# Respirable Dust Monitoring for Underground Coal


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### *Executive Summary*

The "*re-emergence"* of coal mine worker pneumoconiosis in the Queensland coal mining industry has resulted in community and industry focus on respirable dust exposures and controls.

To identify the underlying causes, sites have been re-assessing their current workforce exposures to respirable dust and the effectiveness of controls.

This paper will look at the challenges of obtaining detailed relevant information, accurate data and the effective communication of risk.

Discussion points include:

- Occupational Hygiene Exposure Assessment Programs
- Worker behaviours towards occupational hygiene sampling
- Common limitations for on-site hygienists
- Level of detail required from workers to effectively assess factors influencing their exposure
- Importance of communication and engagement between occupational hygienists and site representatives
- Data review, interpretations and investigation processes
- Questions on the possible future direction/s of this issue.


### *Introduction*

Exposure to respirable coal dust is regulated in Queensland's 'Coal Mining Safety and Health Regulation 2001' as a time-weighted-average (TWA) exposure of 3 $mg/m^3$ (1). The exposure standard represents airborne concentrations of individual substances, which, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers (2). Given the nature of biological variation and the range of individual susceptibility, it is inevitable that a proportion of those who are exposed to respirable coal dust around or below the exposure standard may suffer effects (3).

This exposure can cause adverse health effects ranging from mild symptoms such as eye, nose, throat irritation and shortness of breath – to more severe effects such as Coal Workers Pneumoconiosis (CWP), chronic obstructive pulmonary disease (COPD), emphysema and chronic bronchitis. In it most complicated and devastating form it can progress to massive lung fibrosis causing severe impairment or death within a few years (4).

CWP is a preventable, employment-related, debilitating lung disease resulting from excessive and generally prolonged exposure to respirable coal dust. The risk of developing CWP is directly related to the composition and size fraction of the dust and the magnitude and duration of exposure (5).

In May of 2015 the Queensland Commissioner for Mine Safety and Health confirmed the first case of CWP, or 'Black Lung' as it is commonly referred as, in thirty years. The Senate Black Lung enquiry reported between October 2015 and April 2016 a further seven cases were confirmed resulting in an industry-wide focus on reviewing, assessing and controlling respirable dust exposure in Queensland mines (6).

The occupational hygiene community takes a pragmatic approach to the measurement and control of hazardous substances (7). Occupational best practice utilises an action limit (50% of the regulatory limit) as a trigger at which additional controls should be implemented to ensure better protection to the workforce. The use of an action limit may also provide a pre-emptive additional protection factor in the event that future health research supports a reduction of the exposure standard.

The measurement of personal exposure to respirable dust is conducted in accordance with Australian Standard *AS2985:*2009 (8). This process requires workers to wear a sampling device in their breathing zone for an extended period of their work shift (ideally a full shift) to ensure that a representative sample of their exposure during all activities is collected. Results are a gravimetric determination of an average exposure over the sampling period, which is directly compared against the relevant exposure standard. Results do not take into account personal protection afforded by the use of respiratory protective equipment.

This process is the only regulator-accepted method of assessing worker exposure against the regulatory exposure limit. There is also currently no legislative requirement as to the level of competency required to conduct these measurements.

There is more to the process however than just handing out sampling equipment and reporting results back to the site. With tighter scrutiny on reviewing sampling data and re-assessing current dust controls, sites are requesting clearer information that can assist in determining the causal factors of exposure.

### *Occupational Hygiene Exposure Assessment Programs*

There are a variety of sampling strategies that can be adopted, however it is important for site stakeholders to ask themselves the fundamental question:

"How will the data and information generated from this exercise be used?"

There are two widely used strategies – compliance based programs and comprehensive exposure assessment programs. Both of these have strengths and weaknesses. Traditionally, compliance programs tend to monitor worst case scenarios that may be ad-hoc or complaint driven (9). These programs may not provide an accurate picture of exposure over the long term and may inadvertently direct resources to ineffective controls.

Comprehensive exposure assessments are more favoured by the occupational hygiene community as they are more holistic in nature and are likely to provide a better indication of long term exposure and a more cost effective pathway for control (9). They can however be more expensive to design, implement and maintain in the short term. However, as they are likely to provide a better indication of exposure, the cost can be reduced when offset by more targeted and cost-effective controls.

Whichever strategy is used there are two underlying aspects that could potentially make monitoring a meaningless exercise and a waste of resources. These are:

- The collection of data and information without understanding the purpose.
- Failure to investigate and effectively control elevated exposures.

A well rationalised exposure assessment program relies on a thorough understanding of the workplace exposures. This understanding guides the organisation when:

- allocating resources towards monitoring programs
- identifying whether existing controls are effective
- prioritising suitable and targeted controls
- providing risk communication to workers
- developing worker training programs
- defining specific requirements for personal protective equipment

A comprehensive exposure assessment emphasises an accurate characterisation of exposures and risk to workers under a broad range of operating conditions. It provides the organisation with a robust and transferrable system that allows better understanding of the risks and better positions them to manage those risks.

There are seven main steps to an exposure assessment program (9). These are:

1. ***Establish the exposure assessment strategy and goals***
2. ***Basic characterisation of the workplace, workforce and environment***
3. ***Exposure assessment*** – includes grouping workers into Similar Exposures Groups (SEGs) and establishing exposure profiles for SEG. It is vital that data and information collected during this process is of a high quality ensuring that necessary information is consistently being collected.
4. ***Further information gathering and resolving uncertain exposures***
5. ***Implementing prioritised and effective control strategies***
6. ***Periodic review and reassessment of exposures and workplace information***
7. ***Communication and documentation*** – essential for the success of the entire program.

The ability to understand, prioritise and manage exposures and risks effectively and efficiently requires a more systematic, better documented and dynamic approach than traditional ad-hoc surveys.

A monitoring strategy must be based on multiple measurements of a similar exposure group for it to be meaningful. In order to understand if the risk is at an acceptable level, appropriate sampling, statistical procedures and professional judgement by a competent person must be used to interpret measurement data (10).

The intention of an effective exposure assessment program is to obtain sufficient relevant data to be able to draw informed conclusions around worker exposure and ongoing control strategies. Ideally, the collection of statistically relevant samples

numbers should be the aim. To supplement this, there also needs to be a high level of quality in the information that is collected in relation to the sampling data. This information includes:

- Shift length and rosters
- Specifics of the work conducted by the subject during the sampling period
- Duration of time spent conducting tasks and location of activities
- Controls utilised e.g. ventilation details with regard to worker positioning, dust suppression, personal protective equipment (PPE) use and times
- Production rates
- Break-downs or other factors that aren't considered 'normal'. This includes identifying worker activities conducted during periods of down-time
- Other factors contributing to worker dust exposure that don't necessarily relate to activities conducted e.g. has the panel been recently stone dusted; location of gas drainage points, dust generating activities occurring upwind of worker position.

Due to the difficulties faced by hygienists attempting to conduct thorough observations of all workers, there is always going to be a heavy reliance on using information provided by workers in the evaluation of exposures. To facilitate the information gathering process, workers can be issued with a "Personal Work History" (PWH) record sheet at the start of their shift. Figure 1 is an example of a PWH record sheet.

| NAME: | | SITE: | | DATE: | OCCUPATION: | |
|---|---|---|---|---|---|---|
| WORK AREA: | | EMPLOYEE # | CREW: | SHIFT: DAY / AFTERNOON / NIGHT | | SHIFT LENGTH + ROSTER: |
| Time | | Vehicle ID / Activity *(Dust & noise generating activities conducted or worked adjacent to during survey period)* | Material Being Handled *(Waste / Overburden / Coal)* | Location *(Location where work was being conducted)* | Respiratory Protection Worn | |
| From | To | | | | | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| | | | | | Yes ☐ No ☐ | |
| **Full completion of this work activity log sheet will assist in the evaluation of your exposure data** | | | | | | |
| Respiratory protection type / brand (eg. P2 Mask / 3M): | | | | Have you received training in respiratory protection use: YES / NO | | |
| Was the ventilation in your work area: GOOD / POOR / IMPROVED | | | | Was it a routine day (e.g. No breakdowns, etc): | | |
| Comments: | | | | | | |



**Figure 1:** Example of Personal Work History (PWH) Sheet

A PWH should contain pertinent information that will assist in the exposure assessment process, such as:

- Site, date and name of worker
- Worker occupation or SEG No.
- Shift roster information
- Personal protection worn
- Other comments (i.e. control failures, breakdowns)
- Areas worked, tasks and time taken to conduct these tasks

Workers are instructed to complete this throughout the shift. Therefore it is important that workers are educated on the importance of reporting relevant information.

### *Worker attitudes toward occupational hygiene sampling*

Worker attitudes towards occupational hygiene sampling is a key factor in obtaining quality information. From experience, many workers seem disconnected with the exposure assessment process. These workers feel they are selected for monitoring and have results provided, however are unsure as to the intent of the program, what their role is in its success and what are the key actions arising from the sampling.

Workers need to be provided with awareness regarding the goals of an exposure assessment program, how it will be conducted and the site expectations. They should also be informed of the limitations of the program, time restraints and expected feedback. Experience shows that workers who understand the need behind sampling and are aware of the goals of management and site health and safety representatives are more likely to comply with instructions and contribute positively towards the overall success of the program. This is particularly evident at sites where the workers are part of the process to identify control deficiencies and recommend improvements. When workers are not aware of the process, or their role to play, and subsequently don't provide the necessary information, it is near impossible to draw valid conclusions from the exposure data.

### *Common limitations for on-site hygienists*

The main limitations encountered relate to cost, resourcing, time and access to production areas to facilitate worker observations.

#### *Cost and resourcing*

Obtaining adequate information can be difficult particularly without appropriate resourcing. There is a delicate balance between providing a cost effective service and not compromising the hygienists ability to collect data and information that meets quality expectations. The assistance of site representatives is crucial in achieving this, particularly if / when investigating over exposures or control effectiveness is required.

In addition, there is also a need for a moderate level of occupational hygiene knowledge for site health and safety personnel and industry / union representatives on site. This may involve formal and structured training as their involvement to facilitate occupational hygiene monitoring is also essential in obtaining quality data and information.

#### *Time restrictions*

Time restrictions are one of the greatest challenges occupational hygienists and field technicians face when issuing and collecting sampling equipment due to production pressures. As previously identified, the assistance of management, supervisors and health and safety representatives during this time is critical.

Having defined and centralised areas where workers can be fitted with sampling equipment and meet for retrieval can significantly aid in this process.

Sufficient time is also needed at the start and end of shifts to disseminate and collect the necessary information, particularly where, for a variety of reasons, workers have not provided sufficient information on their PWH Sheets. Several follow-up questions may need to be asked of the worker regarding activities, controls and exposures. This is not exclusive to respirable dust monitoring.

Depending on the number of samples being collected, the complexity of the site (i.e. several different end of shift collection locations), or fatigue management when sampling successive shifts, it is not always possible for the Hygienist to thoroughly review the PWH and ask any necessary questions before the workers depart site.

This time is also an opportunity for workers to discuss and provide insight regarding activities and potential exposures during the shift. The more informed people available to assist with this review stage at the end of the shift - the quicker the process will be while maintaining a quality process. This again highlights the importance of site health and safety representatives being readily available at this time to assist. This is by far the best opportunity to talk to workers and ensure they have provided accurate and required information to be able to evaluate exposures and the effectiveness of current controls.

*Access to site and production areas*

In addition to the information workers provide on their personal work history sheets, hygienists also need to have an understanding of how the site operates. Without this it is difficult to determine if workers are providing accurate information. This includes, and is not limited to:

- Knowing the active areas of the mine at the time of the survey period
- Changes since previous surveys, if any
- Details about current controls e.g. ventilation plans
- Equipment used and how it is operated e.g. longwall cutting patterns may impact worker positioning
- Production details
- Details of PPE supplied on site and programs to support their effective use.

The best way to collect this data is by conducting observations of workgroups during routine activities. Access to site is essential to facilitate this. From a logistical stand point this information can be difficult to collect particularly when health and safety personnel don't have access to all areas therefore requiring additional resources. This is considered a limitation however every effort should be made to encourage the observations of work practices. The better understanding that the hygienist has of the site operations and controls; the better chance they have to be able to comprehend and evaluate exposure and provide recommendations for improvement.

***Data review, interpretation and investigations***

A review of all occupational hygiene data / reports should be done within a timely manner. This should include comparing results against previous surveys to determine trends or long term exposure averages.

Following occupational hygiene monitoring further investigation may be necessary. Even when a high level of information is provided by the worker and site, causes of

elevated exposure may still be unknown. The investigation process should include worker consultation to obtain a thorough understanding of work activities, locations and potential other high risk activities that occurred that may have impacted on their exposure. As this will be a retrospective investigation the ability for the worker to recall pertinent details will be limited with a greater time between sampling and follow-up investigations.

Where the cause of exposure is still unknown there may be a need to re-assess with previous data to determine if the measured exposure was considered ‘normal’ or an outlier resulting from an ‘unusual’ event. Fundamentally sites need to remember that sampling is not a control strategy. Ongoing monitoring should be used to assess the effectiveness of implemented controls and to assess the risk to worker health.

Low exposures should also be reviewed to determine if that particular worker conducted the task differently resulting in a reduced exposure when compared to others in the SEG. This practice could be adopted by all, reducing overall exposures for a group of workers.

Given the ever changing nature of the mining environment there is difficulty in collecting comparable data under similar conditions. Particularly in underground workings, there can be a strong correlation between measured exposures and changes in production rates or the operating environment, such as ventilation conditions. This poses a great challenge when trying to collect representative data or when trying to identify causes of varying results over the long term.

There are many tools / equipment that can be used to facilitate timely investigations. Due to the delay between sampling and the issue of results using traditional personal sampling methods (in accordance with AS2985) there is heightened interest in the use of real-time instruments to measure instantaneous exposure to airborne contaminants. When used appropriately, these instruments can provide immediate insight into sources of exposure. Again, with all sampling the fundamental question needs to be asked.

“How will the data and information generated from this exercise be used?”

Real Time Dust sampling also requires good observations and quality information from workers. Without these the data collected is limited in its use.

Situations where the use of real-time instruments can be of value include:

- educating personnel on worker positioning in relation to dust generating activities
- assessing effectiveness of controls
- assessing exposure trends over a shift
- using it as a point source (sniffing tool) to identify and somewhat quantify sources of dust emission

Figure 2 represents a data plot without observations. Consider what this data-plot would tell you without the observations?

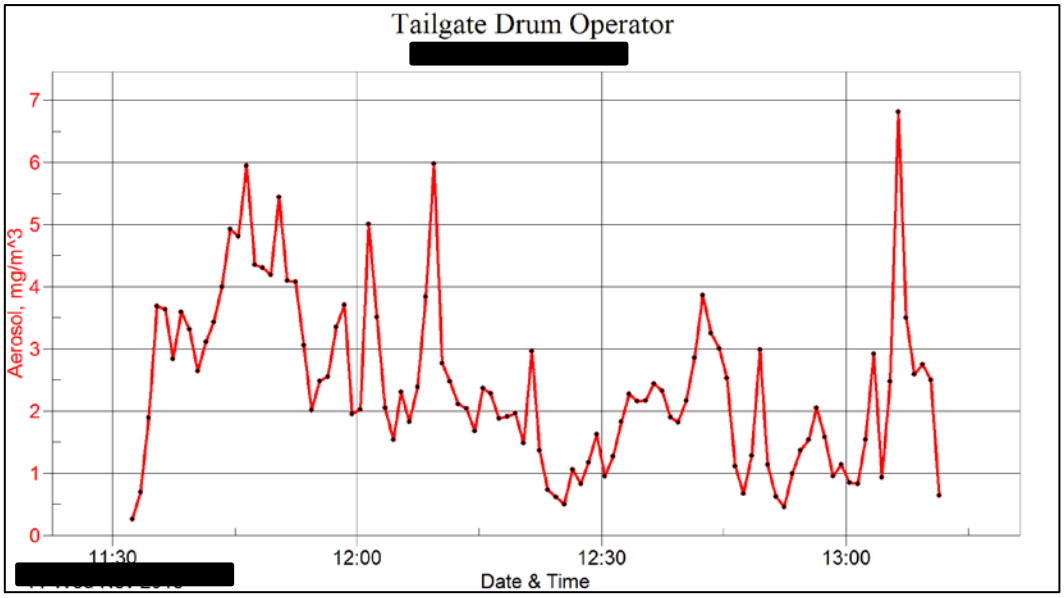


**Figure 2:** Real Time data-plot without observations

Figure 3 is the same data-plot with supporting information.

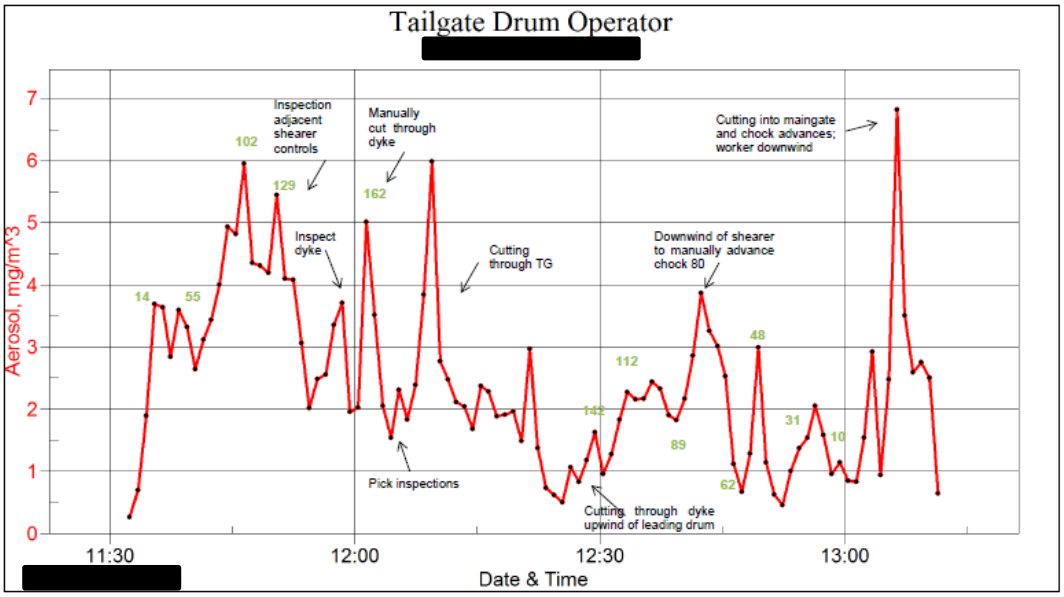


**Figure 3:** Real Time data-plot with observations

Before using real-time instruments it is important that operators understand the sampling technology, limitations of these instruments, data output parameters and differences between results obtained from real-time instruments when compared with traditional personal sampling.

Static (or fixed) sampling can be used to measure area-specific dust levels and identify sources and causes of dust generation. Static sampling is also a valuable tool for assessing the effectiveness of controls and understanding background dust levels at specific locations. Dust measurements collected at static sampling points are not representative of actual worker exposure and therefore should not be directly compared to regulatory limits. The selection of sample location is very important to determine what the data is telling you. There also needs to be an understanding of

what activities are occurring upwind of the static sample locations that may impact on results. When repeating sampling any variations in location, production, controls etc. need to be noted as part of the result evaluation.

### *Future direction of this issue*

With the heightened awareness and occurrences of occupational illnesses as a results of respirable dust exposures in Queensland underground coal mining, there is a need for sites to be proactive in their approaches to overcoming this issue. As an initial step sites should form a committee with relevant stakeholders to oversee activities involving investigations and dust mitigation strategies. A well-structured committee should draw participants from a range of stakeholders including:

- Coal Mine Workers
- Deputies
- Ventilation Officers and Engineers
- Management
- Maintenance personnel
- Health and Safety team
- Site industry / union representatives

A combination of control strategies will need to be adopted to provide an effective and long-term solution to respirable dust exposure. Engineering strategies, when designed and implemented effectively will provide the best long-term solutions for dust control. These strategies include:

- The use of automation and remote control technologies for production areas. This is one of the most effective long term solutions as it re-locates workers outside of dust generating activities.
- Knowing ventilation patterns. Where is dust migrating? This then leads into education around worker positioning to minimise exposure. Correct worker positioning in relation to dust generating activities can have a significant impact of exposure levels.
- Focussing on improving dust suppression at the source. Once becoming airborne, respirable dust particles are very difficult to capture using dust suppression techniques. Focus should be on suppression at the source rather than capture in the pathway.

Personal Protective Equipment is the last line of defence and should not be solely relied on. However in underground mining environments there tends to be a heavy reliance on their use. This should involve addressing the suitability and effectiveness of respiratory protective equipment (RPE) and include auditing the site's respiratory protection program. This audit should review:

- Documented RPE policies and procedures
- If the selection, use, maintenance and limitations of respiratory protection is adequate and in accordance with AS/NZS 1715 (11);
- Suitability of RPE storage
- Training and competence records
- Fit testing frequency and results
- Clean shaven policy. In accordance with AS/NZS 1715 workers required to wear either negative pressure (e.g. disposable dust masks, ½ face canister masks) or positive pressure respirators are required to be clean shaven to maintain an adequate seal to the worker's face (11).

- Random inspections to ensure respiratory protective equipment are being worn in mandatory requirement zones.

All aspects of the auditing process should be documented and kept on record. This provides evidence to show that respiratory protection is being used correctly and therefore should provide the level of protection assigned to the respirator in accordance with AS/NZS 1716 (12).

### *Conclusion*

The accurate and thorough measurement and assessment of coal dust exposures are critical factors in understanding the extent of the CWP risk to coal workers. The underpinning requirement is to understand how the data and information generated from exposure monitoring is to be used.

In order to make informed, accurate and relevant decisions that positively contribute towards protecting the workforce, industry must consider the following key points:

1. Encourage and facilitate active worker and management engagement and participation in the exposure assessment program.

2. Ensure that the exposure assessment program is adequately resourced to achieve the program goals.

3. Collect quality supporting information to make informed decisions.

4. Interpret, understand and act on the data to reduce worker exposure and risk of CWP.

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