

Mine Real-Time Personal Respirable Dust and Diesel Particulate Matter Monitoring

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ABSTRACT

An overview is given of two new developments in mine atmospheric monitoring. A new personal dust monitor (PDM) that gives real-time respirable dust readings is discussed. The unit is mounted within the miner's cap lamp battery and internally measures the true particle mass of dust collected on its filter. Samples are available for later mineralogical analysis and results do not exhibit the same sensitivity to water spray as optically-based measurement approaches. The technique achieves microgram-level mass resolution even in the hostile mine environment and reports dust loading data on a continuous basis. The monitor has been evaluated under an Australian Coal Association Research Program (ACARP) grant and is being adopted for statutory mine respirable dust determinations in the United States (US). The monitor has particular application for determining location of high dust sources. It can evaluate the efficiency of engineering means of suppression and other approaches to reducing dust levels.

It has been recognised that the PDM's unique measurement approach has application to allow real-time atmospheric diesel particulate matter (DPM) monitoring. The industry has no real-time atmospheric DPM monitor at present. Recent surveys in New South Wales and Queensland show significant numbers of miners continue to face full shift DPM exposures in excess of internationally accepted levels. Real-time DPM monitoring will allow the industry to pinpoint high exposure zones where a number of trucks and other vehicles work in areas of poor ventilation. Knowledge of high DPM concentration zones allows efficient modification of work practices to reduce underground miners' exposure. Approaches to uses of the DPM form of the monitor and the design of tag boards are discussed. Some outcomes from mine tests with both these new instruments are given.

INTRODUCTION

Mine ventilation is a critical aspect of all underground mines. Mining technological developments and mining environment challenges are necessitating new approaches. This paper in particular examines two areas of new development.

Australian metalliferous mines currently work in a vigorous and expanding sector. High prices and export demand are in the headlines. We are seeing increased production rates and emphasis on block caving, sublevel caving and increasing numbers of open stopes in operations. There is still a ventilation need even with more remote loaders, tramming and possibly trucking. There appears to be a move away from large multi-purpose shafts with more and deeper declines. Belt transport is being used instead of shaft skips or decline trucking. The complexities of supplying high quantity and quality ventilation without major shaft infrastructure are a challenge.

There are an increasing number of small operations. These generally have a small plan area and progress to depth fast. Respirable dust make can be an issue. Many mines face high heat load situations. They also face high diesel exhaust emissions at

the same time and this combination is one of the big ventilation planning challenges.

The network in many modern mines changes daily as stopes or development breaks through. Maintaining an understanding of the ventilation network is a challenge. Improved use of real-time monitoring and control may, in time, allow mines to optimise this situation. Instrumentation developments are allowing improved real-time monitoring of ventilation parameters and particularly gases, respirable dust and airflow. Understanding fires, simulation of fires and training the workforce is an area requiring priority attention.

Ventilation expenditure receives priority when it directly affects production. It is up to the ventilation practitioner to point out the real cost of the ventilation system to the overall mine capital and operating costs. Ventilation costs are not just fan electricity costs and ventilation control device budgets as some may see it. The layout of a mine is largely dictated by ventilation requirements. The provision of a pleasant and comfortable work environment returns increased miner productivity.

Many of the new developments will be contributed to by research activities. The Australian Coal Association Research Program (ACARP) has been outstandingly successful in supporting focused research efforts to benefit coal industry productivity. The five cents per export tonne levy has been leveraged by additional co-sponsoring by operating companies, universities and others. Grants from this source carry prestige and it is hoped the real value of the program will continue. The Australian Minerals Industry Research Association (AMIRA) has in the past funded some significant research in metalliferous ventilation projects. This association no longer appears to be active in the ventilation research areas.

Various mining industry accidents or disasters have led to, or reinforced, a revolution in thinking in many areas of management of the industry. Regulations are less prescriptive and now demand risk assessment incorporating international best practice. Australia is at the international forefront here. There is a much greater emphasis on training at all levels. Much of the industry is actually or effectively long distance commute (such as fly-in, fly-out). It is beyond the scope here to cover the issues that joint management, longer work shift hours and so on present to the management of ventilation. The use of increased numbers of consultants delivers both benefits and challenges.

Vehicles for publication of ventilation innovation for dissemination to the wider industry community are becoming fewer. It is the specialist conferences that have become the main archival repository of our thinking and innovations for reference in the future.

The two areas of new development discussed within this paper have been supported by industry research grants from, in particular, the ACARP with substantial input from the United States agency, the National Institute of Occupational Safety and Health (NIOSH). They are stories in practical application and have received considerable additional industry financial support, mine site testing and evaluation assistance.

MONITORING OF RESPIRABLE DUST

A new personal dust monitor (PDM) for respirable dust developed by the company Rupprecht and Patashnick (now

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Thermo Fisher Scientific) in the US, under a project funded by the NIOSH, has generated promising results in underground coal mine testing performed in the US recently (Volkwein *et al*, 2004a, 2004b). Results from an ACARP funded study undertaken to evaluate this new real-time dust monitor for personal respirable dust evaluation, particularly in engineering studies, have been described by Gillies (2005) and Gillies and Wu (2006).

This paper describes some results from mine studies that have been undertaken using the real-time PDM. The technology that forms the heart of the PDM, the tapered element oscillating microbalance (TEOM[®]) system, is unique in its ability to collect suspended particles on a filter while simultaneously determining the accumulated mass. The monitor internally measures the true particle mass collected on its filter and results do not exhibit the same sensitivity to water spray as optically based measurement approaches. The technique reports dust loading data on a continuous basis and miners and mine operators have the ability to view short-term dust levels. It is believed to be the first personal dust monitor instrument that reliably delivers a near-real-time reading.

The instrument has potential to be used as an engineering tool to evaluate the effectiveness of dust control strategies. Being a personal dust monitor, the instrument measures the airborne dust from the breathing zone region and so has many advantages over instruments that measure from a fixed-point location. It can quickly highlight high dust situations and allow correction. The underground workplace in both continuous miner and longwall face environments has varying respirable dust conditions due to aspects such as ventilation conditions and air velocity, shearer activity and design, chock movement, armoured face conveyor movement, manning position, face time of individual personnel, outbye conditions and dust levels in intake air and measurement instrument behaviour. A study has evaluated the instrument as an engineering tool that can assess the effectiveness of a single change to improve dust levels fast enough to ensure that other aspects have not changed.

The PDM is a respirable dust sampler and a gravimetric equivalent analysis instrument that is part of a belt-worn mine cap lamp battery. The main components of the device include a cap lamp and sample inlet located on the end of an umbilical cable, a belt-mounted enclosure containing the respirable dust cyclone, sampling and mass measurement system. A charging and communication module is used to transmit data between the monitor and a PC, while charging its lithium ion batteries for the next shift. Figure 1 illustrates the unit.

The current US Federal congressional legislative program includes responses to strengthen mine emergency response plans and the Mine Safety and Health Administration's ability to investigate accidents, enforce health and safety regulations, strengthen rescue, recovery and accident investigation practices. It includes a focus to update the 37-year-old respirable dust standard that is not effectively preventing today's coal miners from developing black lung disease. Part of this move may require miners to be equipped with the new PDMs developed and certified by NIOSH and authorise miners to adjust their activities to avoid respirable dust overexposure.

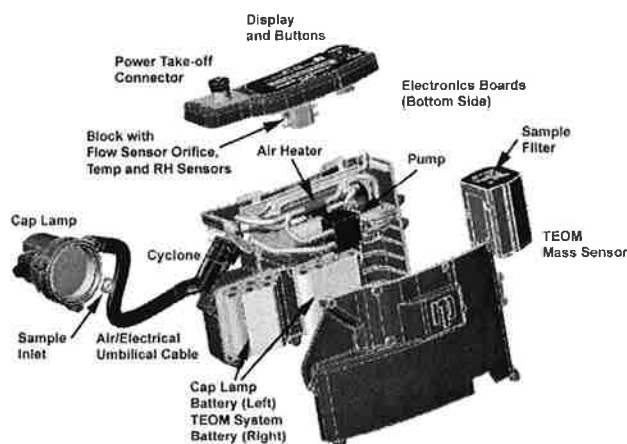


FIG 1 - Major components of the personal dust monitor (PDM).

Figure 1 shows major components of the PDM. The following sections describe underground evaluation exercises that were undertaken to monitor the dust exposure levels of various equipment operators.

Initially tests were undertaken at a development face. The PDM units can give variable time period rolling averages of dust concentration and for engineering evaluation purposes it is better to use shorter time rolling average dust concentration data as the quicker response to monitored changes shows more significant dust concentration variations. As shown in Figure 2, PDM units were put on continuous miner (CM), bolter and shuttle car (SC) operators in tests commencing at 20:15. The face crew was replaced at 21:10 by the second crew as the first crews were released for crib break. The results of the PDM tests are shown in Figure 2 as 15 minute average levels.

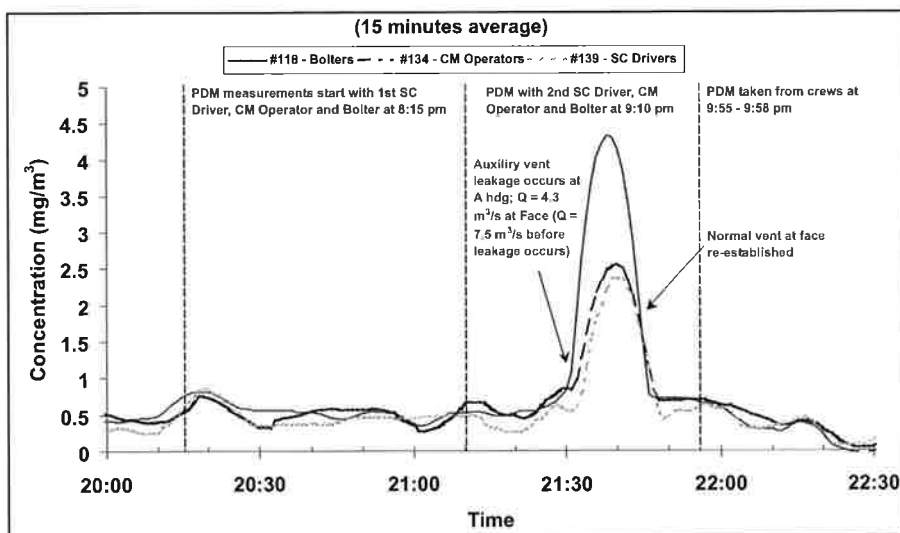


FIG 2 - Development face personal dust monitor (PDM) results.