediate roof becomes shale.

Gas Content of Coal

Three different methods have been used to determine gas content of coal from Bulli Seam at West Cliff Colliery. These are :-

(1) General gas-make in the mine.
(2) Localised gas emission technique and absorption method.
(3) Direct measurement of gas content of coal.

The first method is based upon the total gas emitted into the ventilation stream of

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the mine with respect to the tonnage mined. Observations were made over an extended period when the mine was closed. The difference in the gas emissions was calculated and compared with data from overseas mines (Lama, 1980a). This data gave gas content of coal about $13m^3$/tonne.

The second method is based upon the emission of gas at the face during mining operations and measurement of gas pressure at the face. This data was further extrapolated to the maximum gas pressure measured in the coal. Coal samples were subjected to measured gas pressures (both at low pressure and higher pressure absorption) and the amount of gas absorbed by coal was measured. Based upon the absorption capacity of coal, the gas content of the Bulli Seam was estimated at $17m^3$/tonne.

The gas content of coal was measured directly using core samples from surface boreholes drilled to the Bulli Seam in adjoining areas of the mine using a U.S.B.M. method. The results of these measurements gave a gas content varying from 9 - $15m^3$/tonne.

The high gas content of the Bulli Seam and the speed at which development has proceeded at West Cliff has required new innovations in mine ventilation and control of gas. The brattice venturi system was developed at West Cliff to overcome gas related problems at the face. The quantity of air deemed necessary for a panel to operate at West Cliff is considerably higher than that considered necessary at other collieries within the State. A normal development unit is considered to require a minimum of 20 cubic metres per second at the last line of cut-throughs to allow safe and efficient mining to take place. Once the ventilation quantity drops below 10 cubic metres per second at the face, severe ventilation difficulties are experienced. The high quantities of gas liberated by rapid mining operations require close and continual monitoring of returns. This is particularly accentuated by the need to keep the gas level in the upcast shaft below 1-1/4%. This percentage of methane cannot be exceed as the bulk winder and associated equipment is located in the upcast shaft. This need to closely monitor the percentage of methane in the return system at West Cliff Colliery has necessitated the introduction of a continuous mine monitoring system.

SYSTEM OVERVIEW

The monitoring system installed at West Cliff consists of two large computers which receive information from three major sub-systems, which monitor operations, longwall roof conditions and the underground environment. While this paper is primarily dedicated to aspects of environmental monitoring a brief description of the major components of the system and their function follows :-

The computers are relatively large and powerful machines. They were selected on the basis of being more than adequate for present and proposed future needs. To illustrate the size of the machines, the total memory capacity shared between them is equivalent in size to a library of 1,000 books each of 50,000 words.

Another way to illustrate the size is to say that it would take four working years of a typist, typing at 100 w.p.m. to use up all of the available capacity. The computers communicate with the operators via colour displays and keyboards.

Colour is used to indicate equipment status and alarm conditions in numbers, words, graphs and mimic diagrams.

The system is a CTT 63/40U Central Telemetry Station which was developed by Cerchar Industrie, the research arm of the French National Coal Board and is manufactured by Oldham, France. Over 100 Oldham CTT systems have been supplied around the world. There are currently three in Australia - two at West Cliff and one at Darkes Forest Mine.

The principle of the system is that each of the underground transducers is completely surface powered, and Intrinsically Safe; therefore, with the appropriate exemptions, monitoring can continue in intake and return airways regardless of methane concentrations or adequacy of ventilation. The unique technology pioneered by Cerchar Industrie, which makes the placement of surface powered transducers practical at distances of up to 10km from the surface of the mine, has meant that surface tube bundle systems with their inherent long delays and problems of tube integrity are now redundant.

MINING OPERATIONS MONITORING

Mining operation monitoring is performed by equipment which telemeters information from each conveyor and other fixed underground equipment necessary to move coal from the coal faces to the surface. Information is telemetered from underground over a single telephone line (shared by the I.S. telephone system) and is available initially as a series of lights. However, the information is also collected by a special computer interface for rapid communication to the computer systems.

LONGWALL MONITORING

A total of 12 longwall supports are fitted with transducers for monitoring roof conditions and support performance. Four measurements are input from each monitored support: rear leg and front leg hydraulic pressures and either stress in the rear links or roof convergence of the support. Underground, a battery supported Intrinsically Safe outstation gathers data, reporting all information to a stand alone surface station each 2.6 seconds. The surface station feeds its information to the computers over a fast data link.

ENVIRONMENTAL MONITORING SYSTEM

The environmental monitoring system which is the basis of this paper has the capacity for 80 underground transducers. Currently, equipment is available for 21 areas of environmental monitoring and 6 areas of methane drainage monitoring with 3 transducers in each area. The environmental monitoring system actually consists of 2 identical 40 point systems each providing information from a computer interface to the monitoring computers.

VENTILATION MONITORING SYSTEM

The ventilation monitoring system at West Cliff has the capacity for 21 areas each with transducers for ventilation air velocity (and thence volume), ventilation pressure and methane concentration.

The system includes chart recorders which continuously record the readings and clearly indicate trends in ventilation conditions.

The Oldham methane heads have a range of 0 to 5% and due to use of intermittently activated high temperature filaments, the heads have very good performance in the high methane concentrations that may be encountered. It is apparently true that some types of methane heads are poisoned by prolonged high methane concentrations. To illustrate the point, one transducer in a sealed goaf area was indicating 4% of methane for several days and slowly increasing. This information from the system was used to signal a need for a change of ventilation and to monitor the result.

The velocity transducers operate on the "hot wire" principle giving very good accuracy even at their minimum flow measurement of 0.3 metres per second. The volume of air flowing is computed by multiplying the velocity by the cross sectional area of the roadway and a conversion factor determined for each monitoring station, required because of the location of the transducers in the airway.

Ventilation pressure transducers are from Trolex Products Ltd. of the U.K. The precision differential pressure transmitters are combined with a general purpose "coder" from Oldham to make the surface powered ventilation pressure measurement possible. Ranges in use at West Cliff are 250, 500, 1,000 and 2,500 pascals.

APPLICATION

The following is a diagram of the ventilation around the West Cliff longwall (see Page (6). Note the placement of transducers.

THE ROLE OF THE COMPUTER

While the initial benefit of the monitoring system is derived from the surface indication and alarm checking of each underground measurement, there is much benefit to be derived from computer analysis. The benefits of computer analysis are broadly derived from three areas :-

(1) Commonsense reduction of data which could be done by any qualified mining engineer, but which can now be done continuously and automatically.

(2) Complex analysis which may only be considered feasible with the resources of a large computer available.

(3) The ability to store away records of data trends and events for extended periods and retrieve them with ease for viewing, printing or analysis.

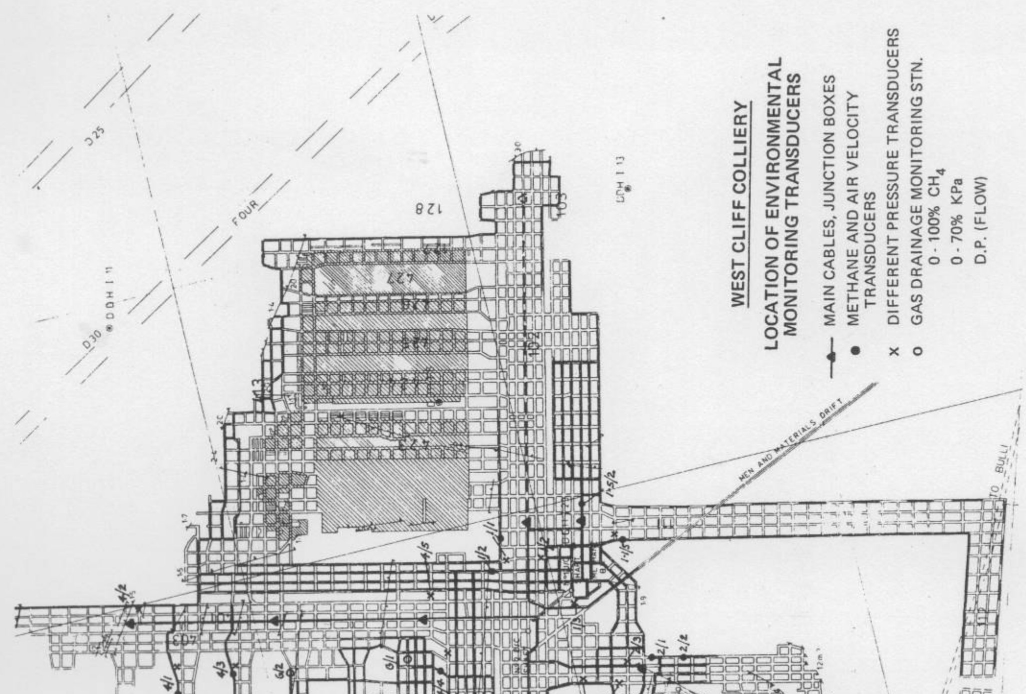
DATA REDUCTION

Rate of Change alarms are the simplest form of commonsense data reduction; this technique allows the computer to see increasing trends which are leading to trouble as an operator would similarly analyse the trace of a chart recorder and discern a deteriorating situation. Simple calculations relating to gas make can also be done continuously to determine whether increased methane concentrations are due to increased gasiness of the seam or reduced ventilation. On the one hand, a ventilation fault is highlighted and located; on the other, a need for increased ventilation is signalled to the ventilation engineer.

Where sufficient flow and pressure transducers are installed, it will be possible to monitor specific roadway or face resistances and raise an alarm if the resistance changes markedly. Thus, a short circuit or roof fall may be detected. While it is safe to say that any of the above could be done quickly by most qualified mine personnel, the benefit of the computer is that such calculations are being done continually, at all hours of the day and night.

COMPLEX CALCULATION

The more complex calculations of interest are based on ventilation simulation


WEST CLIFF COLLIERY
LOCATION OF ENVIRONMENTAL MONITORING TRANSDUCERS
MAIN CABLES, JUNCTION BOXES
METHANE AND AIR VELOCITY TRANSDUCERS
DIFFERENT PRESSURE TRANSDUCERS
GAS DRAINAGE MONITORING STN.
0 - 100% CH4
0 - 70% KPa
D.P. (FLOW)
MEN AND MATERIALS DRIFT
TO BULLI
GEORGE'S RIVER
APPIN
LW1

computer programs of the familiar Hardy Cross technique. Familiar versions of these programs are called "Genesys" and "Ventsim".

Ventilation Simulation programs as originally conceived allow the ventilation conditions of each roadway of a mine to be simulated with regard to ventilation volume and pressure merely by specifying the resistance of each roadway and the fan characteristics.

These programs work on the basis that all air that flows into a roadway junction must flow out and that the ventilation pressure around a closed loop of airways will sum to zero. The quantity of calculation required to analyse a proposed mine of several hundred roadways to determine the flow in each one accurately, given certain fan conditions, is well beyond the capacity of one man and his slide rule or even with a calculator. The benefit of such computer programs is in the design of mine ventilation before a mine is commenced to allow proper planning and fan selection or in an existing mine to test and design proper new developments "on paper" or more correctly, "in computer", before commencing expensive driveages.

With a powerful computer system such as is installed at West Cliff, with 30 to 40 current ventilation readings available, an extra dimension to simulation is available. It is now practical to have a continuously running ventilation model program which uses all of the measured values to allow a more accurate calculation of the remaining airway condition. The result is an overview of the complete mine ventilation conditions to a higher degree of certainty than ever before possible. By applying limit alarms and rate of change alarms to both actual and where necessary, "calculated" roadway ventilation conditions, ventilation disturbances will be detected and their implication for all affected roadways will become evident.

There is considerable scope for software development in this area as is foreshadowed by authors Toshiro Isobe and Yuusaku Tominaga in their paper entitled, "Underground Ventilation Network Analysis by Using Graph Theory", in which techniques for predicting the course of disturbances to mine ventilation by computer was discussed.

DATA STORAGE

The computer undoubtedly comes into its own where the storage of historical data is involved. The computer has the ability to automatically store away the current value of all important ventilation parameters for later retrieval. The storage medium itself, usually magnetic disk or more recently, magnetic bubble memory, is not only compact but provides fast recall of information. This is infinitely more satisfactory than examining roll after roll of chart paper. Storage capacity is also not a problem. On the West Cliff system, using 20% of the total disk capacity, would allow every result from all 80 Oldham transducers to be stored for a period of 86 days. A more economical storage of an hourly maximum, minimum and average would provide over one year's storage in the same space.

CONCLUSION

The complete monitoring system at West Cliff combines the three specialises sub-systems of Mine Operations, Longwall Monitoring and Environmental Monitoring into one by connecting them to a powerful computer system. The ventilation monitoring sub-system provides more up-to-the-minute information for West Cliff Management than any other system installed in a coal mine in Australia. The computer provides the advantages of a highly readable operator display as well as the ability to :-

(1) Continuously run simple check calculations.

(2) Run "on line" simulation programs with continually updated real ventilation parameters provided from the ventilation monitoring sub-system for enhanced results.

(3) To allow the fast retrieval of historical records and present it in readily useable form.

REFERENCES

1. Lama, R.D., P. Marshall, E. Tomlinson and L. Griffiths, 'Investigations into drainage of gas at West Cliff Colliery: optimisation of gas drainage hole parameters', The Australian Journal of Coal Mining Technology and Research, No. 1, 1982.

2. Isobe, Toshiro and Yuusaku Tominaga, 'Underground Ventilation Network Analysis by Using Graph Theory', Paper presented at The Aust. I.M.M. Illawarra Branch Symposium, 1981.

J. ANSELL (Dept. of Industrial Relations): Further to the discussion on the papers this morning - there is a scheme for the monitoring of developing collieries with longwall under gassy conditions. There was one scheme at Westcliff. In each case, only return airways are being monitored. In New South Wales the problem is not the main returns, it's not the longwall faces, it's that little section in front of the last cut-through where ignitions and high methane contents have occurred. What can be done about monitoring that section of the working face area inbye of that last cut through?

K. BURKE (Westcliff Colliery): Not all the stations at Westcliff are in the returns, in fact the longwall is monitored on the intake side as well as on the return - not in the last cut through, no. Having established these stations, the cross-sectional area must be measured because the velocity is being measured so to get the quantity a very accurate reading must be taken and that calibration figure fed into the computer. It is not an arrangement whereby it is practical to move the station every week. An attempt is made to select points in the mine which will be reasonably permanent.

S. GILLIES (University of Queensland): In this paper, an excellent job has been made of collecting mine information and feeding it into a computer. Has anyone thought about using the computer then, together with a network analysis programme to interactively control the ventilation system by changing fan speeds, blade settings, regulator settings, doors or whatever?

I. BURRELL (Material Control Systems Pty. Ltd.): It certainly has been thought about. The first step will be integrate the real time readings into the database to calculate more than just the values that are being measured. In fact, using this technique it will be possible to calculate the flows in almost every part of the mine thereby amplifying the effect of the system. However control of the type discussed, while it's certainly technically possible and something to get involved in, it's something which is a long way off in most peoples' minds because monitoring is really in a stage of infancy, and control is the next big step which hasn't been seriously contemplated.

J. GRIEVES (Taylor-Woodrow Construction Ltd.): The comment in respect of the catalytic detectors was interesting. Please describe in greater detail the interrogation of the CH_4 detectors? Are they serial or parallel in action?

I. BURRELL: Each transducer is interrogated each four minutes which means that for each particular transducer there must be a wait of four minutes between readings which means it's not instantaneous in that sense. When a reading is taken it is a spot reading and in that sense it is instantaneous. On the air velocity sensors they are in fact able to take an average reading over the four minute period, but four minutes is a long time and also it's a very short time - compared to tubes, its instantaneous.