AUSTRALIAN EXPERIENCE WITH THE PERSONAL DUST MONITOR (PDM) AND THE COAL SERVICES AIRBORNE DUST SAMPLING PROGRAM

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ABSTRACT: An outline of Coal Services Health (formerly the Joint Coal Board) airborne dust sampling methodology and exposure standards in the New South Wales coalmining industry combined with 20 years of personal dust monitoring of the mining industry workforce. Periodic health screening and the results of epidemiology studies indicate adherence to current maximum exposure levels is sufficient to maintain a healthy industry workforce. Initial research with the machine mounted continuous dust monitor (CDM) and the progression to the personal dust monitor (PDM) evaluation in Australia. An investigation into the relationship between respirable dust concentration measurements in underground coal mines using the PDM and the current statutory gravimetric measurement technique AS 2985-2004 used in NSW coal mines.

INTRODUCTION

The Joint Coal Board was originally constituted under an arrangement between the Governor-General of Australia and the Governor of New South Wales made pursuant to the provisions of the Coal Industry Act, 1946 (Commonwealth) and the Coal Industry Act 1946 (NSW). In 2001 the Commonwealth withdrew from the Joint Coal Board and those Acts were repealed. As a replacement for the Joint Coal Board under the new Coal Industry Act (CIA) 2001 (NSW) a new corporation was formed, Coal Services Pty Limited (CSPL) which was legislated to oversee occupational health and welfare in the NSW coal industry. The corporation is owned equally by the New South Wales Mineral Council and the CFMEU (mine workers union). The powers and functions of the corporation are stated in the provisions of the CIA which also includes the specific responsibility to monitor respirable dust in NSW coal mines. (NSW Govt, 2001)

Coal Services Health operates the respirable dust sampling program, which is an occupational hygiene service and is complementary to the other health services provided which include mine workers biological monitoring from chest x-ray examination and lung function tests. Since July 1994 the dust sampling service has been on a fee-for-service basis.

HEALTH RISK

The health risk to mine workers has long been acknowledged as being related to prolonged exposure to high concentrations of respirable coal dust which can lead to pneumoconiosis, and when mining high quartz content material, silicosis. Coal mining has historically been associated with the occurrence of disabling chest diseases.

The International Labour Organization (ILO) Classification System, the international standard, is the system used by Coal Services Health to grade pneumoconiosis on chest radiographs of coal miners. Under this system, there are four major categories used to grade the severity of pneumoconiosis. Essentially, category 0 is the normal state (no pneumoconiosis), category 1 is mild pneumoconiosis, category 2 is moderate pneumoconiosis, and category 3 is severe pneumoconiosis. It is generally agreed by clinicians, that symptoms of pneumoconiosis are not experienced until category 2 is reached. At category 1, most individuals would be unaware of the presence of early pneumoconiosis, and would not normally be restricted in work or leisure activities.
When the Joint Coal Board was established in 1948 pneumoconiosis was prevalent among coal miners (16% all categories, 4.5% category 2 or worse). Today, the prevalence is so low that no new cases of pneumoconiosis have been detected in the last 15 years. The incidence of pneumoconiosis in NSW is among the lowest in the world. For the last 10 years the rates of pneumoconiosis in NSW continues to be less than 0.5%. (Coal Services 2004)

STANDING COMMITTEE ON DUST RESEARCH AND CONTROL (SDC)

Coal Services Pty Limited (formerly the Joint Coal Board) has since its inception actively pursued the eradication of dust related disease among coal miners and in 1954 established this committee to provide expert advice to the NSW coal industry on respirable dust issues. It is constituted from representatives of the colliery proprietors, mining unions, government departments, industry consultants and the Coal Services Health medical and technical personnel. The SDC was instrumental in the introduction of the gravimetric sampling method and the setting of the current exposure standards. The main role of the SDC is as follows:

- Monitoring the results of respirable dust sampling
- Evaluate dust hazards
- Research improved dust control methods
- Disseminate information
- Educate mine personnel in matters related to dust control

The SDC meets bi-monthly, usually at mine sites. The SDC endorses the use of proper ventilation and dust suppression strategies to control dust-related lung disease in the NSW coal industry.

AIRBORNE DUST MONITORING SERVICE

The Coal Services Health (formerly the Joint Coal Board Medical Bureaux and JCB Health) dust monitoring service is laboratory quality accredited and has been the sole organization involved with personal dust monitoring in the NSW coal industry since the current regulations (CMRA, 1982) were gazetted in March 1984. The service has the total support and acceptance of both management and the mineworkers unions.

From March 1984 to December 2004 the specified limit for respirable dust other than quartz-containing dust was 3mg of respirable dust per m$^3$ of air sampled. The specified limit for quartz-containing dust was 0.15mg or respirable quartz per m$^3$ of air sampled.

Following a change to the sampling pump flow rate for Australian Standard AS 2985-2004 and the National Occupational Health & Safety Commission (NOHSC) adopting a limit of 0.1 milligram (mg) per cubic metre (m$^3$) for quartz the specified limits for airborne dust at NSW coal mines were changed in January 2005. For underground mines the specified limit for quartz-containing dust is 0.12mg of respirable quartz and the specified limit for respirable dust, other than quartz-containing dust, is 2.5mg. For open cut (surface) mines the specified limit for quartz-containing dust is 0.1mg of respirable quartz and the specified limit for respirable dust, other than quartz-containing dust, is 2.5mg. The details are in the 17 December 2004 NSW Government Gazette Notice (Appendix A).

The frequency of sampling, places and persons to be sampled in each part of a mine are specified in the gazette notice contents (Appendix B). In NSW sample collection commences at the time of leaving the crib room at the start of the shift and ceases on arrival at the crib room at then end of the shift sample period. Sampling procedure and analysis to AS 2985-2004, although the sampling period where practicable should be not less than five hours (NSW Govt. 1984).
While it is the responsibility of mine management to meet the frequency of sampling required by the CMRA regulations 1999, the Coal Services Health monitoring programs are structured in such a manner that management’s obligations are tried to be fulfilled where possible.

The integrity of results is guaranteed by a Coal Services Health employee present in the workplace during the sampling shift recording such information as ventilation quantities, blocked sprays, operator location, water pressures or anything which may affect results. Results are used solely to identify problem areas which may exist and are not used at any time for punitive measures. Where areas of high dust concentrations are found too exist efforts are directed to these areas in order to rectify the problems. These efforts to improve dust results in many cases involve Mine Management, Mining Unions and Coal Services Health initiatives.

As per the CMRA Regulations 1999, the results of the sampling are forwarded to the colliery manager, senior government inspector of coal mines, united mineworkers district check inspector and included in the Coal Services Health dust database.

If the result of any sample exceeds the specified limit a re-sample must be taken within 7 working days in similar circumstances to those existing when the sample was collected. If the resample still exceeds the specified limit the district government inspector of coal mines may, in writing direct the colliery manager to carry out additional procedures to reduce the concentration of airborne dust (NSW Govt, 1999).

**COAL SERVICES HEALTH DUST DATA BASE RESULTS**

By the end of 2004, after nearly 20 years of sampling, over 55,000 personal dust samples (including re-samples) have been collected from over 12,000 mining locations. Sampling locations were 30% longwall faces, 62% underground other than longwall (mainly continuous miner panels) and 8% open cut/washeries. From 1984 to 1997 the sampling location mix was 65% underground other than longwall and 5% open cut/washeries, increased sampling at open cuts in the last 7 years has seen that % change. An average of over 2,500 personal dust samples at over 500 mining locations were collected per annum between 1984 - 2004.

In NSW during the period 1984-2004 the number of underground mines reduced from 67 to 27, mainly with the closure of non-longwall mines. Open cut mines increased in that period from 18 to 25 mines. Total raw coal production in the period increased from 68.3 million tonnes in 1984 to 152.3 million tonnes in 2004. Underground production increased from 42.2 million tonnes to 48.9 million tonnes and open cut production substantially increased from 30.7 million tonnes to 103.4 million tonnes during the same period. Raw coal production from open cuts in 2004 was over two thirds (68%) of NSW total production. Longwall mining during 2004 represented over three quarters (76%) of underground raw coal output (Coal Services 2005).

In 1984 nearly 19,000 people were employed in the NSW coal industry. The underground mines employed over 15,000 and the open cuts only 4,000 people. In 2004 the average number of employees in the underground sector was just under 5,000 people and the open cuts nearly the same at just over 5,000 people. On average an open cut mine worker produces twice as much coal per hour as an underground employee.
COAL SERVICES ORDER 40 - ABATEMENT OF DUST ON LONGWALLS

Another initiative of the Joint Coal Board and continued by Coal Services by its role in the area of airborne dust was the issue of Order 40 on 5 July 1990. This order requires the manager or owner of any mine operating by longwall or shortwall mining methods to obtain Coal Services approval prior to the commencement of production in any longwall or shortwall block. Results of dust samples from previous longwalls are examined prior to approval. Most approvals granted are subject to some form of imposed conditions to control mine worker exposure to airborne dust.

The advent of Order 40 appears to have created a more positive and co-operative attitude towards dust control measures by both management and unions.

INITIAL RESEARCH OF THE CONTINUOUS DUST MONITOR

In 1997 the Joint Coal Board (now Coal Services) Health & Safety Trust granted funding for an evaluation of a real time dust sampling device which utilised the technology of the tapered element oscillating microbalance (TEOM) continuous respirable dust monitor that was being developed in the USA. The research funding was to evaluate whether the TEOM continuous respirable dust monitor was suitable for application in Australian coal mines and would it provide useful data to control employee exposure to respirable coal dust, under Australian conditions? The project was in two stages the first stage being for two members of the SDC to visit the USA to technically evaluate the suitability of this instrument for use in Australia. At the conclusion of this technical evaluation a decision would then be made whether to proceed with the second stage, an operational evaluation of the instrument under Australian conditions.

In 1998 Brian Davies and Denis Glover visited the USA and reported the following:

• The TEOM technology as developed by Rupprecht & Patashnick Co., Inc.(R&P) appears to be excellent and may well be the basis of all dust monitoring in the future, especially if a miniature personal monitoring device is developed.
• Technical evaluation of the continuous dust monitor (CDM) in the USA was not as advanced as expected, giving rise to serious concerns for stage two, the purchase of an instrument for trials in Australia.
• An offer of a spare CDM instrument from the National Institute of Occupational Safety & Health (NIOSH) was a possibility for trials in Australia.

In 1999 NIOSH decided not to provide additional funding towards the future development of the machine mounted CDM and concluded the following:

• The machine mounted CDM cannot be used to accurately represent mine workers exposure to respirable dust.
• The instrument’s accuracy could not be determined by underground mine testing; however between working shifts the variability was approximately similar to gravimetric personal samplers.
• For a further test program to be considered, the reliability of the machine mounted CDM must be significantly improved.

An evaluation of the CDM in Australia was therefore not going to proceed. Although the USA was switching focus to incorporating the CDM technology into a personal sampling device and if this occurred an Australian coal industry evaluation was possible.
EVALUATION OF THE R&P PERSONAL DUST MONITOR (PDM) IN AUSTRALIA

A project team from the Coal Services SDC was established in 2002 to progress the possibility of the evaluation of the PDM in Australia, as R&P had successfully developed TEOM technology into the PDM. A proposal was to reactivate the original Health & Safety Trust funding for an Australian evaluation and formalise arrangements with R&P to obtain instruments for trial in Australia.

The Health & Safety Trust project aims were as follows:

- Introduce the R&P Inc PDM to operators, employees and other stakeholders in the NSW coal industry.
- Investigate the relationship between respirable dust concentration measurements on underground coal miners using the PDM and the current statutory measurement technique used in NSW (AS 2985-2004). Undertake both lapel and helmet sampling locations.
- Evaluate the reliability, field worthiness and technical value of the PDM under Australian coal mining conditions.

Agreement on sampling protocol was finally settled with R&P and NIOSH in 2004. Three PDM instruments arrived in Australia in April 2005. Initially the intention was to seek NSW Government Inspectorate temporary approval for the PDM and cap lamp at the trial mine site. The application was not progressed due to incomplete tests to satisfy IEC 60079 part 0 &11 and AS/NZS 62013-2001. The instrument manufacturer or his agent will probably apply in the future for the overall approval to use the PDM in NSW underground coal mines.

The Australian Coal Association Research Program (ACARP) also granted funding to Stewart Gillies – Gillies Wu Mining Technology Pty Ltd for a project on using the PDM for personal respirable dust evaluation particularly in engineering studies. The objective of this study is to evaluate the PDM in its capability as an engineering tool to quickly and accurately measure changes to longwall dust levels at operator locations after implementation of a dust control improvement.

The project was undertaken over 4 months from April to July 2005. (Gillies, 2005)

COAL SERVICES NSW TRIAL MINE SITE

West Wallsend Colliery was chosen due to the low prevalence of flammable gas. Under the Coal Mines (Underground) Regulation 1999 the mine electrical engineer allowed the use of the PDM’s during the trial period as non-approved portable electrical apparatus (NSW Govt,1999). Longwall mining was chosen for the trials due to accessibility and the potential for high dust concentrations. Due to longwall goaf caving restrictions, wind blast controls the PDM trial start was delayed until June 2005 and the number of samples collected was less than originally planned.

SAMPLING METHODOLOGY

The PDM unit was programmed for crib room to crib room sampling as per the current practice in NSW underground coal mines. The Coal Services (CS) Health sampling technician was required also to wear two additional sampling pumps and cyclones. One cyclone was attached to the lapel, and the other cyclone was fitted with a tube extension to sample adjacent the PDM sampling inlet point on the helmet at the cap lamp, all samples in the breathing zone as per AS 2985-2004.
FIELD DATA RECORDING SHEETS

The full details of each sampling work location, mining equipment, work task and ventilation were recorded in the dust monitoring log sheet as per Figure 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Velocity:</th>
<th>Height:</th>
<th>Width:</th>
<th>Volume:</th>
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**Figure 1**

**SAMPLING PROCEDURE**

Two CS Health sampling technicians collected 18 sets of samples over a 3 week period. Only 2 PDM units were used during the evaluation trials. The sampling pumps were calibrated each shift and all measurements undertaken in accordance with AS 2985-2004. All analysis was conducted in the CS Health Argenton laboratory, which is NATA lab Accredited. A sample of the PDM printout is shown in Figure 2.

**Figure 2**
PRELIMINARY SAMPLE RESULTS

The paired respirable dust sample filters were analysed gravimetrically and the results compared to those obtained from the PDM unit. Results were conducted only for respirable dust, no quartz analysis was undertaken. A complete statistical analysis of the results has still to be completed. The preliminary comparative results for the PDM’s shown in Figure 3 and Figure 4.
COMMENTS ON THE PDM TRIALS

The PDM unit was comfortable to wear compared to the traditional cap lamp battery pack. The programming and downloading of data from the PDM was relatively easy to operate. Indicative results of dust exposure highlighted the importance of operator location in relation to dust levels.

The comparative results show some promise, however further testing at a number of different mines, seams and environmental conditions is required to provide statistically valid data for a true comparison with the current gravimetric method of sampling. When the PDM unit is fully approved for use in underground coal mines in NSW, Coal Services Health would plan to obtain a number of the PDM units and undertake that further evaluation.

REFERENCES:

NSW Govt. 2001 Coal Industry Act 2001. NSW Govt. Printer: Sydney
NSW Govt. 1984 Coal Mines Regulation Act 1982 No 67. NSW Govt. Printer: Sydney
NSW Govt. 1999 Coal Mines (Underground) Regulation 1999. NSW Govt. Printer: Sydney

ACKNOWLEDGEMENTS:

- West Wallsend Colliery management and employees for their invaluable assistance throughout the PDM evaluation project.
- CS Health Environmental Monitoring Group, especially Glenn Goodwin and Mark Shepherd for all of the underground dust sampling
- Dr Brian Davies – AEHS, for help with the PDM project design, instrument procurement and project review.
By this notice the following limits are specified for respirable dust:

Specified Limits for Respirable Dust – Underground Mines:
For the purpose of Clause 161 of the Coal Mines (Underground) Regulation 1999 (definition of ‘specified limit’), the specified limit for quartz-containing dust is 0.12 milligrams of respirable quartz and the specified limit for respirable dust, other than quartz-containing dust, is 2.5 milligrams. These limits are with respect to the mass of respirable dust per cubic metre of air sampled and apply only to the underground parts of underground mines. The limits below for open cut mines apply to the surface parts of underground mines.

Specified Limits for Respirable Dust – Open Cut Mines:
For the purpose of Clause 29 of the Coal Mines (Open Cut) Regulation 1999 (definition of ‘specified limit’), the specified limit for quartz-containing dust is 0.1 milligrams of respirable quartz and the specified limit for respirable dust, other than quartz-containing dust, is 2.5 milligrams. These limits are with respect to the mass of respirable dust per cubic metre of air sampled.

Definitions:
In this notice:
- “quartz-containing dust” means respirable dust which contains five per cent or more by mass of respirable quartz;
- “respirable dust” has the same meaning as it has in Australian Standard 2985-2004
- “respirable quartz” means the quartz present in respirable dust.

Date of Effect:
This notice takes effect on 1 January 2005.

ROBERT REGAN,
Chief Inspector of Coal Mines

Explanatory Note:
The National Occupational Health and Safety Commission has adopted a limit of 0.1 milligrams per cubic metre for quartz. This is with respect to an 8 hour time weighted average (TWA) and will take effect on 1 January 2005. There has also been a change to AS2985-2004 to bring it in line with the relevant ISO Standard and resulting in a higher flow rate during sampling. Studies undertaken through Coal Services P/L (formerly Joint Coal Board) have confirmed that to cater for the change in flow rate the current limit of 0.15 milligrams is equivalent to a limit of 0.12 milligrams at the higher flow rate. The long standing practice in underground coal mines has been to collect samples from crib room to crib room and for a minimum period of 5 hours. This is to avoid a number of practical difficulties in collecting samples during travel. Research undertaken indicates that crib room to crib room sampling of 0.12 milligrams, at the higher flow rate and with a travelling time conversion factor applied, corresponds to a limit of 0.1 milligrams for portal to portal sampling. The end result is that for underground mines the working limit for quartz is effectively unchanged and remains at a level where silicosis has not been observed in the coal mining workforce.

The change in limit for respirable dust, other than quartz-containing dust, is to take into account the higher sampling flow rate now required by AS2985-2004.
APPENDIX B

TABLE OF LOCATIONS, FREQUENCIES AND PERSONS FOR SAMPLING

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
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</thead>
<tbody>
<tr>
<td>Location</td>
<td>Frequency of Sampling</td>
<td>Persons to be Sampled</td>
</tr>
<tr>
<td>(a) in each part of the mine where longwall mining is carried out.</td>
<td>each producing shift at intervals not exceeding six months.</td>
<td>samples to be collected from the breathing zone of at least five persons including, where possible: - a shearer-loader operator, - two powered support operators, - a deputy, and - one other person to be selected by the manager.</td>
</tr>
<tr>
<td>(b) in each part of the mine where a continuous mining machine operates.</td>
<td>each producing shift at intervals not exceeding twelve months.</td>
<td>samples to be collected from the breathing zone of at least five persons in each unit including, where possible: - a continuous miner driver, - a sideman or cable handler, - a shuttle car driver, - a deputy, and - a boot end attendant or other person to be selected by the manager.</td>
</tr>
<tr>
<td>(c) in any place in or about an underground mine other than those referred to in (a) or (b) above, but including crusher stations and wateriest</td>
<td>at intervals not exceeding twelve months.</td>
<td>samples to be collected from the breathing zone of at least one person.</td>
</tr>
<tr>
<td>(d) in any place in or about an open-cut mine where dust may be present.</td>
<td>at intervals not exceeding twelve months.</td>
<td>samples to be collected from the breathing zone of at least one person.</td>
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NOTE:

1. Any further samples required by regulation will be additional to these prescribed frequencies.
2. In the case of (c) or (d) the manager shall select those activities where workmen are likely to be exposed to airborne dust. Such selection shall be notified on a yearly basis to the District Inspector who may require additional activities to be sampled.
3. Samples and analyses conducted by or for the Joint Coal Board may be used by the manager as part or the whole of the required number of samples to be collected for a given period.
4. Persons sampled shall, as far as possible, remain at the same job for the duration of the test.