THE MONITORING OF MINE ATMOSPHERES IN U.K. COLLIERIES

By
W.M. Robertson[1]

ABSTRACT

[illegible] describes the progress made in [illegible] the introduction of [illegible] of the mine atmosphere [illegible] collieries. Brief descriptions are [illegible] portable and fixed point [illegible] developed for this [illegible] available for [illegible] to the surface are [illegible]

[illegible] outlines some of the [illegible] out both in the [illegible] on the development [illegible] of fire detection. Some [illegible] work are illustrated [illegible]

INTRODUCTION

[illegible] and expansion of environ- [illegible] collieries, during [illegible] undertaken because [illegible] of modern mining has [illegible] standards of control of the [illegible] The immediate objective is to [illegible] early detection of [illegible] additionally, the mon- [illegible] of immeasurable [illegible] a fire or ignition. The [illegible] resulted in a consid- [illegible] the safety of the mine, since [illegible] benefit of instant avail- [illegible] measured data.

Further progress can be expected, from future improvements in the accuracy, reliability and durability of existing detectors and transducers, the development of new transducers and the introduction of improved techniques for the interpretation of collected data on gas emission patterns and the composition of the underground environment.

Monitoring can be done by both portable and fixed instruments. Portable instruments have the advantage that they can be moved about to make tests at any place in the workings, whilst fixed instruments are limited to indicating the conditions at a single established point. Fixed instruments, however, have the merit that their output can be communicated continuously to a central control station, and they can be designed to continue reporting information in an atmosphere that has become irrespirable. In collieries where there is a liability to such environmental problems as sudden heavy methane emissions, coal and gas outbursts or spontaneous combustion monitoring is likely to extend to all districts.

Full scale schemes of monitoring and transmission of environmental data have been in operation for some five years at Manton and Broadsworth collieries in South Yorkshire and building on the experience gained at these first two installations, environmental monitoring with data transmitted to the surface has been extended to a further six collieries in the U.K.

SENSORS AND SYSTEMS

Through the joint efforts of the N.C.B.'s

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Mining Research & Development Establishment and Scientific Control, sometimes in collaboration with manufacturers, sensors have been developed to measure the following environmental parameters:-

a) Concentration of methane in mine air,
b) Concentration of methane in methane drainage pipelines,
c) Flow in methane drainage pipelines,
d) Velocity of ventilating air,
e) Concentration of carbon monoxide,
f) Concentration of carbon dioxide,
g) Concentration of oxygen,
h) Presence of smoke.

Further research is currently being undertaken to develop a sensor to measure temperature and humidity and new types of fire detectors. Current work on fire detectors is discussed in more detail later in this paper.

Portable Instruments

Although continuous monitoring by fixed sensors provides information to enhance safety and assist decision making, fixed detectors can be sited at only a limited number of representative positions and do not eliminate the need for some spot testing by officials. Often it is impracticable to position fixed instruments at points of particular environmental risk (e.g. fast ends) and spot testing by underground officials is the only reasonable alternative. Portable instruments are also required for workings without telemetering systems and for intermittent testing at points of anticipated local risk.

Portable instruments currently available for roving inspections, etc., include methanometers and oxygen meters. Hand held methanometers of various types have been in use for over three decades, the present holding being of the order of 8,000. The current design is the D6 diffusion methanometer, which is light, compact and robust, with a range 0-5% methane. This instrument is carried regularly by officials. For measuring high concentrations of firedamp in drained methane, behind stoppings, etc., over 1,000 HC methanometers (0-100%) are in service, and an improved model is being designed.

A portable methane indicator which is hung up at the working place throughout the shift, to monitor continuously, is the automatic firedamp detector (AFD) which indicates in the range 0-3% methane and incorporates a red alarm light that flashes when a pre-set concentration is exceeded.

A hand held oxygen meter that has recently undergone successful trials operates by diffusion of oxygen to a galvanic sensor using a metallised membrane as electrode. The partial pressure of oxygen is indicated on a scale marked in three coloured bands (14-19 kPa in red, 19-20 kPa in white, 20-24 kPa in green; 1 kPa representing approximately 1% oxygen), and an alarm is sounded when the partial pressure of oxygen falls below a set limit.

Fixed Monitors

Where information on the composition of the atmosphere inbye is to be continuously available at a central control station, either or both of two monitoring systems are being used, namely:-

a) in-situ transducers from which output signals are telemetered to the control station, and
b) tube bundle systems which convey air from a number of sampling points underground to an analyser at the control station.

The former have the advantage that indication at the control station is immediate which could be important for firedamp. The latter have the advantage that other gases as well as firedamp can be very accurately [illegible] or sophisticated analytical [illegible] at the surface.

First installed in the U.K. more than ten [illegible] ago, the tube bundle system is now [illegible] extensively in British collieries, [illegible] all collieries that are vulnerable [illegible] spontaneous combustion. Telemetering of [illegible] measurements from transducers [illegible] surface control station is being [illegible] only where it is possible to [illegible] a system that already exists for the [illegible] of production operations. At [illegible] not equipped with a general [illegible] system, and vulnerable to an [illegible] hazard, automatic warning of an onset [illegible] can be provided by means of portable [illegible] and/or in-situ methane monitors linked [illegible] warning system.

As fixed monitors of environmental [illegible] the following instruments are in [illegible] use:-

(a) BM1 for general body methane concentration
(b) BM2H for drained methane concentration
(c) BA2 for air velocity (by vane anemometer)
(d) BA4 for air velocity (by ultrasonic vortex shedding)
(e) BP1 for methane pipeline gas pressure, or differential pressure for determining gas flow (by Bourdon gauge)
(f) FS270 smoke detector (by the effect of smoke on electron flow through air ionised by americium 241)

All the above, except the smoke detector [illegible] the first generation of BP instruments, [illegible] an analogue signal as well as an alarm [illegible], which can be transmitted. The [illegible] head is operated by a cable-connected [illegible] assembly comprising rechargeable battery, recorder and indicator/control units which are intrinsically safe. The output alarm signal, being itself intrinsically safe, is often emitted to a circuit that furnishes a visual flash and/or an audible bleep every second under alarm conditions (every fifteen seconds when healthy). The output analogue signal is not intrinsically safe, and therefore an approved Barrier Unit must be interposed in its transmission circuit.

Usually an instrument assembly is powered from a direct current supply that is intrinsically safe to the latest British Group 1 standard, the battery being brought into use automatically in the event of failure of the mains power supply. The battery most commonly employed is a 7 amp-hour, trickle-charged in-situ; fully charged it will provide power for a weekend but after that a full recharge requires five days. Also available is a larger battery of 20 amp-hour which will power a monitor for 7 days, but must then be taken to the surface for recharging. For tele-transmission the current from the sensing head is converted to a d.c. output between 0.4 and 2.0 volts.

The BM1 single head fixed monitor for general body concentrations of methane in the range 0-3% is based on a low power pellistor incorporated in a Wheatstone bridge. It has two signal output sockets. Over 700 are in use.

The BM2H single-head high concentration (0-100% methane) fixed monitor, designed for firedamp drainage work, works on the principle of thermal conductivity and diffusivity, and provides two low level alarms. It requires a differential pressure to drive the drained gas sample through the detector head. Some 200 have been manufactured.

For air velocity two types of monitors are available, with three speed ranges (0-2, 0-5 and 0-10 m/s), for use in airways, fan drifts, at booster fan sites, and in auxiliary ventilation systems. Of the BA2 single-head rotating vane air velocity monitor, some 80 have been installed. The more recent BA4 air velocity monitor utilises the fact that, when air flows passed an obstruction, vortices are formed downstream at a rate which is proportional to air speed. The frequency of the vortex shedding is detected by an ultrasonic beam downstream and converted into the standard 0.4 to 2 volts d.c. output. About 20 are in use.

Most monitors of the flow of air in ducts are of the on/off type and are activated by the differential pressure generated either by a fine grid or by symmetrical, equal contraction/expansion devices. This pressure differential is transmitted to an electrically approved pressure switch that energises an alarm light if the flow falls below a set percentage of the normal value. These devices, usually fitted at the inbye end of a duct system, can be connected to a BP1 pressure monitor if analogue signals are required. For indicating duct air flow, swinging gate, pitot tube and venturi devices are also employed.

The three-module BP1 pressure monitor is designed to measure static and differential pressures in air and gas flow systems. Equipped with two separate pressure transducers it can measure either a static and a differential pressure or two static pressures or two differential pressures.

An example of an infra red analyser used as a fixed point continuously recording underground instrument is the UNOR CO analyser. It is not widely used in the U.K. but finds some application in situations where sealing off operations are in progress. The UNOR's main advantage, that of simultaneous indication, in the pit and in the control room at the surface, must be set against its relatively high capital cost coupled with the practical problems and difficulties of maintaining and calibrating sensitive and sophisticated analytical instruments in underground mining conditions. Another drawback is that an interruption of the power supply to mine workings makes the system inoperative, often at times when knowledge of the prevailing conditions in an incident would be invaluable.

The only ionisation smoke detector used in Britain is the Trolex P3270 instrument. Minerva type T868 smoke detectors were first installed underground in Britain in 1962, but unfortunately these early detectors were very sensitive to dust and dampness and this often caused instability and false alarms.

The Cerberus Company of Switzerland produced a redesigned ionisation chamber to reduce susceptibility to dust and moisture and to improve stability and this was incorporated in the Trolex Smoke Detector type P3270 which superseded the Minerva detector in N.C.B. mines in 1975.

Tests carried out in a surface fire gallery, using the Trolex P3270 instruments to detect small fires, over a range of ventilating air speeds, indicated serious shortcomings in the performance of this equipment since often it failed to respond to smoke at low ventilating speeds. This led to the modification of the outer case of the instrument in order to make the detector more accessible to fumes. When this instrument was tested in the gallery, using a variety of smokes produced from fires made up of coal, oil, wood and plastic conveyor belting either singly or in combination, it did not always detect smoke in wind speeds above 3m/s but otherwise the device would operate rapidly, once smoke produced early in the fire, had reached the detector. It appeared that if the smoke could be attracted to the detector then the performance might be improved. A number of modifications [illegible] device, designed to improve the [illegible] in high wind speeds, have been [illegible] external devices and shields [illegible] design will successfully [illegible] in wind speeds up to 8m/s. It [illegible] that though the currently [illegible] detectors are capable of [illegible] satisfactorily over a reasonable [illegible] velocities, there are a [illegible] where they may not be [illegible] reliable. Underground experience [illegible] accumulated. About 2000 instruments [illegible] in U.K. mines.

[illegible] System

[illegible] narrow bore tubes to [illegible] the surface has found wide [illegible] in the U.K. and there are about 100 [illegible] in operation in N.C.B. mines. [illegible] installation with sampling points [illegible] from 10 to about 60 can be [illegible] situations ranging from [illegible] locations, e.g. headings [illegible] to conveyor roadways and faces [illegible] to districts, main [illegible] shafts. It will operate [illegible] of an underground power supply [illegible] a degree of flexibility in the [illegible] monitoring of additional points as [illegible]

[illegible] makes possible the use of [illegible] non IS laboratory-type [illegible] one for each component gas. [illegible] carbon monoxide, methane and [illegible] is by infra red absorption, for [illegible] paramagnetic method. Aspiration [illegible] the tubes is continuous and samples [illegible] to the analyser train sequentially [illegible] zero and span facilities can be [illegible] incorporated in the cycle or [illegible] at will. In this way analytical [illegible] guaranteed not only for CO but for [illegible] number of gases. Operation in a [illegible] clean and vibration-free environment with ready access for maintenance or repair ensures a degree of reliability on a par with the highest standards of a laboratory type operation.

The operation of the system is controlled by a mini computer which is programmed to store data, continuously interrogate the available information, and flag up warning of abnormal situations, display information on a VDU and print out results as necessary.

The system provides currently the only reliable and cost effective way of monitoring carbon monoxide levels from a multiplicity of widely spaced sampling stations underground. With such coverage there should be no place in the pit where the insidious development of fire can proceed unnoticed for any length of time.

Its other role, that of an environmental gas monitor, proves invaluable during operations involving the sealing off of districts and in recovery operations following incidents such as gas ignitions. Its value in these situations derives from its independence of electricity underground or of men underground, its ability to monitor toxic or explosive atmospheres at concentrations well above those where such analysis in situ would be neither possible nor permissible, and automatic operation for long periods when mines are not manned.

The tube bundle will, of course, respond to open fires and in several instances has given timely warning of conveyor fires caused by defective rollers. Clearly however, the likelihood of success in such cases depends on the rate of fire development relative to the delay time of the sample in the tube and its subsequent presentation to the analytical system. The Australians and Americans have considered it worthwhile to reduce tube delay by adopting wider bore tubes and installations using positive pressures of about 4 bar at the [illegible] device, designed to improve the [illegible] in high wind speeds, have been [illegible] including external devices and shields [illegible] latest design will successfully [illegible] in wind speeds up to 8m/s. It [illegible] emphasised that though the currently [illegible] smoke detectors are capable of [illegible] satisfactorily over a reasonable [illegible] of ventilating velocities, there are a [illegible] of conditions where they may not be [illegible] reliable. Underground experience [illegible] accumulated. About 2000 instruments [illegible] installed in U.K. mines.

[illegible] Tube Bundle System

[illegible] gas through narrow bore tubes to [illegible] on the surface has found wide [illegible] in the U.K. and there are about 100 [illegible] installations in operation in N.C.B. mines. [illegible] form of installation with sampling points [illegible] in number from 10 to about 60 can be [illegible] to cover situations ranging from [illegible] individual locations, e.g. headings [illegible] to conveyor roadways and faces [illegible] specifically to districts, main [illegible] and shafts. It will operate [illegible] of an underground power supply [illegible] a degree of flexibility in the [illegible] monitoring of additional points as [illegible]

[illegible] arrangement makes possible the use of [illegible] of sensitive non IS laboratory-type [illegible], one for each component gas. [illegible] for carbon monoxide, methane and [illegible] dioxide is by infra red absorption, for [illegible] by a paramagnetic method. Aspiration [illegible] all the tubes is continuous and samples [illegible] admitted to the analyser train sequentially [illegible] automatic zero and span facilities can be [illegible] incorporated in the cycle or [illegible] at will. In this way analytical [illegible] is guaranteed not only for CO but for [illegible] number of gases. Operation in a [illegible] clean and vibration-free environment with ready access for maintenance or repair ensures a degree of reliability on a par with the highest standards of a laboratory type operation.

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[illegible] the NCB's Scientific Department [illegible] a programme of investigations to [illegible] an underground fire detection system. [illegible] types of sensors were initially [illegible] in the laboratory, involving tests [illegible] criteria as specificity of detection, [illegible] sensitivity, signal output, zero drift, [illegible] durability, effects of change in [illegible] and temperature, etc. From the [illegible] of these observations it was considered [illegible] semi-conductor sensor was a feasible [illegible] to pursue in the development of an [illegible] fire detection system.

[illegible] the series of laboratory tests, one [illegible] commercially available semi- [illegible] was considered most suitable [illegible] a fire detection transducer [illegible]. A number of these sensors from a [illegible] were subjected to quality control [illegible] for comparability in behaviour and, from [illegible] obtained, were judged to be of [illegible] uniformity.

[illegible] series of experimental tests, involving [illegible] of coal, wood and P.V.C. belt material, [illegible] out in a surface fire gallery to [illegible] the response of these sensors with [illegible] acceptable and possible alternative [illegible] under investigation.

[illegible] results of one such test are shown in [illegible] form in Fig. 1. These graphs [illegible] the marked difference in response of [illegible] semi-conductor sensor compared to the infra [illegible] and electrochemical cell with each [illegible] to give the same response to CO.

This is because whilst the infra red detector and electrochemical cell can be more or less totally specific to carbon monoxide the semi-conductor responds to a wide variety of oxidisable gases found in the products of combustion from a fire.

Trace A refers to an electrochemical CO sensor

Trace B refers to a non-specific electrochemical cell with little or no CO response

Trace C refers to an infra red gas analyser

Trace D refers to a selected semi-conductor

These results, which were repeated on several occasions, were sufficiently encouraging to justify pursuing a development programme based on the semi-conductor sensor.

After a critical examination of changes in stability, sensitivity and general behaviour of the semi-conductor sensors, both short term and long term, a test unit was designed and built for underground trials. These prototype units referred to later as FIDES have been, and are being, operated underground at specified collieries for extended pit trials under a letter of no objection issued by the Mines Inspectorate.

These trials commenced in January 1980 and in order to obtain as much information as possible from them, the widest possible spectrum of variations in environmental conditions was chosen. Valuable information has been obtained from these trials (which are not yet complete) and as an illustration, a number of examples are given in Figs. 2-4.

Examples of incidents occurring at different collieries and recorded by the 'Fides' installation are illustrated in Fig. 2.

The incident at Colliery A is one of spontaneous combustion, monitored over a period of two to three months. Traces from selected 24 hour periods show the progression of the spontaneous combustion in time from the normal ambient condition (i) through the stages of increasing activity (ii to iv). After location and subsequent treatment of the fire a return to the normal background level (v). It has been generally observed that as spontaneous combustion increases the short term variations in the signal increase as observed for (iv) in the illustrations. At this particular installation a continuous signal from the 'Fides' is transmitted to the surface and an instantaneous recording obtained. This enables management to be continuously made aware of the current environmental situation underground.

The trace from Colliery B illustrates the development of a belt fire 3 miles away from the sensor. A sustained general increase in signal over 2-3 hours is clearly apparent despite the superimposition of the shot firing peak.

The traces from Collieries C and D show incidents of hot roller fires, in these cases, indicating the rapidity of progression particularly Colliery D where quick recognition followed by action has to be taken to avoid a potentially dangerous situation developing. The incidents at Collieries C and D were of much smaller magnitude than at Colliery A.

Figure 3 illustrates traces from a colliery, taken over a typical three day period which serve to demonstrate the correlation in signal output between the 'Fides' sensor and a carbon monoxide sensor both continuously monitoring from the same underground site. The carbon monoxide sensor receives the sample air via the tube bundle system whilst the 'Fides' is sensing the air 'in situ' at the underground site. The Sunday traces show that the electrical 'noise' level of the Fides is negligible compared with the environmental 'noise' normally encountered underground during the working week.

Recorded traces from other underground installations at different collieries are shown in Fig. 4, illustrating the effects of different environmental conditions upon the 'Fides' sensor. The first part of the traces illustrates little activity in the early morning with the increase of activity during the working day associated with shotfiring, diesels or coal mining operations.

At Colliery 1 the trace is from an intake paddy roadway showing the sharp signal peak caused by exhaust fumes from diesel locomotives passing in close proximity to the Fides sensor head. Being an intake roadway changes in general background response level normally associated with the 'coal winning' operations are not seen cf Collieries 2 and 3 below.

At Colliery 2 the trace is from a return roadway showing the effects of shotfiring in a colliery where there are no diesel locomotoves present. The general rise in background level is a typical phenomenon attributable to the effects of 'coal winning' as seen in a return roadway.

The more complex trace from Colliery 3 shows the effects of both diesel locomotive exhaust gases and shot firing fumes in a return roadway, superimposed on a generally increasing background signal from working day activities. The diffuse nature of the trace attributable to diesel exhaust fumes (generated remotely) contrasts with the example from Colliery 1.

The trace from Colliery 4 is from a return roadway where a 'salvaging' operation is taking place and where there is no diesel activity and little or no shotfiring taking place.

From an inspection of these traces it is clear that the recognition of a fire situation could be complicated by the appearance of other concentration peaks which are combustion operations, not conventionally regarded as fire, because they fall into the category of a

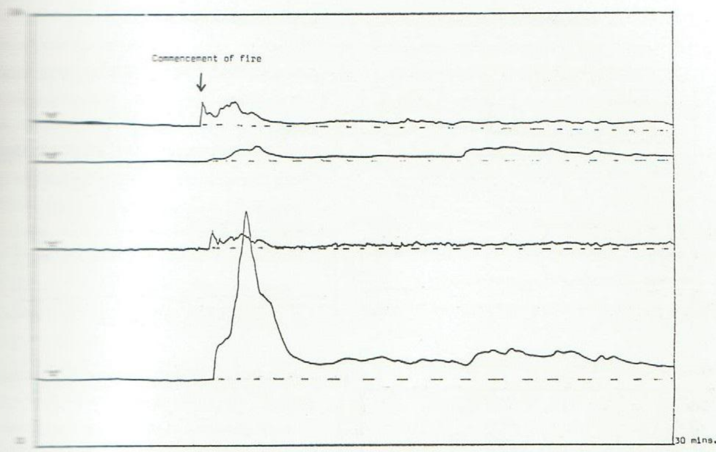

Fig. 1 - Relative effect of "fire gases" on different transducers each similarly calibrated to carbon monoxide

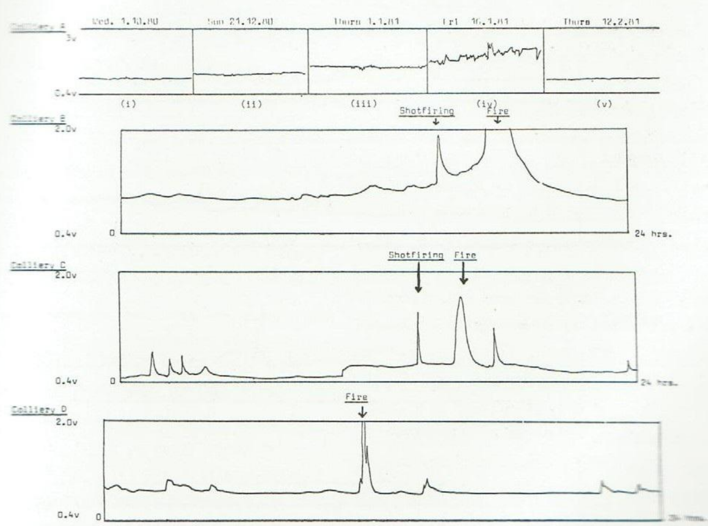

Fig. 2 - Recorded traces from colliery 'incidents' using Fides

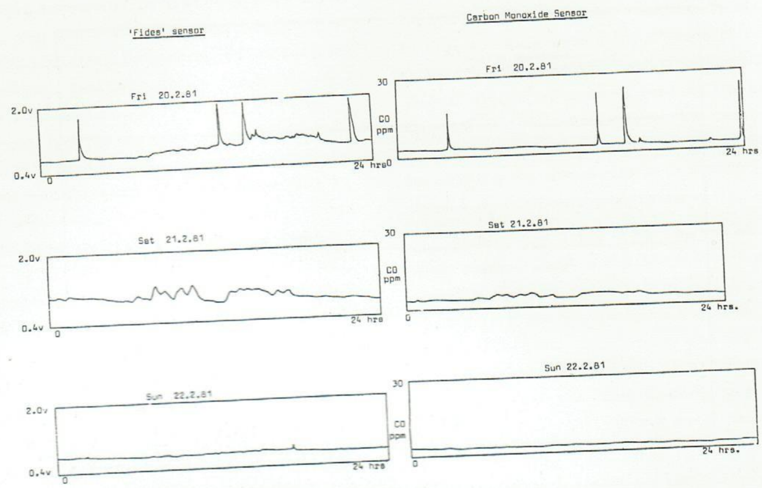

Fig. 3 - Correlation between Fides semi-conductor based detector and carbon monoxide data continuously recorded on site

Fig. 4 - Effect of different site conditions on characteristics of trace recordings

[illegible] operation. They may be transient in [illegible] in shotfiring, or more prolonged and [illegible] variations at a more or less steady but [illegible] level, characteristic of diesel [illegible] activity and which represent no more [illegible] fire which is contained and controlled. [illegible] (or some closely related component) is [illegible] as a parameter which is more or less [illegible] to fire then the problems of avoiding [illegible] alarms may not then necessarily depend on [illegible] of a combination of different detectors [illegible] be reduced to no more than the need to [illegible] between legitimate and non-[illegible] combustion.

[illegible] approach currently under examination [illegible] a critical interpretation of 'Fides' [illegible] mathematical terms involving such [illegible] as rate of change, peak height, peak [illegible] and peak frequency. The next stage [illegible] deriving a suitable 'formula' which [illegible] and effectively distinguishes an [illegible] fire at a given level of [illegible] (say 99%) and this would form the [illegible] a computer programme. Priority [illegible] certainly be given to immediate [illegible] or near off-scale readings as this [illegible] a dangerous situation requiring [illegible] alert and urgent attention. [illegible] it may be necessary to make variations [illegible] numerical values to suit different [illegible] different situations within the same [illegible]

[illegible], one can say that the work [illegible] so far on semi-conductor type [illegible] extremely encouraging and indicates [illegible] have the advantages of long life, [illegible] not permanently poisoned by exposure [illegible] gases, resistant to rough handling, [illegible] of sensitivity over long periods (more [illegible]) of exposure to mine [illegible]. A possible disadvantage may be [illegible] sensitivity of the sensor to a wide [illegible] oxidisable gases, not necessarily associated with fire. As indicated in an earlier paragraph this difficulty may be overcome by processing the signal in a micro-computer to 'filter out' the spurious peaks and regain a sensitive and reliable alarm setting.

CONCLUSIONS

The paper has summarised, albeit somewhat briefly, the present position in N.C.B. mines with regard to the comprehensive monitoring of the underground environment. Developments are being continuously pursued in search of new detectors and of improvements in existing sensors.

Because circumstances at individual mines can vary so widely, the type of monitoring system will differ significantly from one pit to another. Precisely what system is installed will be determined by such factors as liability to spontaneous combustion, rate of methane emission, existence of high risk areas, amount of goaf area, length of conveyor roadways, maximum acceptable response time, etc. Some or all of these factors need to be considered in order to be certain that the system will provide adequate coverage. In all cases, however, any comprehensive monitoring system will comprise two or more different sensors which are complementary to each other. The choice should go to the most effective (in terms of reliability, performance and ease of maintenance) arrangement combining, if necessary, the best features of two or more detectors operating on different principles.

In this paper the emphasis has been placed more or less solely on the environmental aspects of the monitoring process and its proven impact on the provision of increased mine safety and indirectly improved confidence and morale for the work force. Management, too, cease to be plagued by fears and doubts about unknown or incipient developments during periods when the pit is unmanned. In the event of a developing incident the provision of comprehensive and factually accurate information to management is the key to prompt and decisive corrective action without recourse to guesswork.

ACKNOWLEDGEMENTS

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DISCUSSION

[illegible] (Dept. of Mineral Resources): [illegible] semi-conductors is very [illegible] there have been some un- [illegible] in the past with semi- [illegible] the paper a lot of these [illegible] to be overcome. It was [illegible] the work done has now virtually [illegible] effect of methane on the semi- [illegible] Does this also apply to [illegible] that is, a plug of carbon dioxide [illegible] does it remain insensit- [illegible] the zero stability of the semi- [illegible] mentioned as very good. Would [illegible] still be good if it was [illegible] in an intake and hence subjected [illegible] in ambient temperature and relative [illegible]

[illegible] Laboratories, U.K.): [illegible] of available commercially [illegible] semi-conductors. After going through [illegible] of them the one was chosen which [illegible] for this particular [illegible] With the semi-conductor selected [illegible] it has been found that by running [illegible] a fairly high temperature the res- [illegible] is completely eliminated. That [illegible] disadvantage in the sense that the [illegible] power demand. But probably [illegible] be easily overcome in any production [illegible] As regards sensitivity to CO_2 in the [illegible] referred to, there is no positive answer [illegible] for sure. If there is an answer [illegible] sent by letter from the U.K. With [illegible] the second question, at least two [illegible] shown relating to semi-conductors [illegible] in intake roadways. The answer to the [illegible] is, yes, the detector is not affected [illegible] in humidity and temperature and has [illegible] a steady base line throughout the [illegible] life.

C. ELLIS (Department of Mineral Resources): Regarding the stated desirability of eliminating unnecessary response from the detectors and in particular from shotfiring and from diesels, reference was made to having used programming of a computer to filter out effects that weren't wanted. Has any work been done or consideration been given to relating the changes in combustion products to changes in oxides of nitrogen, because oxides of nitrogen would be produced both by diesels and by shotfiring, but not in appreciable quantities by fire.

W. ROBERTSON: The answer to that is yes. The possibility of identifying shotfiring peaks by measuring oxides of nitrogen is being looked at, but without much progress along that road yet.

C. HARVEY (Westcliff Colliery): On one of the slides it was shown that it was possible to measure both methane purity as a percentage and total airflow. Is it necessary to have both a BM1 and a BA2 or BA4 for this? The other question is what is the effect of water both as droplet and freeform on the BM2H?

W.M. ROBERTSON: Two machines are needed. Ventilation flow is referred to general body air measured by a BA2 and the concentration of methane in the drained methane system is measured by a BM2H. Water vapour is a bad thing in a BM2H and it needs to be avoided as far as possible. This should have been referred to before. The BM2H measures the concentration of methane in the drained gas. When the equipment is set up one has to be very careful to take account of carbon dioxide which always exists in drained methane and can be as high as 8%. The instrument has to be calibrated with a standard gas that corresponds to the gas being drained.

Water obviously is very undesirable in any sensing head of this type, as in this katharometer device. It should have been pointed out that there is a large filter, between the sampling line and the sensing head, which is there to take out water and dust.